Feline Medicine for Veterinary Technicians

Edited by **Paula Plummer**





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Feline Medicine for Veterinary Technicians

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Edited by Paula Plummer

LVT, VTS (ECC, SAIM, CP-fe)
Texas A&M College of Veterinary Medicine & Biomedical Sciences
College Station, Texas, USA

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This textbook is dedicated to veterinary technicians and their feline patients. May this textbook be the resource you need to become your best feline patient advocate.

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List of Contributors

Ellen M. Carozza, LVT, VTS (CP-Feline)
The Cat LVT LLC.
Herndon, Virginia USA

Jaci Christensen, BAS, LVT, VTS (Oncology)
Veterinary Medical Teaching Hospital
Texas A&M College of Veterinary Medicine
& Biomedical Sciences
College Station, Texas, USA

Christina M. Daigle, LVT, VTS (CP-C/F)
Kindred Spirits Veterinary Clinic
Glenburn, Maine, USA

Monique Feyrecilde, BA, LVT, VTS (Behavior), Elite FFCP Veterinary
Teaching Animals
Maple Valley, Washington, USA

Kelly M. Foltz, BA, AAT, CVT, LVT, RVT, VTS (ECC)
BluePearl
Tallassee, Alabama, USA

Amanda Friedeck, BS, LVT, VTS (Dermatology)
Veterinary Medical Teaching Hospital
Texas A&M College of Veterinary Medicine
& Biomedical Sciences
College Station, Texas, USA

Kristie Garcia, LVT, VTS (Cardiology)
Garden State Veterinary Specialists
Eatontown New Jersey, USA

Lanette Jordan, BS, LVT, VTS (Anesthesia and Analgesia)
Veterinary Medical Teaching Hospital
Texas A&M College of Veterinary Medicine
& Biomedical Sciences
College Station, Texas, USA

Camille Kelly, CVT, VTS (ECC)
University of Florida, College of Veterinary Medicine
Gainesville, Florida, USA

Chastity Ketchum, LVT, VTS (Internal Medicine-SA)
Veterinary Emergency Group
Charleston, South Carolina, USA

Paula Plummer, LVT, VTS (ECC, SAIM, CP-fe)
Veterinary Medical Teaching Hospital
Texas A&M College of Veterinary Medicine
& Biomedical Sciences
College Station, Texas, USA

Rhonda South-Bodiford, LVT, VTS (SAIM)
Veterinary Medical Teaching Hospital
Texas A&M College of Veterinary Medicine
& Biomedical Sciences
College Station, Texas, USA

Courtney Waxman, MS, CVT, RVT, VTS (ECC)
Veterinary Nurse Consulting, LLC
Green Cove Springs, Florida, USA

Ann Wortinger, BIS, LVT, VTS (ECC) (SAIM) (Nutrition), Elite FFCP
Appalachian State University, Veterinary
Technology Program
Belleville, Michigan, USA

Jan Yaroslav, RVT, VTS (Dentistry), VTS (CP-Feline)
Chico Hospital for Cats
Chico, California, USA

Preface

As a credentialed veterinary technician, I have dedicated my career to the idea of "lifelong learning" as outlined in the Veterinary Technician Oath. This commitment extends to both my personal development and assisting others in achieving their goals. A significant part of my career has been focused on caring for my patients, particularly feline patients. Serving as a patient advocate is a great privilege that I hold dear. Being their voice in times of need, providing support, and ensuring their well-being are the most rewarding aspects of my role as a veterinary technician. Early in my career, this meant acquiring as much knowledge and skill as possible to effectively advocate for my patients. As my career has progressed, I have transitioned into sharing knowledge with others so they, too, can become the best veterinary technicians and patient advocates they can be.

This book is designed for clinical veterinary technicians working with feline patients. It caters to those working in multi-species hospitals as well as those exclusively with feline patients, offering comprehensive knowledge about this species. It also targets individuals aspiring to become a feline veterinary technician specialist. The book covers a broad knowledge base of feline diseases, including physical examination findings, clinical signs, and step-by-step procedure lists for common diagnostic techniques.

The book is divided into sections that address patient care needs and special considerations for feline patients, as well as systematic diseases and conditions. The first section focuses on the cat and specific considerations, covering topics from behavior and interactions to feline-specific pharmacology and analgesic considerations. The second section delves into patient care, including critical thinking, wound care, and bandaging. The third section focuses on diseases and conditions of the feline body systems. The companion website offers study questions for each chapter, educational tools, and clinical handouts, providing study materials and clinical tools for readers.

The book is a result of the collective effort of a group of phenomenal veterinary technician specialists dedicated to feline patients. Your devotion to this book as well as the profession inspires me to continue to grow and reach for the stars. It has been my honor to work with you all.

Paula Plummer

Acknowledgment

As I sat down to write this portion of the book, I quickly realized how challenging this page would be. I took a moment to reflect on my years as a credentialed technician and I am reminded of so many people that I not only consider a friend but family. So many people have touched my life and helped shape who I have become not just a technician but as a person. There are a few that I want to recognize a little more formally.

First and foremost, I give all the glory and recognition to God. His grace has provided me with this extraordinary life and has made endless opportunities possible. Reflecting on my career, I realize that many mentors were strategically placed in my life at pivotal points, guiding and shaping my professional journey. I am forever grateful to each of you for generously sharing your knowledge and unwavering belief in me, providing constant encouragement to reach for greatness.

To my husband, Josh, thank you for years of constant support and encouragement to reach for the next dream. I call myself blessed to walk through this life by your side. And to my family and friends, your constant presence in my corner is not just comforting, but inspiring.

Without the dedication and hard work of all the contributors and the publishing team, this book would not have been possible. I extend my heartfelt gratitude to everyone involved for bringing this cherished dream to fruition.

About the Companion Website

Feline Medicine for Veterinary Technicians
is accompanied by a companion website.



http://www.wiley.com/go/plummer/felinemedvettech1e

The website includes:

- Over 200 study questions related to each chapter of the textbook
- Educational and case-based videos
- Procedural checklists
- Client educational tools
- Feline dental radiograph guide
- Educational handouts
- Figures and tables from the book

1

Feline Behavior

Monique Feyrecilde BA, LVT, VTS (Behavior), Elite FFCP Veterinary

TECHNICIAN TIDBITS

- Cats share behaviors with other species and have unique feline behaviors.
- Emotions impact feline welfare and quality of life.
- All animals learn via essentially the same mechanisms.
- How cats sense and perceive the world impacts their behavior inside and outside the veterinary hospital.
- Recognizing normal and abnormal behavior positions professionals to help clients and facilitate a healthy human–animal bond.
- Understanding the learning theory is essential for veterinary professionals.
- Screening for common unwanted behaviors should be part of every veterinary visit.
- Incorporating behavior into every visit improves the lives of both cats and people.
- The three most common cat behaviors that clients describe as problematic can sometimes be prevented or reversed.
- Early detection improves the prognosis for treating problematic behaviors.
- It is not necessary to know everything about behavior modification to provide early detection.
- Building a referral community allows rapid referral when indicated.

All animals share certain behavioral traits and also have unique species-specific behaviors. Essentially, most animals learn through the same mechanisms. They acquire behaviors and abandon behaviors based on whether the behaviors are effective from the individual animal's point of view. Emotions impact the animal's overall experience, future decision-making, and even affect how memories are stored in the brain [1, 2]. To fulfill our vocation as veterinary professionals, we need to take time to understand the behavior of our patients: how they learn, how species are unique, and how they are similar. Differentiating between normal and abnormal behavior, anticipating how an animal will respond in a given situation, and knowing how to modify or change behavior are all crucial skills for veterinary professionals [1, 2]. In this chapter, we discuss how cats are similar to other species and how they are unique.

The human–animal bond is the heart of veterinary medicine. How animals behave can have a dramatic impact on the quality and length of the human–animal bond. A strong human–animal bond protects the physical and emotional health of cats. When we take the time to understand feline behavior, we can be good stewards of the human–animal bond. Caring stewardship improves the welfare for both pets and people [2, 3].

1.1 Sensation and Perception

Animals are equipped with a sensory system that gathers information from the environment. Sensory information is transmitted to the brain, where it is decoded. Decoding sensations into useful information is called perception. Senses drive perceptions and perceptions impact behavior. Cats share similar senses to other mammals, including sight, olfaction, hearing, tactile (touch), and taste. How cats sense and perceive the world is unique, and understanding their special sensory organs and perceptive abilities allows veterinary professionals to provide the best possible care.

1.1.1 Hearing

Sounds are measured by their frequency, measured in hertz (Hz). Cats have very sensitive hearing, with an approximate range spanning 55–79 000 Hz. For comparison, dogs hear frequencies between 67 and 45 000 Hz, and humans can only hear 20–20 000 Hz [2]. Cats are born with their ear canals closed and incompletely developed. As their ears open between 7 and 14 days of age, they begin to sense and perceive sounds in the environment [1]. Much like humans and many other mammals, as cats age and the hairs inside the inner ear stiffen, they will not hear higher frequencies as clearly [2]. Individual variation occurs, and some cats may be entirely deaf for part or all of their lives. Many of the sounds cats make are accompanied by a tactile experience. Purring is a good example. Neonatal kittens and deaf cats can perceive purring and will express vocalizations even if they cannot hear themselves [1].

When working with cats, providing an environment free from loud and shrill sounds will help them be more comfortable. For training purposes, a marker sound is often useful. Hospitalized cats should not be housed near equipment with high-frequency emissions, such as ultrasonic scalers or cleaners, as this may cause undue stress even though human caregivers are not able to fully hear these sounds [2].

1.1.2 Olfaction and Pheromones

Olfaction, or sensing and perceiving odors, is an important part of the lives of cats and how they communicate. When odor molecules enter the nasal epithelium, they will encounter olfaction centers that transmit this information to the olfactory bulb in the brain. Humans have about 5 million receptors. Cats have 150–200 million [2]! Cats spend a similar amount of time as dogs investigating odors in the environment. Odors that seem pleasant or mild to humans can be quite strong to cats, and potent chemicals and cleansers can cause "nose blindness" [1]. Nose blindness is when the olfactory center is temporarily overwhelmed by strong or noxious information. Being nose blind is uncomfortable for cats because it limits their ability to scan the environment for odor in a normal way.

Pheromones are another means of chemical communication for cats. Individual species have their own pheromones, and they are unique and specific to a given species. For example, humans cannot detect dog pheromones, and dogs cannot detect cat pheromones. Fear pheromones from a dog will not prompt a fear response in a cat, but fear pheromones from another cat may [1]. Pheromones are sensed by the Vomeronasal Organ or VNO. The VNO is considered part of the olfactory system, but pheromones and odors are different. Cats deposit pheromones in the environment via glands in the paws, cheeks, chin, mammary glands, anal gland secretions, and urine to share information about age, health, sexual and reproductive status, territory, and social interactions [1]. Synthetic pheromones simulating the F3 fraction deposited by facial rubbing can sometimes have a calming effect on cats. Many cats prefer and enjoy petting and touching the areas where the facial glands are located [4]. Figure 1.1 shows the locations of facial glands in cats.

1.1.3 Vision

Cats are very sensitive to both contrast and motion, but the spectrum of colors they see is far smaller than that of humans and dogs. Cats' eyes have about 10% of the number of color receptors found in human eyes. Because they have tapetum lucidum, cats have superior vision under low light conditions [2].

When training cats, consider using high-contrast items for treats, targets, beds, scale pads, feeding stations, and toys. Moving toys are often more exciting to cats as a reward than stationary items.

1.1.4 Tactile and Touch

In the veterinary setting, many of our patient interactions involve touch. The density of nerve-ending distribution over the body affects how intense a sensory input when it reaches the brain. Individual variation will determine how each animal processes and responds to touch. Take the example of tickling: touching a ticklish person and a non-ticklish person in the exact same way produces two very different responses [1, 2, 4]. This is due to individual variations in how the two different brains perceive similar raw sensory data. Perception drives behavior.

Similar to humans, dogs, and many other mammals, cats have a higher density of nerve endings around the face, lips, ears, paws, and genitals with the trunk having a lower density of nerve endings per square centimeter of surface area. Cats also have special sensory hairs (vibrissae) on their lips and cheeks, chin, above their eyes, and on the caudal aspect of the forelimbs above the carpal pads.

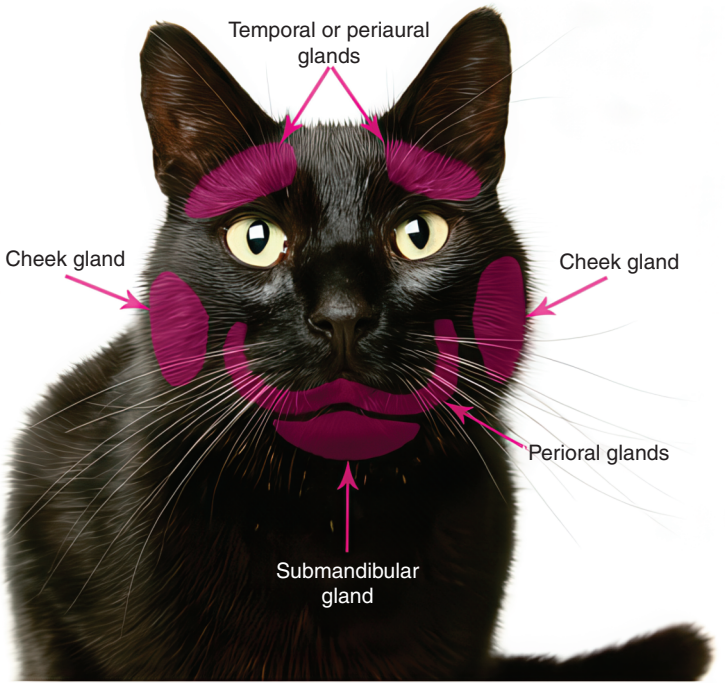


Figure 1.1 Facial gland locations in cats. Many cats prefer petting and touching in these locations. *Source:* International Society of Feline Medicine (ISFM).

When planning touch for cats, consider how they experience these sensations. Starting touch in a less sensitive area and gliding to a more sensitive area is a good general practice [1–4]. For instance, if touching a forelimb, begin touching the back of the head or shoulder, then glide down the limb and avoid putting excessive pressure on the vibrissae. Many cats enjoy tactile stimulation around their cheeks, head, and rump areas. Pleasurable tactile stimulation is often a valuable form of distraction and reinforcement when interacting with and training cats. Actions such as tapping a cat's head should not be used as a distraction, because it relies on an unpleasant or annoying sensation in a very sensitive area of the cat's body.

1.1.5 Taste

Cats have about 500 taste receptors, while most humans have between 4000 and 9000 taste receptors [2]. Olfaction and taste are closely linked, and the palatability of food often relies more heavily on odor than flavor for cats. Based on anatomical studies, it is believed cats detect savory and bitter and show a decreased response to salty and sweet. Cats are somewhat unique in their propensity to develop rapid conditioned taste aversion. Just a single experience triggering an unpleasant taste response can lead to a cat showing extreme behavior when presented with the same odor (predictor of taste) in the future [3]. This can be particularly problematic when administering medications, and formulations should be considered with this behavioral need of cats in mind [2].

1.2 Feline Body Language

Animals rely heavily on body language to communicate their thoughts and feelings, and to broadcast their intent about upcoming actions or behaviors. Veterinary professionals can carefully observe feline body language to provide the best possible veterinary experience, help cats participate in training and conditioning programs, and assess responses to behavioral therapies.

When first learning the body language signals of cats, it can help to evaluate each body part of interest, and then consider the whole picture and the context before arriving at an interpretation. Since cats do not share our human language, we will never be able to ask about their precise intention, but through careful and repeated observation, we can anticipate the likely sequence of a cat's behaviors based on their body language.

1.2.1 Arousal and Stress

Arousal refers to the overall emotional state of readiness to act or react [2]. Cats experience enhanced arousal when they are excited, pursuing prey, playing, greeting friendly people or animals, or participating in fun activities. Arousal is also increased during times of stress when the fear response has been activated and cats must respond to a perceived threat or conflict. Evaluating the overall context of the observed behavior helps guide the interpretation of a cat's body language. For instance, when pupils are mentioned, consider the ambient light. Dilated pupils can be a sign of stress, or dim lighting [1]. Context matters.

1.2.1.1 Calm or Relaxed

A calm or relaxed cat will express a low level of arousal and will appear comfortable. The cat may appear neutral or solicit interaction. Sometimes, these signals are referred to as distance-decreasing signals because they invite interaction.

Pupils: Appropriate to ambient light.
Eyes: Open and attentive or squinting with slow blinking, may hold prolonged eye contact if something is interesting.
Brows: The muscles between the eyes are relaxed, creating a soft or neutral brow.
Ears: Muscles around the ears are relaxed and the ears are held in a neutral or slightly forward position.
Lips and whiskers: The commissure is relaxed, the whiskers are neutral and positioned to the side.
Body tension: The cat's muscles are largely relaxed. If lying down, often the cat will be stretched out or rolled on a hip. If walking, the cat will cross open spaces and appear free in its movements.
Tail: When walking, the tail is held up and the tip is often curled over. Tail movements are fluid with relaxed muscles.
Proximity: Will approach or will not move away when approached.

1.2.1.2 Mild to Moderate Stress

A cat experiencing mild-to-moderate stress will appear more aroused and settle less frequently. The cat may solicit interaction, but its body language when soliciting will appear more tentative. Mildly or moderately stressed cats may appear ambivalent, as though it is difficult for them to decide if they wish to approach or would prefer more distance.

Pupils: Partial pupillary dilation, or frequent changes in pupillary size.
Eyes: Open, slightly squinting, or mildly wide eyes. May intermittently look away or beyond rather than giving direct eye contact.
Brows: The muscles between the eyes have some tension, drawing the brows together.
Ears: Muscles around the ears have increased tension, and the ears may be held higher on the head and forward or to the side.
Lips and whiskers: Commissure tightens slightly, appearing as a smaller or more closed mouth. Whiskers may pull forward or move between forward and side orientation.
Body tension: Muscles will have more tension. If the cat is lying down, paws may be folded close to the body. If walking, the cat may stay closer to walls or be less likely to cross open areas.
Tail: When walking, the tail will be visible but may be high or low-slung. Tail movements are less fluid, and the tip may twitch. If lying down, the tail may be pulled close to the body.
Proximity: Unlikely to approach, likely to look away, lean away, or move away when approached.

1.2.1.3 Severe Stress

Severe stress in cats will manifest as a freeze, flee, or flight response. All of these are distance-increasing requests.

Pupils: Pupillary dilation beyond what is appropriate for ambient light.
Eyes: Widened with direct staring or tightly closed while looking away.
Brows: Tight muscles across the top and back of the head pulling the brow tight.
Ears: Muscles around the ears have increased tension, ears held to the side or flattened.
Lips and whiskers: Tight commissure, mouth may be open or vocalizations observed. Whiskers tensely held far forward or folded flat backward.
Body tension: Tense muscles are either frozen completely or ready to spring forward or away.
Tail: When walking, the tail may be switching or lashing or held tightly down or under the body. When lying down, the tail is held tightly to the body or may slash intermittently side to side.
Proximity: May either flee, freeze, and fail to approach, or rapidly approach with or without subsequent retreat.

1.2.2 Predatory Body Language

Cats are natural predators, but kittens learn to hunt from their mothers. Kittens raised indoors without an example of hunting behavior shows the predatory sequence, but actually killing and ingesting prey is much less likely compared with kittens taught by their mothers [3]. Cats hunt using stealth, speed, and surprise. When observing prey, cats often crouch, intermittently freeze, move, and stare intently. They may seek cover, such as vegetation, rocks, or a piece of furniture to conceal their position. When approaching prey, cats stalk with a low-slung body before pausing to prepare to pounce, followed by a forward or upward leap and grab. If the prey item is large or engaging in self-defense, the cat may grasp with its forelimbs and kick out repeatedly with the hind limbs. This maneuver is also used when cats are playing, fighting, or engaging in serious self-defense [5].

1.2.3 Play Body Language

The body language of play and predation has a great deal of overlap in many carnivorous and hunting species. Hiding, stalking, pouncing, grabbing, biting, and kicking can all be observed in play between cats, toy-directed play, and human-directed play. During play, many cats engage in repeated leaps rather than the single pursuits observed in the predatory sequence. Why? Because the toy is still present and a bird or mouse will have escaped. Sometimes during play, arousal levels increase and the play may tip over into a fight-or-flight response. It is always advisable to use toys to play with cats rather than hands and feet to avoid accidental injury if play becomes too intense.

1.2.4 Body Language in the Veterinary Setting

Preventing and reducing stress for feline patients is of paramount importance. Veterinary professionals are obligated to prevent and reduce pain and suffering in animals. Emotional pain is equally important as physical pain [2]. Furthermore, clients who perceive their cats experience stress in the veterinary hospital or find visits unpleasant will be less likely to bring their cats for healthcare [1, 2, 4]. Reduced healthcare is a fact of veterinary-related stress in cats. Refer to Chapter 2, "Feline-friendly Interactions," for an in-depth discussion of best practices for welfare-centered visits.

1.3 Community Behavior in Cats

Free-living cats in communities, such as feral or semi-feral colonies will show some unique behaviors while others overlap with the lives of housecats. Free-living cats are organized in complex social groups, with affiliations or friendships building between specific individuals. The colony will have a group scent that all colony members recognize, and most colonies are antagonistic toward cats outside their own colony [1]. Colony size and behavior are dependent on the resources available. Abundant resources may support large colonies and decrease conflict between cats, while scarce resources may limit colony size and result in increased antagonistic behavior between cats.

Female-based family relationships form the basis of many colony structures, including multi-generational families. Queens may co-parent multiple litters of kittens, and toms may assist in rearing kittens by grooming, displaying hunting behaviors, and defending against cats from other colonies and predators [3].

Friendly relationships between cats often include touching noses, allogrooming, traveling together, spending time in close proximity, mirrored or parallel activities, community sleeping, sharing resources, mutually defending territory, and raising young. It is rare for an outsider to join an established colony, but it does occur. In the uncommon event, an outside cat joins a colony, numerous interactions are required over some time before the cat is accepted.

The territory is delineated and maintained with scent marking. Urine, feces, anal sac secretions, pheromone markers, and visual marks made by clawing are all used to identify colony territory and resources [1, 3].

Colony behavior is relevant to housecat behavior in a number of ways, especially in multi-cat households.

- Maternal-kitten and family relationships are most likely to be peaceful between cats.
- Accepting an outside adult cat requires numerous positive interactions at a distance if the outside cat will be accepted at all. This dramatically impacts adopting additional adult cats into an established household.
- A group of cats within a household will develop a community scent. When this community scent is disrupted by moving, changes in physical health or reproductive status, or visits to the veterinary hospital by one cat followed by a return home, antagonistic behavior may be seen between cats.

- Cats are excellent at social learning, observing the behavior of another cat, and then acquiring a new skill or habit.
- Marking behavior is completely normal and necessary in cats but can manifest in ways, which are unacceptable to clients.

1.4 Sexual Behavior in Cats

Female cats (queens) reach sexual maturity between 3.5 and 12 months of age. Males can reach sexual maturity as early as 3.5 months of age, but 6 months is more common. Once sexually mature, queens will have an estrous cycle every few weeks during the breeding season. Depending on location, weather, daylight length, and resource availability, cats are generally polyestrous from spring through autumn, and anestrous in winter months. Cats are induced ovulators, meaning when in estrus, they will only ovulate once copulations have occurred. The estrous cycle consists of proestrus and estrus, followed by either diestrus (if the female ovulates), interestrus (if no ovulation occurs), or anestrus which is a period of seasonal inactivity [6].

During proestrus, queens generally show 1–2 days of vocalizing, rubbing, kneading, rolling, and allowing males to approach more closely. Males attempting to copulate during proestrus will be met with aggressive displays by the female. Estrus follows when the female is receptive to copulation. During estrus, females do less rolling and rubbing, and more posturing paired with increasingly intense vocalizations. Estrus posture includes forelegs on the ground, lowered head, elevated rump, and tail held up and to the side to facilitate breeding. Females will mate with multiple males, preferring familiar over unfamiliar males. Males will approach, grasp the female by the scruff of the neck, mount, and breed. Copulation is rapid. The cat's penis is barbed and may cause discomfort when removed, resulting in females hissing, turning, swatting, and chasing the male. Males generally retreat to a greater distance immediately after copulation [6].

Intact males will generally vocalize, mark with urine, feces, pheromones, and claw markings, and seek closer association with females in attempts to breed [1].

When handling cats, consider how the natural behavior of cats may impact their experiences of touching, handling, and being restrained. Scruffing cats can prompt fear and defensive aggression and is to be avoided. Surgical sterilization is recommended for all pet cats to facilitate the welfare of both cats and humans, as well as to prevent unwanted litters. Cats are remarkably prolific in their reproductive cycle.

1.5 Elimination Behaviors

To meet the needs of cats, it is important to understand their normal elimination behaviors (Unwanted elimination will be addressed later in this chapter.) Kittens begin to explore substrate and location for elimination around 1 month of age. To void the bladder, cats will generally enter the elimination area, dig a small hole, turn around, squat to urinate, and then cover or manipulate the substrate. Digging is less frequent prior to defecation, and feces may be covered or left on the surface [1].

Cats, in general, have been shown to prefer large, uncovered, unlined litter boxes filled with finely granulated, unscented litter. Individual cat preferences may vary. The litter box should be large enough for the cat to enter, dig, turn around, eliminate, and cover without touching the sides, top, or other soiled areas. Many commercially available litter boxes are too small for an adult cat. Automatic litter boxes can be favored by some cats because the litter is always clean; however, the mechanism may frighten some cats, and often the size of the box is quite small and enclosed [2] (Figure 1.2a,b).

Cats will use urine and feces to mark territory. Sterilized and intact cats of both sexes will use eliminations to mark territory and send social signals. Intact males are most likely to engage in urine marking, and castration can reduce marking behavior by 90%.

1.6 How Cats Learn and Modifying Behaviors

Cats are intelligent, and like every animal, they are learning all the time. Life experiences, environmental conditions, and training will all influence which behaviors cats display. Individual variation on the part of the cat, the home, and the client affects learning, behavior, and behavior change. Behavior modification is essentially aligning the behavior of a pet with the expectations of the client. In many cases, both the animal's behaviors and the client's expectations require modification for success. Helping clients have realistic expectations while educating them in effective training and behavior modification will best protect the human–animal bond.

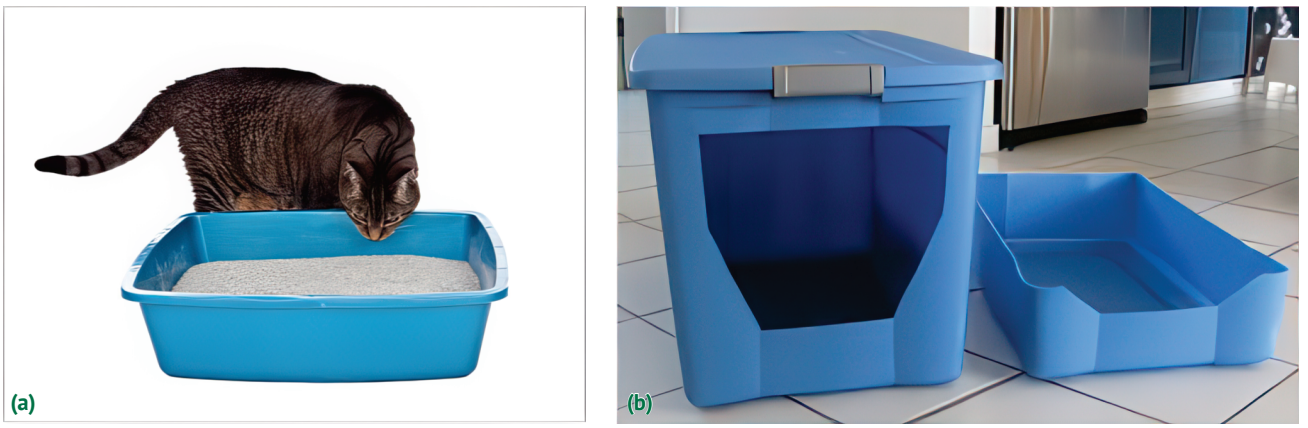


Figure 1.2 (a and b) A commercially available litter box that is too small contrasted with a litter box of sufficient size constructed from a storage bin. *Source:* Monique Feyrecilde.

To promote the best possible environment for learning and welfare, cats need to have their basic needs met. Safe housing, nutrition, healthcare, adequate physical and mental exercise, and social contact with preferred associates will contribute to good cat welfare [1, 2, 5, 6]. In this chapter, we will discuss classical conditioning, sensitization, desensitization, habituation, counterconditioning, operant conditioning, and functional or applied behavior analysis. A simplified version of each concept will be presented. Please note there are deeper complexities to every concept that are not discussed at this introductory level. Understanding each of these concepts is helpful for every veterinary professional. However, it is perhaps more important to realize that while we may discuss these terms individually, they all have the potential to occur simultaneously. Learning happens all the time, and all types of learning can and do overlap.

1.6.1 Classical Conditioning

Classical conditioning describes the process in which a previously meaningless or neutral stimulus is paired with an already meaningful stimulus, creating a new response even when the second stimulus is absent. The response is generally not under the direct control of the animal and includes emotions and reflexes, such as salivation [1, 2] (see Table 1.1).

1.6.2 Sensitization and Habituation

Sensitization and habituation are nonassociative learning protocols where the animal either develops a stronger response or a weaker response to the same stimulus when it is presented repeatedly. Sensitization is when a stronger response occurs, and the animal attends the stimulus more closely over time. Habituation is when a weaker response occurs, and the animal eventually stops attending the stimulus entirely [1, 2]. Sensitization is more likely to occur with more intense stimuli, while habituation is more likely with harmless stimuli [1]. Accidental sensitization is a common error when handling patients in the veterinary setting, or for cats who require serial treatments, such as daily pills or frequent injections [2]. An individual animal's temperament, learning history, and resilience to stress will impact how likely they are to be sensitized or become habituated to certain stimuli [1].

Table 1.1 A summary of behaviors associated before, during and after classical conditioning.

Before conditioning	During conditioning	After conditioning	Results
New pet carrier presented → no response	Carrier presented → cat placed into carrier and car ride	Carrier presented → cat hides behind sofa	Carrier alone prompts fear response of car ride
New carrier presented → no response	Carrier presented → Treats placed near carrier for cat to eat	Carrier presented → cat seeks treats	Carrier alone prompts pleasure response for treats

Sensitization example:
Low battery beep in fire alarm → cat notices and is startled → alarm beeps → more intense startle with fear response → alarm beeps → startle, fear, hiding

Habituation example:
Phone rings → cat notices → phone rings → cat notices but does not attend → phone rings → no response

Sensitization and habituation make good evolutionary sense, as they allow animals to avoid potentially dangerous situations and ignore unimportant stimuli [1].

1.6.3 Desensitization and Counterconditioning

Systematic desensitization is the process of preventing a stimulus from prompting a strong response by controlling the intensity of the stimulus and keeping it below the animal's threshold of response [2]. Counterconditioning is replacing an existing response with a new response to the same stimulus. Systematic desensitization and counterconditioning are commonly used together to achieve behavior modification [1].

Steps of systematic desensitization and counterconditioning:

1. Identify a nonstressful starting point.
2. Identify body language signs indicating the animal is below their response threshold. These will be mild signs and should be free from signs associated with stress.
3. Identify a way to elicit the desired response, such as pleasure, anticipation, or appetitive responses. The author calls this the "Happy Button."
4. Identify the trigger stimulus.
5. Consider ways to systematically divide the trigger stimulus into many tiny approximations or baby steps, called "exposures."
6. Pair a series of nonstressful exposures with the "Happy Button," gradually increasing intensity over time until the full-intensity stimulus prompts the "Happy Button" response.

Systematic desensitization and counterconditioning may take a few seconds, a few years, or be impossible. If the animal already has an existing intense response to the trigger, desensitization and counterconditioning will be more difficult [2]. If the animal's current response is neutral or mild, the process will be easier [1].

Example: Injections

1. Identify a nonstressful starting point:
   Cat sitting in cat bed.
2. Identify body language signs indicating the animal is below their response threshold:
   Present: Soft eyes, neutral whiskers, ears forward and relaxed, muscles soft, tail relaxed, or elevated.
   Absent: Pupil dilation, ears folded or flat, whiskers far forward or folded flat, tail tucked, crouched posture, etc.
3. Identify a way to elicit the desired response, such as pleasure, anticipation, or appetitive responses. I call this the "Happy Button":
   Squeezable tuna flavor cat treats.
4. Identify the trigger stimulus:
   Giving a vaccination.
5. Consider ways to systematically divide the trigger stimulus into many tiny approximations or baby steps, called "exposures:"
6. Pair a series of non-stressful exposures with the "Happy Button," gradually increasing intensity over time until the full-intensity stimulus prompts the Happy Button response.

Figure 1.3 shows the injection ladder.

Video 1.1 (see the companion website) shows an example of using desensitization and classical counterconditioning to create a functional and pleasurable injection behavior for a feline patient. You will see the injection procedure is broken down into many small exposures, and each exposure is paired with presenting the cat's favorite canned food. The timing of this exposure is important. Ideally, the exposure predicts or occurs simultaneously with pressing the "Happy Button."

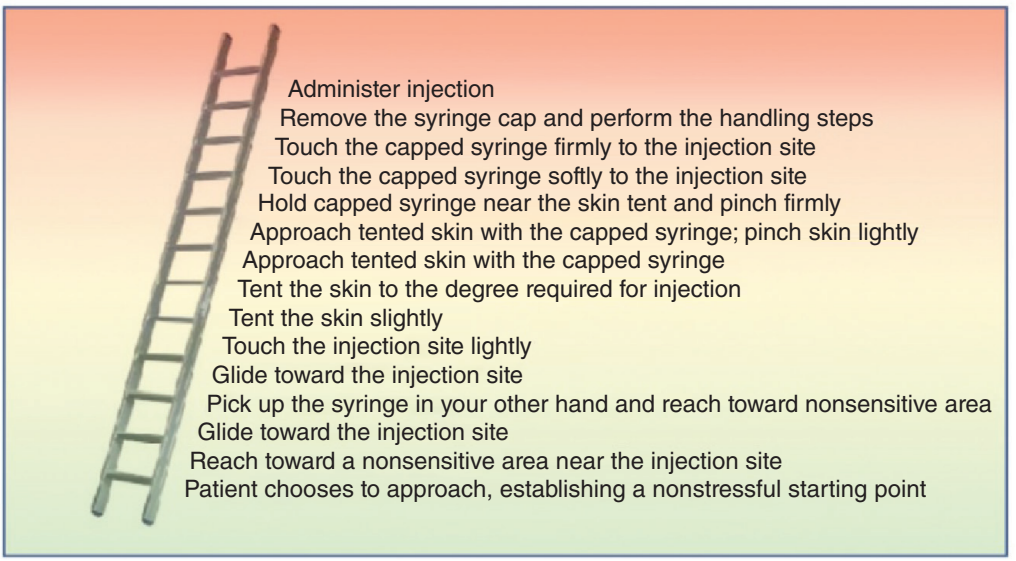


Figure 1.3 An example exposure hierarchy or exposure ladder for subcutaneous injection. This is only one example. More rungs may be needed for certain cats, while rungs may be skipped in other cats. Courtesy of Monique Feyrecilde, Cooperative Veterinary Care 2nd Edition, Wiley Blackwell 2024.

The goal of the procedure is to link feelings of contentment, pleasure, and appetitive response with the injection sequence. This author uses a short version of this technique for virtually every feline injection administered during wellness care with excellent success.

1.6.4 Operant Conditioning

Operant conditioning is one way to describe how animals learn new behaviors, why they continue existing behaviors, or why they may decrease and abandon behaviors over time based on the consequence or event that immediately follows the behavior [1, 2]. In this context, "consequence" simply means what happens after a behavior. It does not carry any emotional or value connotations. The same is true for the terms reinforcement, punishment, positive, and negative.

There are two basic categories of consequences when we use operant conditioning to describe behavior: Reinforcement and Punishment. Reinforcement is anything that results in a behavior happening *more* frequently, more intensely, or for a longer duration in the future. Punishment is anything that results in a behavior happening with *less* frequency, intensity, or duration in the future. Each type of consequence comes in two varieties: Positive or Negative. Think of these as mathematical terms, not pleasant vs. unpleasant. Positive means something is added to the situation from the learner's perspective. Negative means something is removed from the situation from the learner's perspective.

So the four quadrants of operant conditioning are:
Positive reinforcement: ADDING something to INCREASE behavior.
Positive punishment: ADDING something to DECREASE behavior.
Negative reinforcement: REMOVING something to INCREASE behavior.
Negative punishment: REMOVING something to DECREASE behavior.

Figure 1.4 shows a visual representation of the quadrants.

Example: Positive Reinforcement
Cat steps onto cat bed → treat is delivered → repeat
Over time, the cat steps onto the cat bed more often, more quickly, and remains there for a longer duration.

The behavior of stepping onto the bed is being positively reinforced. The cat also is likely to have feelings of pleasure and contentment (simultaneous classical conditioning).

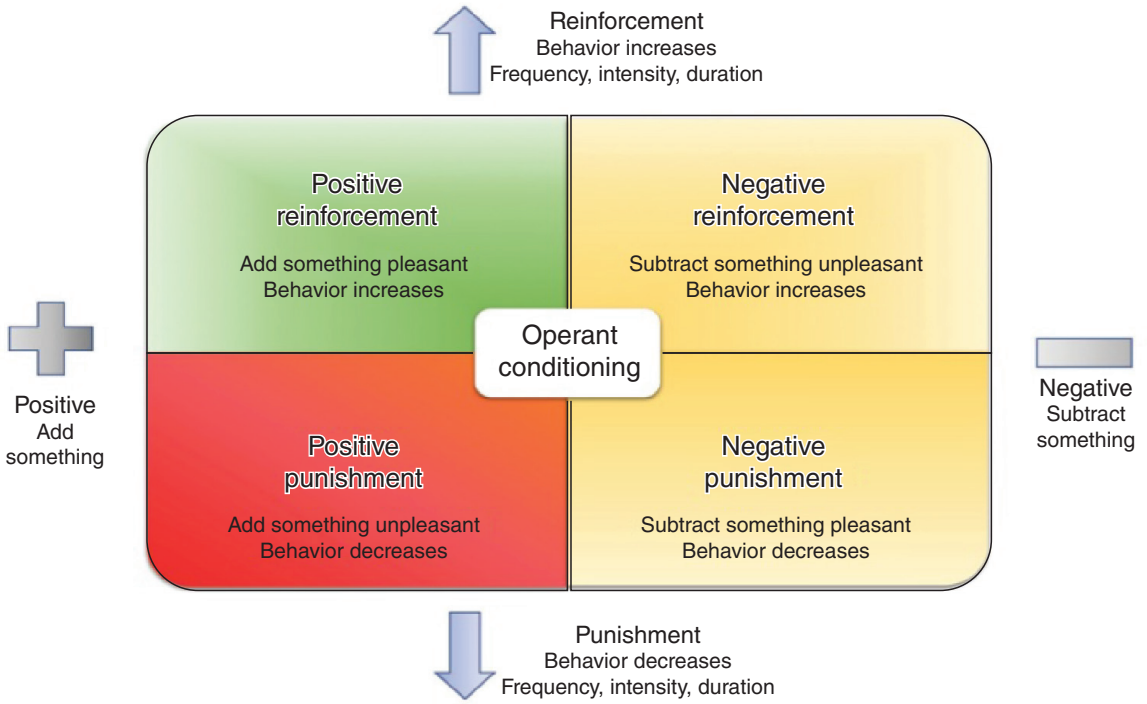


Figure 1.4 The quadrants of operant conditioning, are used to describe changes in behavior over time associated with specific consequences following a given behavior. Courtesy of Monique Feyrecilde, Cooperative Veterinary Care 2nd Edition, Wiley Blackwell 2024.

Positive reinforcement is effective when what is being added is desirable or pleasurable for the individual cat. Treats, tactile rewards, access to a favored spot or bed, and toy play are all common things used to offer positive reinforcement for most cats. Positive reinforcement training is considered a best practice for pets because it is safe and enjoyable, communicates to the animal what to do, and maintains behaviors while also protecting the human–animal bond.

Example: Negative Reinforcement
Driver turns on car ignition → loud beeping occurs → driver fastens safety belt → beeping stops.
Over time, the driver fastens their safety belt more quickly to avoid the beep.

The behavior of seatbelt fastening is being negatively reinforced.

This example shows one of the problems with negative reinforcement: it involves using something the learner will work to *avoid*. Intentionally setting up the environment or interaction based on having the learner avoid things can create a welfare concern. It is easy to prompt feelings of fear and stress when using negative reinforcement.

Example: Negative Punishment
Cat is playing with a toy and swats client's hand → toy is removed.
Over time, hand swatting during play decreases. The behavior of hand swatting is being negatively punished.

You may be able to imagine the cat who is playing becoming confused or frustrated when the toy is removed. The cat may even try harder to reach the toy, or swat at the hand again. One of the risks of negative punishment protocols is causing frustration, confusion, and distress. Punishment protocols do not demonstrate to the animal what *to do*, only *what not to do*. Learning is slowed, and the animal may even choose to opt out of the interaction completely.

Example: Positive Punishment
Driver is exceeding the speed limit → a police officer issues a speeding ticket.

Over time, the behavior of exceeding the speed limit when a police officer is decreased, and the behavior of scanning for police offers is temporarily increased.

Consider this example carefully. Did the target behavior of speeding actually decrease? Probably not. But it was replaced with a behavior of scanning for police. Why did not it work? Because it did not fulfill the requirements for successful positive punishment [1–3].

1. The punishment must be required promptly.
2. The punishment must occur every time the behavior is performed.
3. The punishment must be sufficiently aversive that the learner will avoid it.

So what went wrong? Most drivers have a learning history of intermittently exceeding the speed limit without receiving a speeding ticket. The attempt to change the driver's behavior will not succeed if the criteria for punishment are not met.

Example 2:
Driver is exceeding the speed limit → a traffic camera measures the driver's speed and automatically mails a speeding ticket to the driver's home.
Over time, the behavior of speeding *in this specific location* is decreased.

In this example, positive punishment is working, but only in the specific context of one location where the speed ticket camera is present. In other locations and contexts, the driver may be less careful with their speed. Context is important and punishment does not easily generalize to behaviors happening in a wide variety of locations or contexts.

It is considered best practice to avoid causing intentional stress, fear, confusion, or avoidance during training. Promote welfare in all interactions by selecting cat-friendly methods. To evaluate a method, run through this simple checklist:

1. Does it show the cat what *to do*? Yes
2. Does it deliver something pleasurable or desirable to the cat? Yes
3. Does it enhance the human–animal bond? Yes
4. Does the behavior change relatively quickly? Yes
5. Is there a risk of fear or confusion? No
6. Could it cause pain or avoidance? No
7. Is it intrusive to the cat or the person involved? No
8. Is it physically and emotionally safe for the cat and person? Yes

If the protocol does not satisfy this checklist, carefully consider if it is appropriate to use. Consult a trusted colleague or consultant before proceeding. Figure 1.5 shows a visual representation for selecting the least invasive and minimally aversive procedures for behavior change.

1.7 Functional and Applied Behavior Analysis

Consequences are only one part of cultivating, maintaining, or changing behaviors. One model for evaluating behaviors is the Applied Behavior Analysis (ABA) system. Using the ABA framework, it is possible to evaluate the function of a given behavior to better understand, and thereby potentially modify it.

1.7.1 The A-B-Cs of Behavior

A simple form of ABA is to observe the behavior of interest and consider what comes before and after the behavior. *Antecedents* come before the behavior. Antecedent is the "A" in A-B-C. There are distant and near antecedents. Locations, sensory information, social signals, handling interactions, and trained cues are all types of antecedents. Controlling, adjusting, changing, or maintaining antecedents influences behaviors. *Behavior* is the "B" in A-B-C and refers to the behavior of interest. *Consequence* is the "C" in A-B-C. Consequences are what comes after a behavior from the cat's perspective (see Table 1.2).

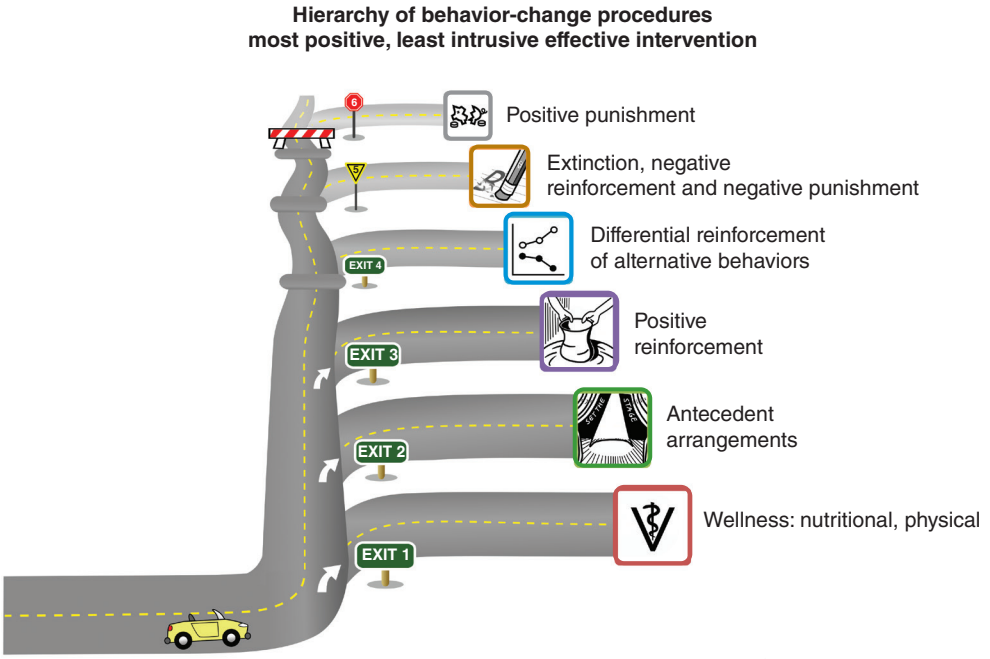


Figure 1.5 The hierarchy for selecting procedures to induce behavioral change. *Source:* Dr. Susan Friedman, Behavior Works.

Table 1.2 A summary of events during the A-B-Cs of behavior.

A = Antecedent: What occurs before the behavior being analyzed from the learner's perspective.
B = The behavior being analyzed.
C = Consequence: What occurs after the behavior being analyzed from the learner's perspective.

The A-B-Cs take into account the animal's motivation for performing behaviors. Multiple antecedents can be present, multiple behaviors can be happening in rapid succession, and multiple consequences can occur. Keen observational skills, detailed history-taking, an excellent understanding of feline body language, and good client communication skills are all important for successful behavior analysis. Documenting behaviors on video or in writing, especially over a period of time, can be extremely useful.

Take a stepwise approach when exploring behaviors using ABA:

1. Identify the **B**ehavior of interest.
2. Identify the **C**onsequences from the cat's perspective.
3. Identify the **A**ntecedents present before the behavior occurs from the cat's point of view.

Modifying consequences and controlling or changing antecedents can both help create desired behaviors or change existing behaviors. A multimodal approach is often most successful.

1.7.2 Example: Giving a Pill

In this introductory text, we will review a simple example of using the ABA model. Deeper multi-level analysis is possible as practitioners become more advanced, but the fundamentals are where it begins for everyone.

A client has been instructed to give her cat a pill every 24 hours, and the medication is needed for the rest of the cat's life. The client reports she was able to give the pill successfully for a few days, but now when she gets out the pills, the cat runs away and hides under the couch. If she tries to remove the cat from under the couch, the cat swats with his front claws.

There are two behaviors of interest listed in this scenario: running away and swatting.

B = Running away
C = Negative reinforcement – the pill bottle and client are removed/further away (feelings of relief and increased safety)
A = Presence of the client and the pill bottle – several experiences of being caught and receiving a bitter pill

Earlier, we discussed that classical and operant conditioning are not happening exclusively or in a vacuum. It is highly likely this cat has an emotional fear response to the pill bottle, a classically conditioned taste aversion to the pill, and a functional effective response that is being negatively reinforced for running away.

B = Swatting with claws
C = Negative reinforcement – the client's hand is removed (feelings of relief and increased safety)
A = Hand approaching while a cat is hiding under the sofa

For both behaviors, there are also more distant antecedents and contextual or environmental antecedents. Time of day, room of the house, number of people present, associated sounds, associated odors, verbal cues, owner body language, and more can all be part of the antecedent picture. Carefully questioning the client or watching a video of the sequence can help identify true antecedents. Watch for the very earliest sign of a change in behavior from the cat: tense body, looking away, leaning away, walking away, dilated pupils, or other signs of stress and the beginning of the retreat. Examine what happened immediately prior to the start of the behavioral sequence.

Once the behavior of interest has been identified, preferable replacement behaviors should be explored. Choose a replacement behavior that allows the cat to access positive reinforcement. Depending on the complexity of the selected replacement behavior, it may need to be broken down into multiple approximations, or small steps toward the goal. A successful treatment may incorporate shaping a behavior, desensitization and classical counterconditioning, and operant conditioning to reach a goal. That may feel like a lot of jargon, but it can be simple and effective.

1.7.3 Putting Together a Plan

Continuing the example of administering a pill, there are multiple possibilities.

Possible behaviors:

- Cat comes to a designated medication station to receive pills
- Cat consumes plain pill voluntarily
- Cat allows the client to administer the pill with a finger
- Cat consumes pill inside a treat
- Cat consumes medication compounded into a more palatable formulation (e.g., liquid)
- Cat allows the client to administer pill with a device

All of these behaviors begin with the cat being present and coming to the medication station to have their medicine given. The behavior of running and hiding needs to be replaced before the pill administration behavior is addressed.

Any complex behavior can be divided into many smaller, less complex approximations, with each approximation resulting in positive reinforcement. The deciding factor for when to deliver reinforcement is whether specific criteria have been met. Increasing and decreasing criteria is part of the art of training. The learner needs to be able to understand the criterion, and the criteria need to be manipulated so the learner receives sufficiently frequent reinforcement so they stay engaged with the process and make progress toward the goal behavior. Sessions should be kept short (1–2 minutes). Cats are adapted to eat multiple small meals throughout the day: when using food reinforcers, plan wisely with the understanding many cats satiate quickly. In this example, we will refer to food reinforcement as giving a "treat," but some cats may prefer tactile reinforcement or play with a toy. Remember, the learner determines what is reinforcing and rewarding. The change in behavior over time will tell the trainer if reinforcement is occurring. Is the behavior increasing in frequency, intensity, or duration? Tracking results informs the process.

Possible progression for teaching the pill behavior:

A: Presence of a comfortable mat or bed to be used as a medication station, cat is relaxed and in the vicinity of the bed. The pill bottle is NOT present. Trainer and treats are present
B: Cat looks at the bed
C: Treat delivered between the cat's starting position and the bed

A: Treat delivered between cat's starting position and the medication station
B: Cat walks toward the treat
C: Cat eats treat
A: Cat eats treat while facing the station. A second treat is placed on the station
B: Cat moves toward the station
C: Cat eats treat

Several repetitions of this session until the cat is walking all the way to the bed when the trainer shows up with a treat.

A: Station is present, a cat is relaxed, trainer and treats are present, the pill bottle is present in the environment not held in the hand and not near the station
B: Cat walks to the station
C: Treat delivered
A: Treat tossed off station for the cat to chase, while the cat is gone the pill bottle moved closer to the station but is not held in the hand
B: Cat turns and returns to the station
C: Treat delivered on station

In this example, a training "Loop" is being created. The Loop starts and ends with reinforcement. By using a "reset treat" tossed off the station, the trainer sets the cat up for another repetition, and another opportunity for reinforcement. During each repetition, the pill bottle is moved closer until it is sitting next to the station. It can then be held in the hand, and even rattled. By controlling the intensity of the pill bottle stimulus, the trainer is using principles of desensitization. Because the cat's emotional status is changing from avoidance and fear to anticipation of a treat, classical counterconditioning is happening. As the behavior of running away is being replaced with the behavior of coming to station, operant conditioning, and operant counterconditioning (also called response substitution) are occurring as well.

If the cat shows signs of returning stress, or the medication station behavior happens more slowly, criteria for reinforcement should be lowered temporarily *and* the pill vial stimulus needs to be presented at reduced intensity.

A practical note: When a cat has a strong conditioned taste aversion to a specific pill, it may be necessary to place the medication inside an unflavored capsule, or compounded into a chew, treat, or liquid. Conditioned taste aversion is difficult to reverse once established. The strong aversion may also "poison" the entire antecedent sequence associated with prior pill administration. The medication station may need to be set up in a room where the cat has never been medicated, and a treat wrapped around a plain capsule, or a syringe or dropper filled with liquid food only be delivered for many repetitions before medication can be reintroduced. For this reason, any time medication is prescribed, a behavior-aware means of *how* to give the medication needs to accompany the information of *what* to give [2]. Clients need guidance to prevent creating aversions to interactions and medications. Many free client education videos and handouts are available at www.fearfreehappyhomes.com to simplify the process.

1.8 Common Unwanted Behaviors

Surveys have demonstrated that many cats relinquished to shelters have behaviors their families found problematic. Euthanasia for behavioral reasons is more common than any veterinary professional would hope. Preventing and addressing common unwanted behaviors in cats help preserve the human–animal bond and protect cat welfare. The three most common unwanted behaviors described by clients relinquishing cats are elimination outside the litter box, destructive behaviors, and human-directed aggression [7].

1.8.1 Elimination

The most common unwanted behavior cat owners describe is problematic elimination. Generally, this means any elimination in the home outside the litter box. With elimination concerns, early detection has a strong impact on the prognosis for resolution. The veterinary team plays a critical part in early detection. Simply asking clients during every visit. "Have you noticed any urine or feces outside the litter box?"

Many physical disorders, illnesses, and injuries can lead to unwanted elimination in cats. There is also a significant crossover between gastrointestinal (GI) and urinary disorders and elimination concerns. For example, a cat with inflammatory

bowel disease may urinate outside the box, rather than defecate outside it. Some physical maladies that can contribute to unwanted eliminations include:

1. Pain: Any source of pain can result in unwanted elimination in some cats. Osteoarthritis, tooth resorption, GI pain, urinary pain, ocular pain, otitis, etc. Carefully rule out pain in any patient displaying unwanted elimination.
2. GI Illness: Any source of GI irregularity, urgency, frequency, or discomfort.
3. Urinary tract disease.
4. Any illness associated with polyuria and polydipsia, such as diabetes mellitus, renal disease, hyperthyroidism.
5. Changes in mobility and strength.
6. Changes in hearing or vision.

For these reasons, a health database should be collected for cats displaying unwanted elimination.

In some cases, physical illness can lead to unwanted elimination, but the elimination can become habitual. This is particularly common with pain-related elimination. If a cat associates pain and elimination, it can be challenging to achieve a return to the litter box because the cat will anticipate a painful experience based on past learning. Treating the source of pain may need to be combined with remedial house training for best results. The latrine area may need to be relocated, and changing the size and shape of the litter box can also help [1, 3, 4].

1.8.1.1 Housetraining

To a certain extent, housetraining comes naturally to many cats. Particularly, kittens raised in a home environment will have developed a substrate and location preference starting between 4 and 8 weeks of age. That being said, assuring clients understand the needs of cats and proper litter box etiquette is an important part of the veterinary team's responsibilities.

1.8.1.2 Meeting the Needs of Indoor Cats

Meeting the social, physical, and intellectual needs of cats has been shown to have a protective effect against unwanted elimination [8]. Litter box etiquette is an important part of the picture. In addition to selecting an appropriate-size box and litter texture, choose a location, which is easy for the cat to access and free from obstacles, such as tight spaces which can be blocked by other pets. Large homes will need more than one litter box to prevent cats getting caught short in a distant part of the home. The litter box will need to be kept clean. Educate clients to scoop any clumps daily, discard and refresh all litter weekly, scrub the box well monthly, and consider replacing the box annually. All plastics will eventually hold odor, regardless of how fastidiously clients clean the box. Figure 1.2a,b shows an example of a litter box that is too small and a homemade litter box constructed from a storage container that is acceptable in size. Homemade boxes also have the advantage of customizing the entry height to accommodate kittens and cats with diminished strength or mobility [1, 3].

The Ohio State University Indoor Pets Initiative provides a great deal of information regarding meeting the needs of indoor cats. Cats need appropriately preferred locations to scratch, elevated areas to rest and explore, toys that suit the individual cat's play style and prey preference, good nutrition, and freedom from unnecessary stress, such as conflict with other pets or people [8].

1.8.1.3 Urine Marking

While humans may not appreciate urine marking (or marking with feces or anal sac secretions), this is a normal behavior of cats. To prevent unwanted urine marking in the home, cat owners can:

1. Supervise adequately: Especially after the first marking is left in a specific area, do not allow the cat in that area without supervision, if possible.
2. Reduce stressors: Competition for food, resting places, social contact, or preferred toys can increase stress in cats. Stress and urine marking, unwanted toileting, and many other undesirable behaviors are closely linked in cats.
3. Exercise and enrichment: Provide daily exercise and enrichment. Consider offering food using foraging toys for at least one meal per day. Provide locations for preferred types of scent marking, such as scratching pads and posts.

Checklist for addressing elimination concerns in cats:

1. Take an elimination history every time cats are presented to the veterinary hospital.
2. Provide a medical workup for cats with unwanted elimination. Treat any underlying illnesses.
3. Toileting and urine marking can occur together or separately and have separate treatments.
4. Ensure good litter box etiquette.

5. Consider a "litter box buffet" to assess cat preference for substrate, location, and litter box style. Provide the cat's most preferred litter box moving forward.
6. Coach clients on meeting the needs of indoor cats. Stress reduction and optimal emotional welfare have a protective effect for unwanted elimination.
7. Screen for punishment which increases fear and stress. Yelling, hitting, squirting with water, static shock mats, etc., can all increase stress and do not address the underlying issue.
8. Management. Restrict access to areas where unwanted elimination occurs.
9. Remedial housetraining, including restricting access to a smaller portion of the home and gradually increasing freedom when litter habits are more stable, can be helpful.
10. Be prepared to refer. Veterinary teams should be familiar with referral options, including diplomates of the American College of Veterinary Behaviorists (DACVB), Certified Applied Animal Behaviorists (CAAB), Associate Applied Animal Behaviorists (ACAAB), and Certified Cat Behavior Consultant (CCBC) (see Table 1.3), to support families when the case is beyond the comfort level of the team.

1.8.2 Destructive Behaviors

The second most common objectionable behavior cat owners describe is destruction inside the home. This is predominantly unwanted elimination and scratching behavior.

Every cat needs the opportunity to engage in normal scratching behaviors. Even cats whose claws have undergone onychectomy will continue the motor patterns associated with scratching [3, 8].

Some reasons cats are believed to engage in scratching:

1. Deposit pheromones for social signaling
2. Leave visual markings for social reasons
3. Maintain the feet and nails
4. Stretching
5. Pleasurable sensations

Cats will have individual preferences for the location, substrate, and orientation of scratching surfaces. Common commercially available substrates, including carpet, fabric, sisal, wood, and cardboard. Some cats prefer upright surfaces while others may have a tendency toward flat scratching. The best way to prevent unwanted scratching is to provide multiple substrates in multiple orientations in socially important areas within the home. Tucking away the cat tree in a spare bedroom will decrease the likelihood of use.

Cats also respond well to positive reinforcement for scratching in desired areas. Delivering treats, catnip, preferred tactile contact, and toy play immediately after cats scratch in the correct location helps encourage them to continue to do so in the future.

Table 1.3 A summary of veterinary behavior organizations.

Professional	Designation	Degree required	Written exam	Practical skills evaluated	Continuing education requirement	Code of ethics
Veterinary behaviorist	DVM, DACVB	DVM, residency	Yes	No	Yes	Yes
Veterinary technician specialist	LVT/CVT/RVT, VTS (behavior)	Technician credential	Yes	Yes	Yes	Yes
Certified applied animal behaviorist	CAAB ACAAB	PhD MS	No	No	Yes	Yes
The International Association of Animal Behavior Consultants certified consultants	CCBC	No	Yes	No	Yes	Yes

1.8.3 Human-directed Aggression

Aggression is a normal form of communication in all animals, including humans. Most aggressive displays are distance-increasing signals, where the animal is trying to diminish feelings of threat or fear. True aggression involving scratching and biting is biologically expensive. Engaging in a fight can result in injury to both parties, so usually, smaller signs of discomfort are communicated over a distance before an interaction escalates to true aggression [1]. The following is an overview of some common forms of human-directed aggression seen in feline patients. Diagnosing and treating aggression requires specialized knowledge and is best referred to a veterinarian with additional training in behavioral medicine. Preventing common forms of aggression is an important task for all veterinary professionals.

1.8.3.1 Play-related Aggression

Cats are extremely agile and love to chase, grab, bite, and kick during play. Play can become very intense at times, with high levels of excitability [3]. Clients should be educated to use toys rather than hands when playing with kittens and cats. Cats develop preferences for specific kinds of toys and play styles. Fostering a desire to play appropriately with toys and never grab, bite, or kick hands is one of the most helpful things clients can do to prevent play-related aggression in cats. Avoid petting or stroking cats during toy play when they are highly aroused or excited to diminish the risk of being swatted or bitten. If the kitten or cat is showing signs of over arousal, such as piloerection, dilated pupils, repeated biting, growling, or redirecting toward hands instead of a toy, clients should take a break from play. Play should foster a strong and healthy human–animal bond. Physical and verbal reprimands during play should be avoided, because these can cause increased arousal and also prompt a fear response in cats. Fear during play can diminish the cat's ability to trust humans and hands, leading to further problems [5].

1.8.3.2 Fear-related Aggression

Fear-related aggression can happen in a variety of contexts. One of the simplest things veterinary teams can do to help cat families is to educate clients about the body language of fear, anxiety, and stress. Cat owners should monitor for hiding, slinking, and hugging walls when moving through the home in addition to the body language cues discussed earlier in this chapter. If the cat is showing signs of fear, the first steps of treatment are identifying and avoiding known triggers while an appropriate treatment plan can be created.

Socializing kittens and cats to household noises, human contact, contact with other animals, carrier travel, car travel, etc., can help protect against some forms of fear-related aggression. For kittens and new cats in the household, the following process can be helpful:

1. Identify what the cat's lifestyle will look like. Analyze the lifestyle picture for people, animals, objects, surfaces, and situations the cat will encounter.
2. Identify what the cat likes and enjoys, such as treats, toys, and tactile interactions.
3. Carefully introduce the cat to lifestyle situations, objects, and interactions at a low level of intensity, paired with something the cat enjoys.
4. Monitor for signs of stress. If the body language of stress is observed, the stimulus is too intense and needs to be broken down into smaller exposures.
5. If the cat appears comfortable, the stimulus can be increased in intensity over time, continuing to pair it with things the cat finds pleasurable in an effort to build a positive welfare-centered learning history.

1.8.3.3 Behavioral Medicine for Cats

Establishing behavioral diagnoses and prescribing medications is the role of the veterinarian [1, 2]. For practices where behavioral medicine is not available, be sure to be familiar with local and virtual referral options so families can receive the help they need. In much the same way a cardiac case is referred to a cardiologist, or a general practice veterinarian may refer a complex fracture repair to an orthopedic surgeon, so too can behavior cases be referred to board-certified veterinary behaviorists, or to veterinarians with advanced training in treating behavior concerns [2].

Behavior medications fall into two basic categories: baseline or mainstay medications and short-term or event-related medications. Baseline medications are given daily and generally take 4–8 weeks to achieve stable therapeutic serum concentrations. Short-term or event-related medications are given on an as-needed basis and generally have an onset between 1 and 3 hours after administration, lasting between 6 and 12 hours per dose depending on the agent prescribed. The goals of administering behavior medications are to relieve and prevent fear and stress, help regulate neurochemistry to improve the

quality of life of the cat and their ability to learn new skills, and to reverse harmful behavior patterns starting at the neurochemical level. A wide variety of both mainstay and event-related medications are available for cats and can be extremely helpful [1, 3, 4].

1.9 Behavior Emergencies

True behavior emergencies are uncommon in cats, but veterinary teams should be well versed in proper triage to identify and respond promptly should an emergency arise.

1. Human–animal bond endangered
2. Human-directed aggression with injuries
3. Any behavior involving significant self-harm or danger of injury
4. Aggression toward other animals

Behavior emergencies need to be scheduled for an evaluation and either treatment or referral immediately. Customer service teams and technical staff should all be trained to detect these important cases and triage them appropriately [1].

1.10 Incorporating Behavior into Everyday Veterinary Practice

All pets display behaviors, and all pets rely on an intact human–animal bond for their health and welfare. Families living with pets deserve a good quality of life as well. Incorporating feline behavior into everyday veterinary practice is one-way veterinary teams can meet the needs of cats and their families and fulfill our true vocation of caring deeply and well for our patients and their people. While incorporating behavior into practice can feel complicated, we will discuss three key ways to get started.

1.10.1 Include Behavior Questions in Every History

Each time a cat is presented for care, it is appropriate to take a general history. Adding two simple questions to the history can help detect behavior concerns and improve the lives of cats and their families. Asking open-ended questions rather than yes/no questions will yield more information from pet owners in general.

1. "Tell me about any concerning behaviors you have seen, or any changes in your pet's behavior."
2. "Tell me about any mistakes outside the litter box."

It can feel intimidating to ask these questions at first, because the veterinary team may not know how to address or potentially solve every unwanted or concerning behavior in their patients. It is not necessary to know how to fix everything before asking the question. Detection is the first step; the rest can follow. A pleasant side-effect of incorporating behavior questions into the history is that it teaches clients the veterinary team is a good source of information about behavior, and that they should call us if they observe any concerning behaviors or changes.

1.10.2 Build a Referral Community

A referral community is a must for every veterinary practice. Veterinary teams should dedicate some time and effort to identifying and evaluating fellow behavior professionals in the region. If there are no local positive reinforcement-based feline behavior professionals, many also offer treatment at a distance via telemedicine.

Veterinary behaviorists are veterinarians who are board-certified in the specialty of animal behavior. They will be DACVB. Know who your nearest option is, and which specialists offer distance telemedicine so referral is easy and comfortable. Veterinary technicians can also become veterinary technician specialists (VTS) in behavior and can support veterinarians with prevention and intervention both locally and at a distance.

Behavior consultants are professionals who assist with training and behavior modification but are not veterinarians, so they may not prescribe medications. CAAB will hold a PhD and have passed a rigorous evaluation process. ACAAB hold

a master's degree and have passed a rigorous evaluation process. A small number of individuals hold both a veterinarian's degree and a CAAB or ACAAB, but this is quite rare.

The International Association of Animal Behavior Consultants certifies feline behavior consultants by awarding the CCBC credential. The credential requires extensive experience and education, adhering to a code of ethics, and passing a detailed written examination.

Because training and behavior modification are largely unregulated, there may be qualified professionals without these credentials. Before referring, evaluate individual colleagues to assess their methods, ensure they are a good ethical match, and be sure you have confidence in their skill level for the type of cases you wish to refer.

A robust relationship with your referral community can be extremely rewarding and facilitate the veterinary team's ability to help more families.

1.10.3 Commit to Feline-friendly Methods

Later in this textbook, numerous handling procedures and clinical interactions will be discussed. Committing to feline-friendly methods that protect the emotional welfare of our patients is an important step in incorporating behavior in everyday practice [4].

1. Team members should be trained in evaluating feline body language and feline pain scoring.
2. Hospitals should adopt an emotional standard of care. The emotional standard of care dictates how and when to pause handling or procedures to preserve the emotional welfare of patients.
3. Every team member who interacts with patients should be empowered to pause a handling event and ask for review and revision.
4. Appointment reminders should include information for pet owners about how to safely deliver a calm cat to the veterinary clinic.
5. Clients should be prepared in advance to expect the team to safeguard the cat's emotional and physical health and pause treatments to make a new plan when cats are experiencing fear, anxiety, and stress.
6. Develop language to describe a patient's behavior rather than a label about the patient themselves. For example, replacing "fractious" or "spicy" with a description, such as "defensive aggression during rectal temperature," or better yet, a success note, such as "light towel wrap for hiding during blood collection," or "use liquid treat distraction during exam." Fear free has a numeric scale called the Fear Anxiety and Stress (FAS) Scale available for download. Having a standardized way to communicate about patient behavior removes the need for judgmental labels and can improve morale within the team.

In conclusion, cats are unique with respect to their sensations, perceptions, physiology, social structures, and relationships. However, cats share the same mechanisms for learning, acquiring behaviors, changing behaviors, and maintaining behaviors as all other species. Cats have emotional needs and behavioral needs that deserve our attention. By understanding the normal and abnormal behaviors of cats, screening for potential unwanted behaviors during every appointment, and developing a robust referral community, veterinary technicians can dramatically enhance the lives of cats, owners, and fellow veterinary professionals. By committing to choosing feline-friendly methods, we can better fulfill our true vocation of advocating for feline welfare.

See the companion website for further clinical references.

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2

Feline-Friendly Interactions

Ellen M. Carozza, LVT, VTS (CP-Feline)

TECHNICIAN TIDBITS

- Cats have a unique language that the technician in practice needs to understand. By understanding their body language and social cues, we can create safer methods of handling.
- Know the difference between positive and negative emotions in cats. All emotions are normal, and they directly correlate to the stress they are exposed to.
- Life stage handling is an important skill to hone. Each age group has its own needs that help aid in the de-escalation of stress when handled and restrained. Providing simple, yet effective modifications allows for a better experience for both the cat and the technician.
- Be familiar with prescription and nonprescription anxiolytics. Not all cats require full sedation; however, it is important to know when to intervene with chemical sedation.
- Understand stressor stacking and learn how to enhance the cat's experience in practice. Providing positive experiences from an early age creates a better relationship with the medical team.

The cat in the veterinary practice has maintained a reputation for being one of the more difficult species to work with due to a number of factors along with being promoted as low-maintenance pets for cat owners. As veterinary workers, we know that statement is false. Cats actually require unique modifications to work with them on their level, to work with them safely, and to prevent further issues with handling in the future. While a very large number of cats are seen at the veterinary office their first year, less than half return for the future. Why does it stop after that first year? While most of it can be justified with the answer of cats being perceived as self-sufficient and not needing medical care unless warranted, a lot of it is due to avoiding potentially stressful situations, [1] and that puts us in a tough spot. We want cats to receive optimal medical care, but we have to make accommodations to avoid stress for these patients to come back for wellness, not just when they are presented with an illness.

Whether you are team canine or feline, it is important to know *why* cats behave the way they do in the clinical setting as they cannot express change emotionally and physically in ways we can easily recognize [2], and how we can evolve our interactions and our handling techniques along with modifying the facility to lower their stress threshold to achieve a positive encounter during their visit during hospitalization. In return for a favorable experience for the team, the client, and the cat, the return rate for future visits is much greater and ultimately can lead to a stronger human–animal bond between care and caregiver.

In 2002, the American Association of Feline Practitioners (AAFP, changed to Feline Veterinary Medical Association [FeVMA] in 2024) and the International Society of Feline Medicine (ISFM) collaborated to create a thirty-five-page document known as "*The Cat Friendly Veterinary Interaction Guidelines: Approach and Handling Techniques*" [3] along with the "*2022 Cat Friendly Veterinary Environment*" [4]. Both outlines provide support to the veterinary teams to aid in understanding the cat's emotions in practice and how to address proper handling to reduce stress in the facility. *At the end of the day, the goal for the veterinary team in practice is to provide as positive an experience as possible for the feline patient regardless of one's personal feelings when working with the species.* While handling and understanding their stress level is important, so is the environment we work with them in. Utilizing the handling interactions along with the 2022 AAFP/ISFM Cat Friendly Environment Guidelines [4] allows the veterinary team to collaborate and have the opportunity to provide better care for their feline patients. See Chapter 3: "Preparing the Veterinary Hospital for the Feline Patient," for further details.

The recommended supplemental video resources included in the documentation for interactions and handling cover: all videos are available publicly for viewing [5].

1. How to interact with your cat: The Battersea Way. Videos available on their YouTube Channel: https://www.youtube.com/@batterseadogsandcats [6].
2. Inhibition and left gaze bias (which is an important cue given, yet, not easily as noticed as body language).
3. Teaching/training your cat to get used to being medicated.
4. Removing cats from cat carriers.
5. How to properly approach a cat.
6. Myofascial examination.
7. Cat-friendly tips for dental examinations.
8. Cat-friendly interactions in practice.

All of these techniques are relevant for use by the veterinary technician as we play a large role in the advocacy and care for the cats we see in practice and are excellent learning tools for use either for evolving your standard of current care and for use in future training of staff.

The 2022 ISFM/AAFP Cat Friendly Veterinary Environment Guidelines does have a *Free On-demand Webinar*: The Cat Friendly Veterinary Environment: Setting Up for Success [7]. Every team member at the clinic, especially newly on-boarded staff, should watch the video to understand where the differences made for cats at the clinic can make an enormous impact on their welfare.

Each veterinary practice's environment is different, and the guidelines provide outlines for success to meet the needs of each clinic and provide the educational tools to make positive and impactful changes to the cats in practice. Ultimately, it is the decision of the practice owner to become a Certified Cat Friendly Clinic and also their responsibility to ensure their employed staff understands and follows their vision of high-quality feline medicine. Yet, you, the veterinary technician, have control over how you want to interact with the cat, and changing your ways of handling and understanding feline behavior can make a significant difference for the patients you interact with.

In this chapter, we will cover the *basics* of what a veterinary technician should understand regarding feline behavior in the clinical setting based on the latest behavioral information provided and make modifications in our practices to prevent escalated situations. By understanding why cats behave the way they do and how we can modify our work routine and changes to the actual environment, we can create a positive work experience with cats. It is important to note that NOT all cats you work with are pet cats. More rescues and community cat programs benefit from you and your colleagues' modifications to make the animals they work with live much better, and they are thankful for it.

Disclosure: The author recommends the citation papers as the information provided in this chapter is simply a condensed interpretation of the master guidelines that are available publicly in the veterinary circuit and provides a more in-depth discussion of feline behavior in the veterinary clinic.

The author also would like to disclose that animal abuse in any shape or form is not appropriate for the sake of performing a task. Cats can stress the point of cardiac arrest and physical injury such as broken bones when being forced into situations that have escalated out of control. If you find yourself placed in unsafe situations and are being required to perform unsafe handling, stop, and advocate not just for the cat but for yourself. No job is worth hurting a patient to the point of physical harm or death. Stop the cycle of abuse, help evolve the methods of handling, and advocate for the cat in the veterinary practice.

2.1 Understanding Cat Emotions and Their Motivations

Cats are a prey and predatory species, and in veterinary medicine, we need to understand that emotions are "*instinctual motivations*" [8] and not the "feelings" as we, a human, would perceive them. They originate from the evolution of the feline species and their genetics for the survival of their species. Cats are not humans, and we need to stop anthropomorphizing their behavior in practice and in the home to understand their unique needs. This includes changing the words that categorize the behaviors we tend to see at the clinic. When the team labels a cat as "aggressive," we are labeling an action. In reality, they are being "protective" of themselves and are acting "offensive" or "assertive" to us while giving clear signals that they are in a high emotional state of arousal (Figure 2.1), feel threatened, and may act accordingly to protect themselves physically.



Figure 2.1 Scared cat – Notice the body language. This cat's whiskers are flared, eyes dilated, ears are rotated to the side, and the body is in a crouching but backing up posture. This cat feels threatened. *Source:* Ellen Carozza, LVT, VTS.

A cat's instinctual motivations include hunting, procreating, and protecting the area where they roam as well as trying to avoid threats to survive. The difference between these motivations is that the hunting instinct is not affected by desexing as that motivation is not driven by the cat's hormones. However, their resources, including hunting, still need to be met to prevent or control unwanted behaviors on our end, allow for easier handling of the cat in the home or at the veterinary practice as well as the reduction of stress in multi-cat households and an increased recognition of disease.

Poorly labeled protective emotions for cats in practice include:

1. Spicy
2. Vicious
3. Derogatory terms to identify a negative response
4. Nasty
5. Evil
6. Aggressive
7. Feisty

While these terms can be lumped together to identify "protective emotions," they are normal reactions seen in a cat that is reacting to a negative stimulus when feeling threatened.

2.2 Be Respectful, Remain Professional; Words Matter

It is important to change you and your practice's terminology as these labels can easily create a negative veterinary team atmosphere when a feline patient with a heightened stress response needs to be seen for care. Remaining composed and professional throughout the entirety of an appointment or hospitalization regardless of the cat's behaviors being experienced and their current emotional state being expressed either in front of the client and/or with your team showcases your dedication and understanding of behavior as a feline advocate in practice. Charts, notes on flow sheets, or any documentation that is part of their permanent record should never have derogatory or poorly labeled behaviors (i.e., aggressive, spicy) listed as warnings to other staff as those documents are considered part of their permanent record. Ultimately, the client can request copies of their cat's medical records at any time to only see how you actually feel about a pet they thought was getting appropriate and gentle care they are paying service for. Once you understand how cats emotionally work and identify the key causing stress factors, they become easier to work with as you will be able to anticipate their behavior before they become a sudden challenge. *The goal at the clinic is to recognize and minimize any triggers, stop and reassess an escalated situation, make any necessary changes, and provide positive reinforcement for the cat to achieve our goal.*

2.3 Feline Emotions: Engaging and Protective – Both Are Normal!

Emotions can be either positive (engaging) or negative (protective) in practice; however, a *positive emotion can quickly turn into a negative emotion rather quickly usually due to* ***fear, anxiety, stress, and/or underlying pain*** *(many times all of them are present).* Your objective is to recognize and prevent or reduce the protective emotions during their stay and while we perform any tasks associated with their visit. *Everyone working with the cat in practice should be thinking: the patient comes first; the team comes second, and the task comes last.* What is going on with the patient to have the emotions that are being displayed? And how can the team cater to those emotions and change their behavior to de-escalate a situation and how can the task be modified to be performed safely (including rewards, modified techniques to hold the cat, anxiolytics, and the use of chemical sedation?) By understanding feline body language and their facial cues (Feline Facial Actions) [9], we can more easily correlate the emotions they are currently experiencing at the clinic and modify our techniques to allow them a better experience at the practice.

While a hard habit to break, having redefined words utilized to better demonstrate the cat's behavior in practice not only explains their behavior more appropriately but helps remove the negative language utilized by veterinary professionals and the public about the species that simply label a behavior *we* consider undesirable. Remember: *cats are reactive, and the behaviors displayed are normal for their response to a situation in the environment they are in.* These survival tactics have influenced their species over thousands of years and generations and need to be respected regardless of the space they share in the home and the clinical setting.

2.3.1 Avoidance

In cats can be displayed as increasing distance or avoidance of eye contact between a person or another cat. Self-protection is the cat's goal, and it is easier for them to limit their own actions vs. reducing reactions in others. Eye aversion is seen as a passive response vs. an active response such as the cat physically removing themselves from a situation. In many cases, these are the cats that attempt to hide under a blanket or will face press into the corner or a cat carrier. You may see a left gaze bias and head turn in these cats as well upon initial greeting (with curled fingers extended toward the cat) instead of the cat reaching out to sniff your hand or even just peering at the cat through the carrier door if attempting to assess the situation (Figure 2.2).



Figure 2.2 Greeting a cat – always offer a curled back of the hand vs. pointing a finger as cats will find it less. *Source:* Ellen Carozza, LVT, VTS.

2.3.2 Repulsion

This is our antiquated term for what we view as their "fight mode." These common active responses displayed by the cat can be portrayed as hissing, swiping, and even chasing when their emotions are escalated due to a reaction by a trigger. Typically, these behaviors have the cat labeled as "aggressive" in the clinical setting. The cat can also display more passive responses displayed as staring or body blocking. In practice, these cats either come in ready to prepare for self-defense due to prior poor experiences, pain, or heightened anxiety from waiting and being exposed to a multitude of stressors.

2.3.3 Inhibition

Is the collection of information about a trigger by the cat without them being actively involved in a situation. This involves the sensory systems of the cat: visual, auditory, and olfactory. While *cats prefer to be at a distance when collecting information*, in the clinical setting, they are forced to collect this information in close proximity (especially when being handled) and can interpret the information as being in danger. The cat's face and head are particularly sensitive and that is their personal space we constantly invade.

2.3.4 Appeasement

While this is also a collection of information about a prompt, this tends to be the less common response in cats due to their nonobligate social behavior. Appeasement displays in the cat involve sensory communication. In the clinic, visual, olfactory, auditory, and tactile senses can be highly stimulated and easily over-stimulated as they gather information about their safety. At times, some of these cats will display the "fake spraying with foot stamping" or rubbing against the walls and chairs in the room and may pay particular attention to areas commonly marked by previous cats.

2.4 Sensory Communication Cats: How Cats Gather and Interpret Information

2.4.1 Visual

Involves giving information and is demonstrated by facial expression, ear positioning, body posture, and pupillary dilation. These constantly change as we interact with the cat. A right gaze bias/head turn may be interpreted as relaxed in the environment.

2.4.2 Auditory

This includes both vocalization and listening. Cats have different levels of vocalization. Whether purring, a meow, or even wailing, it is important to know the difference between their vocalizations and modify our methods of handling and sharing space with them. Watch how their ears rotate on their head, how they can point in the direction of a noise that is of interest or concern, or if the ears flatten when stressed.

2.4.3 Tactile

While reserved for those the cat is familiar with, this is the least likely interaction to be used in the context of appeasement. However, a head bump against the hand as a welcoming gesture of acknowledgment is seen in practice. When introducing yourself to a cat, always extend a clean hand out with fingers curled in toward your palm for the cat to investigate and allow them to accept or reject the gesture.

2.4.4 Olfactory

Active exchange of scent between the cat and the trigger. Facial marking or body rubbing are actions that may be displayed. At times, the cat may be seen "marking" chair legs, door frames, or even their scent along the pant legs of people in the exam room (Figure 2.3).

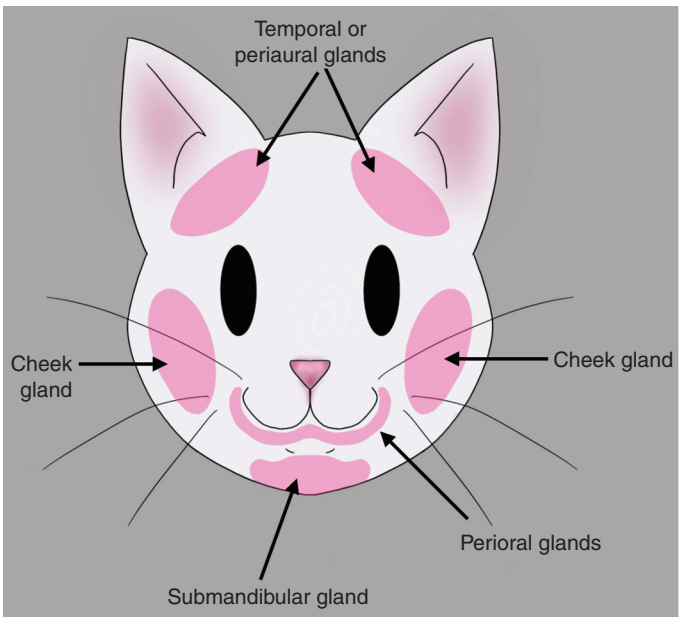


Figure 2.3 Cats use pheromones to "mark" areas that they value, as well as areas they find familiar and safe. The cat's face has four areas where they will use to "mark" areas in the home, the people they enjoy spending time with, and as a cue to other cats as part of their signature scent. Cats in the clinical setting may showcase behaviors of marking with their face against the tables, chairs, and people and tend to respond to more positive touch in those areas during the examination. Allow the cat to smell your hands after touching those areas and they will recognize themselves on you. Infographic based on the FeVMA Feline Facial Glands of Areas of Preferred Touch in Cats. *Source:* Ellen Carozza, LVT, VTS.

2.5 Interpreting Feline Behaviors at the Clinic and Modifying Our Techniques to Prevent Escalation

2.5.1 Confrontational

Perceived as uncooperative behavior toward people due to anxiety, fear/stress, and pain that can start at the beginning, escalate during their appointment, or stay. A left gaze bias or head turn can be a subtle clue that the cat is in a condition of a low level of fear; however, it can quickly escalate into an event that is not desirable and suddenly can become a situation out of control and dangerous to the welfare of the cat and people handling it. However, these cats may also vocalize, hiss, growl, and snort to let you know that you are in their personal space and that you are being perceived as a threat and have given you fair warning. Hissing is a defensive gesture that can be dependent on the level of stress the cat is feeling. From a silent, relaxed hiss to a more visceral (Figure 2.4), curled tongue hiss where you can feel air ejected from the cat at close proximity can warn you ahead of time how you need to evaluate the situation. *When in a confrontational situation, it is better to stop, reassess the current situation, and come up with a better plan of action to safely work with the cat or provide more relief for the animal.*

2.5.2 Avoidance and Inhibition

Due to fear/anxiety, they tend to remain quiet and may meow or show other signs of stress such as lip licking or swallowing. Many times, the lip lick and swallow gestures are not noticed as easily as one may be speaking to the client vs. paying attention to the cat initially. Learned helplessness due to the inability to cope, freezing postures may be seen, and the cat may attempt to hide their face or make themselves as small as possible in the carrier. Avoid hovering or coming at the cat straight on as it is intimidating to a species of prey and predation. Many cats in the hospital that are not provided with a hide box (Figure 2.5) will put themselves into a corner and attempt to escape by climbing the wall (Figure 2.6). Approaching the cat from behind or side eases some of the stress involved. Noise reduction should be made a priority by



Figure 2.4 Hissing cat – hissing is a warning that should not go unnoticed, and it is an indication the cat is at a heightened level of stress and has given you a clear indication that they are going to take the situation further to protect themselves if you continue to work with them without modifying your techniques. *Source:* Ellen Carozza, LVT, VTS.



Figure 2.5 Hide box – hide boxes do not need to be expensive. Simply offering a place where cats can remove themselves from stressful situations and feel safe helps decrease their stress. If a box is not available, you can even use their own carrier as a safe zone. *Source:* Ellen Carozza, LVT, VTS.

speaking in slower, softer tones, and avoiding sounds, such as "shhh," when restraining as it mimics hissing and can actually increase the stress response in cats. Refrain from wearing strong perfumes and using room deodorizers they can be offensive to cats. Careful observation should be made as many cases can become repulsive to the point the cat will attempt to remove themselves from a situation they are being handled; and if they cannot escape, they may urinate, defecate,



Figure 2.6 Avoidance – notice how the cat is stressed to the point they are attempting to escape to avoid the situation. In such cases, these cats need to be offered a hide box while covering the front of the kennel. These cats may attempt to escape when the kennel door is opened. *Source:* Ellen Carozza, LVT, VTS.

and vocalize/cry out of distress and fear [10]. *When a situation escalates to this point, STOP everything as the welfare of this animal is in danger. Reassess and come up with a better plan of action. Do not continue to press this cat's emotional and physical state any further.*

2.5.3 Intercat Tension

Can occur during a multi-pet appointment, boarding, or hospitalization. Fear, anxiety, pain, and the inability to social play regardless of their household bond, can sour quickly in a stressful situation. Many times, intercat tension occurs at home when another pet member takes in the scent from the clinic and will display negative emotions toward that cat that smells of the veterinary hospital. With multi-cat appointments, it is advisable to work with cats singularly and not take both cats out at once to prevent conflict. Cats that are in separate carriers but may display cures such as hissing, growling, and striking at each other through the carriers should be covered with an F3 pheromone towel until ready to be worked with to not only reduce visual cues but provide pheromone therapy of a calm and familiar atmosphere. *Note: Cats that are already in a heightened level of stress may not respond to pheromone therapy.*

2.5.4 Misdirected Predatory Behavior

Is typically displayed by frustrated cats as they are hospitalized or boarding. They are desire seeking and their personal and emotional needs are not being met. The behavior that can be visually seen in practice is the cats actively attempting to open a kennel, remove papers from kennel fronts, or grab at medical personnel when you are near or passing the kennels. Some cats will even reach over to the next kennel to express frustration to another animal. These cats are being prohibited from a desired outcome or even safety particularly if there is no safe space to hide [2].

All of these behaviors are normal responses to the stimuli to which cats are subjected and should not be labeled as a negative behavior. Instead, they should be viewed as behaviors the cat may present with at future appointments and how we can make changes to prevent or dampen the possibility of an escalation.

2.6 Setting Yourself Up for Success

You and your team need to lead a collaborative effort to successfully work with the feline in practice. Knowing where to make modifications and apply appropriate hands-on participation training with the species enhances the medical care they receive at the clinic.

All cats are individuals and should be treated as such, and understanding the influences of the feline patient and resulting behavior during the veterinary clinic can set you up for a more successful encounter [11]. There are many influences that can sway your encounter. Working slowly and methodically and allowing the cat to acclimate during the initial consultation discussion with the client allows you to understand where their stressor may originate from. Examples of influences that change the dynamics of working with each individual cat include:

1. Genetics: pedigree cats vs. nonpedigree.
2. Prenatal stress (was this cat from a feral colony, intentional breeding, or house cat that is simply allowed to have kittens and what stressors was the queen subjected to?).
3. Lack of socialization/bonding with people during the very early sensitive period of development (~2–8 weeks of age).
4. Lack of socialization with other nonhuman species/household pets and other cats.
5. Early removal from queen and siblings/single-hand-reared kittens.
6. Previous negative experiences with unfamiliar people and veterinary visits led to protective behaviors being exhibited.
7. Compromised physical health, including pain and chronic illnesses.
8. Stressor stacking: which is not always taken into consideration as it should be as it plays a very large role in the success of working with the patient.
9. Hospital environmental factors: sensory overload.
10. Cumulative and chronic exposure to protective emotional triggers.
11. Approach and physical handling from unfamiliar people.

2.7 Stressor Stacking: Understanding Stressors that Contribute to Difficult Visits

Cats experience a sequence of stressors when coming into the clinic for a visit. Whichever their lifestyle (either indoor or outdoor or both), to being withheld food by their caretaker or trapped, only to be picked up/chased around the home/dragged out from under the bed and then placed in a carrier that is unfamiliar (especially if not trained for carrier use) and transported to a facility to sit and be subjected to an unfamiliar place that their senses become overwhelmed, then to ultimately being handled by unknown people is known as "*stressor stacking.*" The anxiety, fear, and stress continually build to a point where the cat has had enough emotionally and physically. Many cats have a lower threshold of stressor stacking while in other cats, a higher tolerance may be observed, and it is a situation that can change over time. When you understand where the stressor begins and address the specific issues, you can provide relief and attempt to de-escalate a situation where the cat or the people working with them can potentially be hurt. While the Stressor Stacking infographic by the ISFM/ICC (Figure 2.7) addresses indoor cats only, we can easily modify the scenario for our community cats as well. Regardless of the stressor, it is a disruption to their routine, and cats love routine as it is predictable.

2.7.1 Lifestyle

Indoor-only cats have specific pillars that must be met to create an ideal environment to thrive in and this includes cats who have access to "catios" or are adventurous on a leash. They have not been taught how to survive outside on their own. Likewise, for their outdoor "feral" counterpart, they have their specific pillars that they need fulfilled as well. These cats are not prepared for a life indoors where their only freedom now may only be the size of the home vs. blocks to miles of territory they usually roamed. Moving cats from their normal lifestyle is a stressor that can affect their emotional and physical behavior significantly.

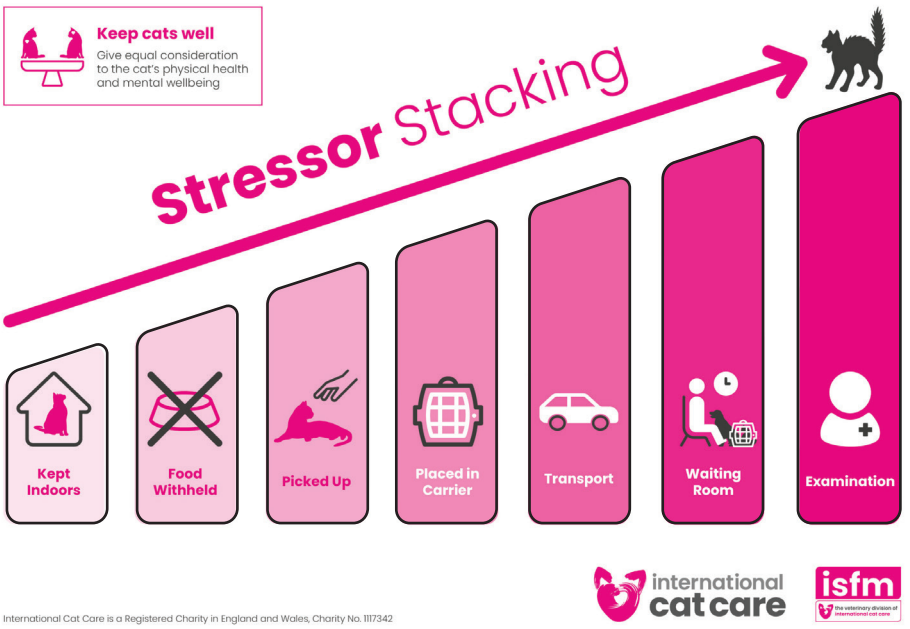


Figure 2.7 Stressor stacking – cats have limitations to what they are willing to cope with. Many cats have low levels of stress while many have higher levels of stressors, they are willing to tolerate before exhibiting behaviors we consider negative. Knowing what stressors they are exposed to before coming to the clinic and which trigger sends them over their tolerance level, we can help modify the stressors that contribute to their heightened emotional level and help prepare for successful future visits. *Source:* International Society of Feline Medicine.

2.7.2 Food Withheld for Pet Cats or Placed in a Trap for Capture

For many cats, food is a motivator. Cats also like routine. Fasting cats disrupt their routine, and nothing is more devastating for our companion animals than missing their meal that should be delivered on time. For our feral friends, we use food as an incentive for trapping, which causes an incredible amount of emotional distress for these cats. All they wanted to do was eat and now a negative stressor occurred during the process of securing an expected, normally occurring meal. Their goal is to either attempt to remove themselves from the situation by attempting to escape out of either end of the trap until they realize there is no escape possible or will showcase behaviors of inhibition and frustration.

2.7.3 Handling

Many cats are keen to understand something negative is occurring once their routine is disrupted and either withdraw or hide from the people they trust. Being chased around the home, yanked out from under the bed, or cornered, these cats can display the same behaviors of avoidance and repulsion and the situation can become dangerous for both the cat and the person(s) involved. Community cats may not prefer to be stalked when traps are set and know when people are waiting in cars while they are assessing the trap and food situation, they are left to make a decision about. To many cats, this is predatory behavior, even at a distance. They trust you enough for food but know something is amuck, but that meal may be more tempting and worth the risk.

2.7.4 Placed in Carrier/Kept in Trap

If the indoor cat is not used to a carrier left out for use as a safe place, the carrier can be interpreted as a negative stressor as the only time utilizing it is for stressful situations. Pulling, digging, or attempted escape are normal behaviors seen with cats that are distressed with the situation. Feral cats will typically display behaviors of attempted escape by checking each

end of the trap by running into the ends to bolt out, or they will hunker down at one end or the middle of the trap accepting their fate that they possibly will not make the scenario out alive. Covering the carrier or trap and giving the cat time to acclimate to the situation by providing pheromones, having the food already laced with an anxiolytic, and holding them in a dark, quiet space helps reduce some of the stress. However, for our community cats, it will never remove all of it due to their lifestyle.

2.7.5 Transport

Cats can and do get car sick either due to motion sickness or distress. Vocalization, open-mouth panting, urination, defecation, or anal gland expression are all signs of distress as well as frustrated behaviors of pulling at the carrier door(s.) Cats that have motion sickness tend to vomit during transport should be addressed ahead of time with an antiemetic at least 2 hours ahead of travel. It is important to remember to cover the bottom of the carrier with an absorbent towel or incontinence pad for easy cleanup and all carriers are to be placed behind the driver or passenger seat on the floor in the back. Traps should have a newspaper on the bottom inside the trap to absorb any bodily fluids and to protect the cat's feet from being caught in trap bars and kept covered at all times. It is advisable to have the traps on top of a tarp or other absorbent material as leakage of urine/feces can still occur as well as some pregnant cats may spontaneously abort their kittens due to stress.

2.7.6 Waiting Room

The sight, sounds, and smell of a hospital are stressors to cats, as their senses are more sensitive than ours. The facility can be loud not only from other animals, people, and machines, but also cats can smell other animals' distress via stress hormones they release.

2.7.7 Examination/Sedation

Cats have boundaries and while we may enjoy working with them, people they are unfamiliar with who are touching them without permission is a stressor and may be unwelcomed. *Under no circumstances should a feral cat be handled without sedation (they must be sedated and recovered in their trap) unless the cat is in absolute distress and has no ability to avoid the situation.* It is important to know feline body language and their facial expressions to know what you are starting out with and then modify your plan of action for these cats. Allowing decompression time of 10–15 minutes in a quiet room can help you gain a lot of traction with being able to work with a cat with a heightened level of stress. While this tends to be a deal breaker for many clinics as the appointment times tend to run longer, it can gain a lot more respect from the patient and the client.

When you understand where the stressor begins, you can easily understand the cat's behavior in the clinic and modify the situation to decrease the level of stress.

2.8 Making Changes at the Clinic

Setting up the clinic for the feline species can help reduce triggers and allow for easier handling, and observation of the cat as they are able to mask a multitude of symptoms to not appear ill. From the moment the cat is taken from its home, their stress response increases and that trigger can cascade into an event that is less than ideal for anyone working with the cat. The appointment begins with the client service coordinator who can identify if the cat needs extra time or additional accommodation or sedation for a successful and minimally stressed appointment.

2.8.1 The Waiting Room

Weather dependent, either have the client sit in the car and wait to be escorted immediately into a prepared exam room when the staff is ready to work with the cat OR have a feline-only waiting room area with *F3 feline facial pheromone* infused towels to cover the cat with. It is ideal to also have feline pheromone diffusers plugged into the wall to infuse the air that can

assist in limiting stress. At no time should the cat be allowed out of the carrier to explore as well as any office pets should not be allowed to roam freely if they are the kind that enjoys walking up to other animals waiting for an appointment. *Cats that are flagged for quick escalation should not be made to wait in the waiting room.* Either keep them in the car to wait their turn or immediately escort them into a clean exam room to allow acclimation.



Figure 2.8 Pheromone towels – Using feline pheromone-infused towels during a visit can help reduce the cat's stress level at the clinic. *Source:* Ellen Carozza, LVT, VTS.

2.8.2 The Exam Room

Ideally, an exam room should be set aside for the sole use of feline appointments. At no time should a sick canine room or euthanasia room be used for feline appointments as cats can catch zoonotic diseases from dogs and are sensitive to smell. Cats can sense if a stressful appointment was performed in a room before them especially if the room is outfitted with cloth furnishings. Cats require a decompression period of 10–15 minutes before working with them. Allow enough time during the appointment to accommodate this.

F3 pheromone towels should be provided for use in the clinic not only to cover the carrier when entering the clinic but also during the appointment (Figure 2.8). The exam room should have a pheromone diffuser with both F3 and appeasement pheromones to aid in calming the cat. Cats should also not be examined on any slick, cold table surfaces. Utilizing yoga mats or table mats allows the cat to have some stability and not feel as vulnerable on slick surfaces. Adding the additional padding also helps prevent heat loss in elderly, neonatal/pediatric patients, and cats who are ill. If allowed, the cat should have the entirety of the examination performed in the bottom half of their carrier that is placed either on the table or the lap of the clinician.

Greeting the cat requires a bit of patience on your part. Holding out a clean hand with your fingers curled in toward the palm showcases a nondominant greeting as an extended palm can be conveyed as a predatory attack, especially over the cat's head and face. It is also important not to make direct eye contact with the cat. Direct eye contact is perceived as a threat. Instead, practice looking above the eyes or to the side of the cat and slow blink! Slow blinking is perceived as nonthreatening, and the cat may reciprocate the blink if feeling more relaxed in the situation. Provide the opportunity for *cooperative care*. Cats that are confident should be allowed to have their carrier opened during the history-taking portion of the appointment to allow them to explore and get used to the room. At this time, speak to the client and ignore the cat allowing it to adjust on its own terms. If allowed, the cat can be lured and trained to lay on a scale with treats to allow it to step upon the scale by itself. This also sets up the introduction between the person taking the history and preparing to work with the animal. Any introductions should be done with your fingers curled in and your palm facing you so that the cat is sniffing the back of your hand. Simply hold your curved fingers out to the cat and wait. If the cat does not want to entertain the invitation, do not push the cat further but let the clinician know the cat is feeling protective over their emotions. Many cats will let you know if you are welcomed into their space by either bumping your hand with their head or begin vocalizing/growling/retreating or ignoring you with their displeasure. It is not recommended to start the appointment off with handling the cat immediately from the carrier to collect the TPR statistics. This can cause the cat to escalate its fear response, prevent more positive handling, and create falsified heart/respiratory rates and temperature. When in doubt, take the temperature last as both the hind end and face (aural temperature) of the cat are their personal zones and many do not appreciate those boundaries being crossed upon immediate introduction.

2.8.3 The Hospital

Hospitalized cats are under constant stress regardless of how they showcase it. The smell, sound, and continual exposure to light prevent them from being able to relax. While there are cats that do enjoy the attention at the clinic, many become inhibitive or frustrated and need additional accommodations to feel safer. If possible, double kennels work best to keep

the cat away from the litter pan as many do not enjoy their food and litter in the same space. Hide boxes provide privacy as well as sheer curtains over the doors. This allows you to look in and see how the cat is doing without completely obstructing the view. Full privacy curtains limiting light exposure can help the cats relax and allow the ability for sleep. Dimming the lights or turning them off in their quarter can make a big difference for many of them.

Constant handling is also a stressor. Limit unnecessary handling and allow the cat to rest. If the cat is not in a crisis, limit the amount of TPRs during the day, especially if the cat is not in respiratory distress or has the inability to maintain their core body temperature. While it is necessary to monitor hospitalized animals, not allowing them to sleep and relax can prevent them from feeling better and not provide the response you are looking for with treatment.

2.9 Know Your Cats: They Are Communicating!

Body language and behavioral responses give a lot of information about the feline patient. However, it can be a language that can easily be misunderstood. Knowing the basic body language that is not only positive but ones that showcases fear/anxiety/pain allows for better engagement with the cat and is key to assisting what kind of handling may be necessary.

Positive body language and behavior responses include:

1. Perky, forward-facing ears.
2. Pupils can be dilated if the cat is playful and interested or normal iris relaxed width is present.
3. Relaxed muzzle and whiskers. Whiskers may respond with interest (move) if the cat is confident and playful.
4. Stretching, rolling, head bumping, body rubbing with purring, and proposing (a cat reaches up with its head for petting) are positive, engaging behaviors.
5. Reciprocated slow blinking.

Protective body language emotions and behaviors include:

1. Ears rotated or flattened,
2. Pupillary responses of dilation or constriction,
3. Rapid or half-blinking,
4. Left head and gaze bias,
5. Focused attention, and
6. Whisker splaying or flattening.

Behavioral responses can have an increasing intensity with cats.

1. Inhibition: passive gathering of olfactory, visual, and auditory information
2. Avoidance: passive eye avoidance, hiding, backing away, and making themselves as small as possible.
3. Repelling/Repulsive/Defensive: hissing/vocalization as a warning, swiping/striking/scratching, and attempted biting.

Knowing what language the cat is displaying during the encounter can assist in what handling methods will be necessary to work with the patient safely.

Protective emotions of frustration are commonly seen in hospitalized cats. Not all frustration emotions lead to confrontational behaviors but can be a sign of attention seeking; however, it can lead to more intense and rapid behavior responses. Consistency is key to providing emotional relief through play, routine feeding, and ensuring that their environmental needs are being met. Monitor for:

1. Displacement behaviors such as rapid grooming or gulping/swallowing.
2. Repetitive behaviors are seen as pacing, persistent vocalization/calling out, pawing, or chewing at kennel bars in an attempt to escape. Grabbing at staff as they pass by or work on a patient adjacent to them for attention is an attention-seeking behavior.
3. Disruptive behavior of rearranging the kennel, knocking food/water/litter pan over.
4. Confrontational behaviors are repelling behaviors with a trigger and the trigger needs to be recognized, stopped, and modified to prevent the behavior. Patience is the key with working with these cats.

2.10 Handling Techniques

With cats, less is best; however, at times, we do need to limit the mobility to our patients when performing diagnostics. Many cats allow specific diagnostics such as noninvasive blood pressure to be performed on their tail while sitting comfortably, others need limited handling or training with a positive reward to encourage them to remain still to prevent a false elevation in blood pressure. This also includes performing blood sampling. Other handling techniques include modified cradle/cuddle hold, towel-wrapping techniques, and semi or full sedation when necessary.

Tip: Use a constant hands-on approach when examining and working with the cats. Always have one hand on them at all times that lets the cat know you are there instead of picking up your hands and placing them back down. This is usually easier with a two-person approach as the handler is always touching the cat with reassurance to the animal and to ensure the other person working with the cat has little opportunity to be in a strike zone if the cat's reactionary behavior suddenly changes. If you are alone working on the cat, have their hind end tucked in towards your abdomen and work with the cat from above.

2.10.1 Positive Reward Training

This is the least hands-on approach with cats. They are simply trained with a highly palatable food reward to allow diagnostics such as weight, aural/core temperature, blood pressure, or observation of an area that needs limited or no touching.

2.10.2 Restraining

Depending on the cat's current stress level and demeanor, many cats will allow handling to a degree but still have a threshold of patience. In rare instances, some cats enjoy handling regardless of who is handling them and how. Their positive reward is attention. Typical positions cats are handled in are as follows (Figure 2.9):

1. *Lateral recumbency* cradle/cuddle hold: the patient is lying either on their left or right side with the limb extended for sampling/nail trim.
2. *Sitting upright* with their head elevated for sampling/imaging: the cat is sitting in a normal upright position with their bottoms and front feet touching the table.



Figure 2.9 Cuddle hold – notice how the cat is allowed to be in a relaxed lateral recumbency position. This allows the cats to have some control over how they are being handled and are more willing to tolerate lab sampling. *Source:* Ellen Carozza, LVT, VTS.

3. *Dorsal recumbency* for sampling/imaging: the patient is rolled onto their back with their fore and hind limbs gently held in place or if they are sedated can be tied/or held back with other props or simply remain lax.
4. *Ventral/sternal recumbency* for sampling/imaging allows the cat to remain in "loaf" position while they are worked on.
5. *Standing* some cats prefer to stand for lab sampling and examination.

Towel restraint allows for the positions above but with the use of a towel as a barrier for safety between the handler and the cat. This helps decrease some of the sensations the cat is exposed to as well as protecting the welfare of the cat and people working with them. Not all cats need a snug wrap, but simply draping can work just as well. Pediatric patients who have their dentition may panic and respond to repel by wanting to bite and flail when restrained. Ones that panic and struggle, even with minimal handling due to them still learning and gathering information about their environment, benefit from towel wraps that include support to their neck and head. The restrainer can simply use a hand towel or wash-cloth as their wrap as the patient is quite small and normal-sized towels are too bulky. Use what is appropriate for the size of the patient. In a pinch, an extra surgical towel works great for these patients as it has a tight, woven weave to prevent accidental scratches and bites from their repelling behaviors due to stress.

2.10.3 Techniques No Longer Accepted

Restraint techniques no longer accepted for use in practice as they escalate the fear response include:

1. Scruffing (Figure 2.10)
2. Clips used on the scruff, also known as "clipnosis"
3. Full-body restraining/hobbling
4. Tight towel or velcro wrap systems



Figure 2.10 No scruff zone – all clinics should strive to be a no-scruffing clinic. Scruffing no longer serves the purpose of restraining cats but contributes to increased stress levels and physical pain. *Source:* International Cat Care, Pledge to Go "Scruff Free" webpage: https://icatcare.org/our-campaigns/pledge-to-go-scruff-free/.

Poor restraining methods in cats, particularly pinch-induced behavioral inhibition [12], can have serious consequences for the feline patient. Cats that have hyperadrenocorticism (Cushing's disease) can be susceptible to thin, friable, and fragile skin that can easily be torn from the body with little force, especially during restraint that exerts excessive force on the tissues. Clipnosis, while toted as a friendlier method and utilizing either binder or clawed clips, can also damage tissue and cause not only emotional distress but localized pain. Full-body restraint, where the cat is placed in lateral recumbency and the fore and hind limbs are held by the hands while extending the cat's spine outward curvature toward the handler and the belly of the cat extends forward, places the cat in a very vulnerable position. Not only can this be painful, but the cat's head and neck are free from restraint and can cause a bite to occur to the handler or the person wishing to perform a task in that area due to the heightened stress response. Overly tight burrito wraps can cause physical harm to limbs that are secured incorrectly or prevent the cat from breathing normally and they can go into respiratory distress.

The following equipment is also no longer recommended for feline-friendly handling in practice or grooming. If you have to think about using these techniques, the task needs to be stopped and re-evaluated for a better approach.

1. Cat bags
2. Arm gauntlets/gloves
3. Muzzles of any kind
4. E-collars/air muzzle/bubble muzzle
5. Anesthetic boxes
6. Pillowcases
7. Mesh cat-nabbers
8. Air muzzles or any device that goes over the head of the cat and encapsulates it
9. Cat bags/body velcro wraps

Regardless of the visibility an air muzzle or e-collar can provide the cat, you still have to place the device around the neck and the cat is still being exposed to the stressors. Cat bags and velcro wraps require you to still manipulate the animal into the device leading toward the opportunity of either the handler, the cat, or both becoming harmed. Just because these devices are available and can be successful in performing the task, does not mean they are acceptable and place the welfare of the cat first. Muzzles are in their personal space, and you cannot see how the patient is responding to the situation. Gloves *DO NOT* allow ease of handling, neither do gauntlets. All they do is aid in the prevention of scratches as cats can bite through them. Another factor that is not readily paid attention to is the lack of cleanliness of these items, and they can act as a vector for many communicable skin diseases such as ringworm. If you have to think about using any of the items in the above list, you should be rethinking how to properly understand feline behavior and work with the cat more safely than just focusing on the task and being pressured to perform for the client or clinician.

2.11 Sedation

The use of sedation for feline patients is more commonly embraced than it has been in the past. Many cats, regardless of attempted training and other methods of attempting to de-escalate stressful visits, require sedation as they are only able to be handled safely with the cat rendered unconscious. Not only does it help decrease the amount of distress, but it also allows for a better physical examination and interpretation of the problem the patient is being evaluated for. Still, many cats are not given the opportunity for sedation as this needs to be addressed as a small procedure that does require monitoring of the patient as cardiopulmonary arrest can occur with any anesthetics used. A pulse oximeter, flow-by oxygen, blood pressure, temperature, and IV catheter should be the minimum of provided safety measures along with regular human touch and auscultation of the heart and lungs during the sedated procedure.

Due to the elevated anxiety and fear response regardless of your experience, *ALL feral cats are to be sedated in their trap and their sedatives reversed and placed back into their clean traps for recovery*. Under no circumstances should TNR cats be recovered outside of their traps. It is OK to reverse these cats and remove their IVC once they have a strong palpebral response as many sedatives can be reversed to allow these cats to be returned back outside within 12–24 hours depending on the combination of sedation used.

There are times that you will encounter pet cats that you can simply not work with safely regardless of attempted de-escalations and that is OK! While it is ideal to get a physical TPR on them, it can be a dangerous situation. At this point,

it is safer for the cat and the people working with them to sedate the cat in the carrier and allow it to sedate there and monitor the cat from outside the carrier visually. Then, once the cat can be safely handled, remove them and begin your work. Communication is key with the client to let them know different accommodation needs to be made to provide the care needed for the cat.

Mild sedation includes the use of an anxiolytic to decrease the stress threshold, yet the patient is fully conscious and aware of his surroundings. Anxiolytics used in cats include:

1. Anticonvulsants such as gabapentin and pregabalin
2. Benzodiazepines
3. Alpha-casozepine
4. Colostrum calming proteins
5. Thiamine
6. L-theanine
7. CBD
8. Homeopathy agents such as phosphorus and plant essences, and
9. Tranquilizers such as acepromazine are no longer recommended for use.

It is not only dose dependent by weight, but cat dependent. As many cats still require further sedation for handling if they are quick to metabolize or are unaffected by the choice of therapeutic agents.

Full sedation is utilized for patients that require complete compliance for a procedure either due to a heightened stress threshold that makes them dangerous to work with safely as well as placing themselves in danger when performing diagnostics that can contribute to further emotional anguish along with physical pain and discomfort. The goal is to remove the stressors to allow a proper examination and diagnostics to be performed. While sedation itself can be a stressor, it is minimal compared to the continued heightened fear response. When fully sedated and unconscious, the cat should have full monitoring performed such as TPR and blood pressure until conscious as well as flow-by oxygen. It is recommended that an IV catheter is placed if using pharmaceuticals to render the animal unconscious in case of an emergency [13]. *The catheter can be placed when the cat is safe to handle and removed when they are beginning to regain consciousness.* While ideally, we would like a catheter placed beforehand, these cases need to have significant modifications made to accommodate for safety. It is important to utilize a catheter that fits the vein comfortably to prevent phlebitis or limb discomfort post-sedation.

2.11.1 The Magic of Multimodal Sedatives

There are a multitude of sedation combinations [14] for use in cats in practice. Each cat should be considered a unique situation and the sedation tailored for their use. "Kitty Magic" is the coined term used for the multisedative cocktail given intramuscularly, which has properties that can be reversed making the experience for the cat and everyone working with the cat seem "magical." The author's combinations can include:

1. Ketamine: a short-acting dissociative anesthetic
2. Midazolam: a benzodiazepine to reduce anxiety and relax muscles
3. Dexmedetomidine: an alpha 2-agonist for sedation and analgesia
4. Opiate: analgesia

The goal of Kitty Magic is to provide analgesia, reduce anxiety, and place the patient in a level of sedation where they can still control their own breathing and safely be handled, then recover quickly (Figure 2.11). Typically, an alpha two sedative is combined with ketamine-a dissociative anesthetic, along with an opiate to provide analgesia, and in some mixes, a benzodiazepine is added to reduce anxiety and as a muscle relaxant. Regardless of the cocktail used, the majority of the drugs are reversible giving the user more control over the patient's sedation. Again, it is highly recommended an intravenous catheter (IVC) is placed when the patient can be handled safely. With dosing to some of the drugs and concerns inquired, especially if requested to not use due to breeder recommendations or a poor previous experience, ketamine is used in low doses in the cat as well as ultra-low doses of midazolam that not only allows for great sedation but an easier recovery that does not leave the cat dysphoric during recovery. The addition of an alpha 2-agonist (dexmedetomidine) gives enough sedation to do minor procedures such as neuters, small biopsies, and intubation is possible. Opiates are chosen at the level of pain the animal is experiencing or the anticipated pain the procedure can produce. When these drugs are used in combination, less is needed to achieve the results you want.



Figure 2.11 Kitty magic. *Source:* Ellen Carozza, LVT, VTS.

2.12 Tips for Safe and Feline-friendly Life Stage Handling: A New Way to Approach Cats

Just as each cat is unique, so are their handling needs for each life stage. The AAFP 2022 Feline Interactions and Handling guidelines should be used as a hospital reference for staff training. As the cat ages, it grows in size and develops underlying diseases. Our handling techniques need to be modified to reduce the level of stress and for safe handling by the care team to not only protect the cat physically but also prevent protective emotions in our younger patients that may become an issue due to poor experiences that occur at their vulnerable learning stages. We need to remain mindful that working with cats requires patience on our part to achieve cooperative care. *Regardless of the life stage, cats should be given a non-slip surface or adequate padding to sit on. Never use a tabletop that does not have padding as it contributes to body heat loss and pain.*

2.12.1 Kittens

Neonates and pediatrics are the smallest and most vulnerable patients seen in our practice. Working with these patients does require a gentle hand while utilizing smaller tools of the trade for obtaining samples and placing catheters and restraints. This is an age group where you must adapt your techniques to provide a high level of care. Tips for neonates and pediatrics include:

1. Warm hands, warm bedding when examined, and a warmed stethoscope as they do not have a plush double coat present as a barrier from the instrument. These patients are prone to hypothermia, and their vitals change quickly in cold environments.
2. Neonates that are in an incubator and need to be removed should be removed with a warmed dish towel and examined on a heat source that is temperature checked to prevent thermal burns. If possible, they should be examined in the incubator and not removed unless they need a procedure or laboratory work performed on them.
3. Most kittens less than 3 weeks of age can be easily restrained cupped in two hands gently holding their limbs and head still.
4. As they age, a dish towel or washcloth can be used to make modified "cat burritos/purritos" for gentle restraint. During this quickly changing period of experiencing their environments and becoming aware of depth perception, many kittens panic when handled. Keep the kitten close to your body when holding them and when working on them, use a nonslip surface and refrain from holding them in the air.

This age is impressionable, and poor experiences at the veterinary hospital at a young age can create a cascade effect for future visits with less compliance and a heightened stress level to begin the next appointment with. Pain and fear from not addressing the small considerations to create a positive visit can directly contribute to their lack of compliance in the future.

Juvenile cats need minor modifications with training from the owner and the staff to create a positive atmosphere at the office. Using baby food, meat tube treats, or even dry cat treats when working with them reinforces behaviors that are positive and can be used to distract the cat when working with them. If these cats have had poor past experiences or have never been exposed at a younger age to clinical stressors, training is an excellent way to earn their trust along with the use of natural anxiolytics if needing a mild reduction in stress.

2.12.2 Adult Cats

Adult cats have different needs as they begin to develop changes in the body that can contribute to pain. During a physical examination, we do not see them express pain until we do something to elicit this response. Arthritis, previous poor experiences being handled, and other comorbidities can cause a cat to escalate rather quickly into a dangerous situation if we do not address the issues we at least know about before restraining them for any tasks. If we know the cat is in pain, we address the pain ahead of time to help decrease that stimulus. Same for anxiety, plan ahead and have the caregiver premedicate the cat, if possible, to help decrease the anxiety the cat may be experiencing. Many of these cats are easily examined in the bottom half of a cat carrier.

2.12.3 Senior Cats

The senior cat or cats with comorbidities are our more fragile patients. Arthritis, various endocrine diseases, and sarcopenia can make extending their legs painful and the delicate, thin skin more susceptible to laceration when clipping fur or even performing venipuncture. Additionally, warm padding is welcomed as well as addressing pain ahead of time to ensure a more positive experience. Refrain from tight wrapping but attempt to see how the cat will allow you to handle them and modify the hold to cater to their current state.

While the cat in practice can be challenging to work with at times, knowing where stressors begin, how to provide resources at home to prevent escalation, and knowing how to modify your techniques while working with them at the clinic provides a superior level of care for a species truly needs the same attention paid to them to remain healthy.

See Table 2.1 for the definition of terms utilized within this chapter.

Table 2.1 Chapter definitions.

Definitions
Appeasement: rarely showcased in cats at the clinic but conveyed in an attempt to de-escalate a situation. In cats, foot stamping, tail quivering/fake spraying, or even licking are examples of appeasement.
Avoidance: to remove oneself from a situation
Cooperative care: training that involves the animal to be a willing participant with handling or working in close proximity with them. The relationship between the person and the animal with cooperative care is that the animal is allowed to say "no" to the situation and the handler/caregiver has to modify his techniques to create a safer working environment that works for the animal to achieve the desired response and to prevent escalation of a stressful situation.
De-escalate: to reduce the intensity of a situation.
Inhibition: collection of information of a trigger by the cat in close proximity and are unable to act relaxed or normally as they would in the home. Many times pinch-induced behavioral inhibition (PIBI) is used on the name of the neck to immobilize a feline patient with a specific restraint technique.
Instinctual motivations: instincts based on the evolution of the species. Hunting is an instinctual behavior in cats.
Left gaze bias: facial actions associated with low fear intensities that include blinking, half blinking, and a turn of the head toward the left.
Life stage handling: specific handling techniques that are modified to fit the needs of the age of the cat and their potential comorbidities associated with age.
Protective emotions: emotions from a cat are commonly viewed as a negative response. An example of a protective emotion in a cat is an aggressive response. Swatting, hissing, and vocalization are examples of protective emotions.
Repulsion: a reaction to a trigger that attempts to create distance or decrease/cease interaction. Swiping is a classic example of repulsion.
Stressor stacking: when different stressors or triggers are stacked on top of each other that directly affects the emotional well-being of the cat, we want to work with and can ultimately create an escalated situation that can easily get out of control.

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3

Preparing the Veterinary Hospital for the Feline Patient

Jan Yaroslav RVT, VTS (Dentistry), VTS (CP-Feline)

TECHNICIAN TIDBITS

- Hospital design and workflow have a significant impact on the feline experience.
- Creating a feline-friendly environment and workflow is a team effort that reduces stress for the patient, client, and team members.
- Identify the "Cat Whisperers" in your hospital to lead and train your team.
- The client/patient experience at the hospital begins and ends at home.
- It is not necessary to do extensive and costly renovations to the hospital to create an environment that is cat-friendly.

The concept of creating a feline-friendly hospital environment was developed by the American Association of Feline Practitioners (AAFP [organizational name change to Feline Veterinary Medical Association in 2024]) in 2012 in response to the decline in feline visits to the veterinarian. AAFP in collaboration with Bayer Healthcare and Brakke Consulting conducted several research studies to determine why cat owners were less likely to bring their cats in for veterinary care. The Bayer veterinary care usage study consisted of three phases, with the final phase ending in 2012. The study included surveys of veterinarians and cat owners as well as focus groups. The cat owners' responses revealed that they did not understand the importance of routine veterinary care, they had trouble getting the cat to the hospital, and both they and their cat were stressed by the experience. The fourth reason was cost. The veterinarian responses revealed that they saw the need to increase feline visits, recognized that cat owners struggle to get their cats to the hospital, and that veterinarian–client communication was important. The veterinarians also realized that cost was a factor. Client–veterinarian focus groups then discussed these concepts. The results of the study concluded that educating clients about the importance of routine veterinary care, reducing the stress of clients and their cats before, during, and after the visit, providing written reports on exam findings and recommended care, and offering preventive care packages were key to increasing feline visits. This landmark study opened the door to finding solutions to problems for the cat, the client, and the veterinary team related to veterinary visits [1].

3.1 General Clinic Preparation for a Feline Visit

The goal of preparing the hospital for the feline patients starts well before the visit and should be considered from the client, patient, and veterinary team's point of view [2]. Many clients schedule an appointment with a good intention of keeping the appointment. They will often call 10 minutes before the visit to say they have to reschedule. Most often it is because they have not been able to capture their cat. They may have let the cat outside that morning, and it has not returned home. Often, they say the cat was hidden somewhere in the house when they brought out the carrier. Sometimes, they know where the cat is hiding but they cannot coax them to come out. Many times, the only time a cat is exposed to a carrier is right before travel and subsequent arrival at a veterinary hospital. The cat associates the carrier with a stressful event. They run or hide, and this can make it very difficult for the client to arrive on time for the appointment. The client removes the cat from its hiding spot and attempts to place them in the carrier. The cat often resists, and this only accelerates the stress for the patient and client. These stressors can compound if the client is successful in arriving at the hospital. The cat may be vocalizing during the trip to the hospital, and the client also becomes increasingly stressed. By the time the client

arrives for the appointment, they are already dreading subjecting their cat to the exam process. This stress also affects the veterinary team. They are faced with handling a difficult patient and an upset client. The solution starts with carrier acclimation. It is recommended to leave the carrier complete with comfortable bedding out in the house where the cat feels comfortable. The use of synthetic feline facial pheromones in the area can be helpful as well. The door to the carrier should be left open to allow the cat to enter the carrier. Food and treats should be available in the carrier to entice the cat and provide positive reinforcement. Once accustomed to the carrier, the cat will associate the carrier with a safe space. Carrier acclimation can be used with an outside cat as well. It will become something they are familiar with in the environment instead of something they only see once or twice a year. Carrier acclimation and proactive ways to make sure an outside cat is accessible should be discussed with every client scheduling an appointment. Customer care team members can also advise the client on carrier selection. Carriers should ideally have at least two doors, with at least one being on the top of the carrier. Providing appropriate carriers for sale at the hospital can make it easier to reinforce the recommendation. Providing a carrier loan program can help a client and patient travel safely to your hospital. More information about carrier choices can be found in Chapter 5: "Client Education and Communication Topics for the Feline Owner." Client education materials are available through FeVMA Visiting Your Veterinarian: Getting your Cat to the Veterinary Practice [3].

The client has been successful at arriving at the hospital. The next step is providing a safe, nonthreatening environment that can make the whole experience less stressful for the patient and in turn the client and veterinary team. The Five Pillars of a Healthy Feline Environment concept was developed by the FeVMA to help veterinary professionals create a hospital environment with the needs of the feline patient in mind (Figure 3.1).

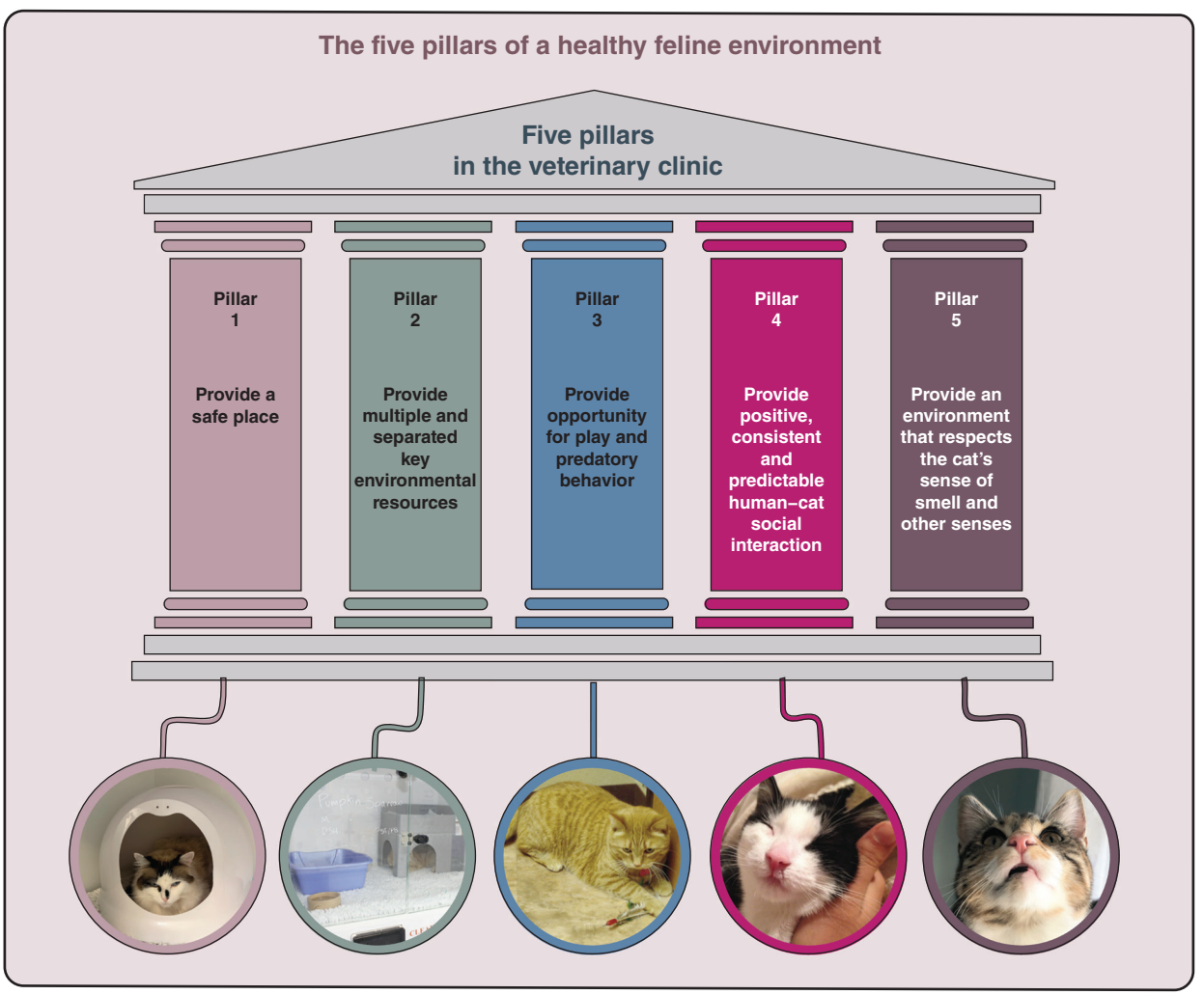


Figure 3.1 Five pillars of a healthy feline environment. *Source:* Reprinted with permission from the Feline Veterinary Medical Association. 2022 ISFM/AAFP Cat Friendly Veterinary Environment Guidelines.

3.1.1 The Pillars of Healthy Feline Environments

3.1.1.1 Pillar 1: Providing Safe Spaces

Providing a safe place for feline spaces increases their ability to cope during a hospital visit. Safe spaces that allow for hiding should be created in all areas of the clinic (waiting areas, examination rooms, as well as hospitalization and boarding spaces). The goal of these spaces is to increase the emotion of safety as well as function as a resting area. A vertical space can be considered and will enable the clinic to expand the overall size and complexity of the environment. This type of space will increase the cat's ability to perform their normal behaviors (jumping, climbing, and surveillance of the area from above). Creative ideas for each area of the hospital will accomplish this goal. The reception area should provide an area for carrier elevation and isolation from other animals. The exam room should provide areas to hide such as a cabinet or drawer or towels to cover the patient. Hospital wards should provide comfortable resting and hiding spaces such as boxes or the cat's carrier and include elevated perches.

3.1.1.2 Pillar 2: Providing Important Environmental Resources

Essential needs for the feline patient include providing food, water, resting areas, perches, scratching areas, litter boxes/trays, and play opportunities (if appropriate). When cats are housed in the veterinary clinic, no matter how long, all of these needs should be met. Options for each resource should be presented for essential needs within the space provided so the cat's preference for their use separately is respected.

3.1.1.3 Pillar 3: Providing Opportunities for Play and Predatory Behavior

Play and predatory behavior are natural and important for cats. These behaviors can trigger a positive emotional state. These desire-seeking motivated behaviors can be triggered by items such as toys, food or treats, increasing positive emotional bias during the entire process surrounding a hospital visit. This pillar is important for cats who are boarding or hospitalized for more than a short time.

3.1.1.4 Pillar 4: Providing a Positive, Consistent, and Predictable Human Interaction

The goal is to create an environment that treats feline patients with respect and thus allows us to be successful with treatment and improve their quality of life. The human–cat interaction at each visit can directly influence the outcome and behavior of future visits. See Chapter 2: "Feline-Friendly Interactions" for more information.

3.1.1.5 Pillar 5: Providing Environments That Respect the Cats' Senses

The veterinary environment should respect the feline senses (smell, sight, and hearing). Information using the senses that are gathered while in the hospital can influence the emotional health of the cat. Sensory overload is a problem for our feline patients. Efforts to minimize noise in all areas such as speaking in low voices, separation from dogs, and playing soft music at low volumes. The cat's sense of smell is much more advanced than ours. The use of perfumes, scented lotions, strong disinfectants, and room deodorizers can be offensive to a cat. Ocular stimulation is also a problem. Providing separate species waiting areas, hospitalization, and treatment areas where cats cannot see other animals is recommended.

3.2 The Reception Area

The reception area should have a separate space that is dedicated to "cat only." A separate cat entrance is ideal. If this is not possible, using a divider of a screen or plants in the cat area to block visualization of dogs and activity in the area, as well as providing a way to elevate carriers and using synthetic feline pheromones is recommended. The area should be clearly marked with signage denoting it is a cat-only area. Have a basket of towels and feline pheromones in the area. The towel can be sprayed with synthetic pheromones based on manufacturer recommendations and placed over the cat in the carrier. Providing hospital-recommended feline treats, toys, bedding, and environmental enrichment items in the reception area for sale is also a way to make the area more feline-friendly. Providing complimentary samples of treats, catnip, and plastic can lids with the hospital logo in a welcome bag that can be handed out by the reception staff is a good idea when medically indicated. Care must be taken to ensure animals that need to be fasted for testing or surgery. These small changes can be easily implemented in a general practice facility with minimal expense (Figure 3.2). Another idea is to escort the client and

patient into the exam room upon check-in or offer the owner the chance to wait in the car with their cat until an exam room is available. Creating "cat only" appointment hours at a multispecies hospital can be a creative solution. The goal is to minimize noise, scents, and ocular stimulation of the patient [4].

3.3 The Exam Room

The design and layout of the exam room are very important to a feline-friendly experience. Designating a "cat only" exam room is ideal. The room should be equipped with items and instruments that are feline-specific such as a tabletop scale and aural thermometer. Provide warm towels sprayed with synthetic feline pheromones. Providing spaces for cats to hide such as a cat tree, climbing wall, or even a drawer in the room can reduce stress. It is important to have everything ready in the exam room tailored to the specific appointment. Have an otoscope, ophthalmoscope, thermometer, and flea comb ready for use on the countertop. Prepare the exam room for the specific type of visit by having supplies in the room to perform diagnostics or treatments that may be needed. Creating pre-made kits for ear problems, eye problems, dermatology, and phlebotomy is a good idea. Provide a container of tasty feline treats in the room. Food distraction during the exam and treatment can be used when medically indicated for positive reinforcement. This will minimize having to go out of the room or open a drawer during the visit and will eliminate the team from entering and exiting the space to reduce noise and motion (Figures 3.3 and 3.4).

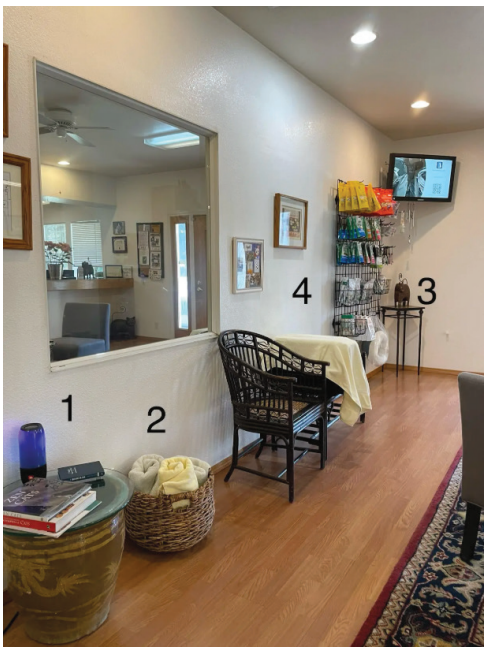


Figure 3.2 Feline-friendly reception area design. 1. Provide a device with feline-friendly music. 2. Provide towels and synthetic feline facial pheromone spray. 3. Provide a bench to elevate the carrier covered with a towel. 4. Provide a display with recommended feline products. *Source:* Jan Yaroslav.



Figure 3.3 Feline-friendly examination room design includes providing an area to elevate the carrier, having all tools ready to minimize, having team members having to leave the room, and using of synthetic feline pheromone diffusor. *Source:* Jan Yaroslav.

The workflow in the exam room is also important for a feline-friendly experience. A traditional veterinary hospital workflow uses an exam room technician entering first to take history and vitals before the doctor enters. The feline-friendly practice uses a doctor in the first workflow. The doctor obtains the history while observing the demeanor of the patient. The cat is allowed to come out of the carrier on their own. Never try to pull a patient out of the carrier by force or shake the cat out of the carrier. If the cat is not voluntarily coming out of the carrier, take the carrier apart and gently remove the cat with a towel. The exam is tailored to the individual patient. Blood pressure measurements are performed before the exam to provide readings before the cat is stimulated. This is done with minimal restraint, with the client present and preferably handling the cat. The most common blood pressure monitors found in veterinary hospitals are Doppler and oscillometric. More information on the proper use of blood pressure monitor equipment can be found in Chapter 6: "Anesthetic Concerns for the Feline Patient."

The cat dictates the order of the exam leaving the most stressful part for last. The exam may be performed on a padded exam table, while sitting next to the cat on the resting bench, on the floor, or by removing the top of the carrier depending on the patient. Using a towel to cover the patient provides a safe space and reduces stress (Figure 3.5). All the tools needed for the exam are nearby. The exam is conducted with minimal restraint whenever possible. The doctor can call for additional assistance if needed. Team members should move slowly and speak in soft, calming tones. The team member will handle the patient using towel techniques if indicated. Chemical restraint is indicated if towel restraint is not safe or effective for the patient or the team. The exam can be rescheduled for another day if there is not an emergent problem. Options include sending home medication to be used



Figure 3.4 Example of providing a safe space for the patient to hide such as a drawer. *Source:* Jan Yaroslav.



Figure 3.5 Example of performing an exam where the patient feels comfortable, in this case, the floor. All the tools needed for the exam are nearby. *Source:* Jan Yaroslav.

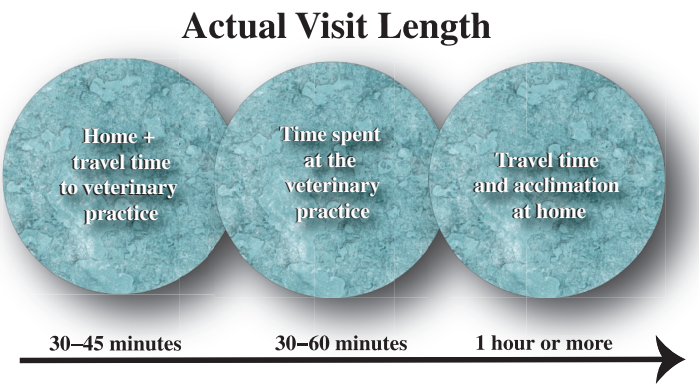


Figure 3.6 The real length of the visit. The visit starts and ends at home. *Source:* Kristin Cooley.

pre-exam or keeping the cat and providing medication in a hospital to reduce anxiety and facilitate the exam. Gabapentin 100–200 mg per cat or 20 mg/kg PO 2–3 hours prior to the visit the next day can be very effective at reducing anxiety about veterinary visits. It is recommended to use lower doses in cats with chronic kidney disease (CKD) or who are debilitated [5]. More information can be found in Chapter 2: "Feline-friendly Interactions" and Chapter 6: "Anesthesia Considerations for the Feline Patient." It is important to schedule enough time to do the exam. Taking extra time to allow the cat to acclimate will save time in the end.

Once the exam is completed, the doctor will discuss the treatment recommendations with the owner. The exam room technician will then discuss the treatment plan, recommendations, and timeline with the owner. The treatments should be done in the exam room whenever possible to minimize patient stress. The owner is given the opportunity to stay with the patient if they wish or may be escorted to the waiting room if they do not wish to be present. Often cats will be more relaxed if their owners are present. This also allows the owner to observe how the team performs the treatments. The exam room technician prepares the discharge instructions and medications as prescribed by the veterinarian and reviews administration directions. It is also helpful to have a protocol that will allow a client to pay the invoice at this time as well. This minimizes the need to have the client and patient move to another part of the hospital. Providing written discharge instructions and answering any questions is a very important step in exam room workflow and can help eliminate any barriers to treatment. At this point, the cat is discharged, and it may seem to the client that the visit has ended when the visit actually begins and ends at home (Figure 3.6). An anxious cat returning home from the hospital may be treated differently by other cats in the household. The cat smells different from its housemates and can be perceived as a threat. Keeping the cat in the carrier and gradually introducing it into the household is advised [6]. It is also helpful to provide several different formulations of medication such as tablets, suspensions, or transdermal gels to make administering medication more successful. Discussing options with the client before dispensing will allow them to pick the formulation that they wish to administer at home. Many drugs may need to be compounded to provide dosages that are appropriate for the feline patient. Compounding can improve palatability and increase compliance. For these reasons, it is important the hospital has a good relationship with a compounding pharmacy. A follow-up phone call by a trained staff member should take place the day after the appointment to check the cat's status and to see if the client has any concerns. More information can be found in Chapter 5: "Client Education and Communication Topics for the Feline Patient."

3.4 The Treatment Room

The treatment room of most veterinary hospitals is usually the hub where much activity takes place. Several animals of different species may be receiving treatment at the same time in a small space. It can be a noisy and stressful place. This can contribute to a very nonfriendly feline environment. Providing a quiet space away from others is important when treating feline patients. Ideally, treatments should be performed in the exam room whenever possible. It can be challenging in a busy multispecies hospital to find a quiet, nonstressful space in the treatment room. The use of a mobile screen divider to create a more private space is a creative idea. Other creative ideas include using other areas such as radiology, special procedure rooms, or an empty hospital ward to complete treatments if an exam room is not available.

3.5 The Surgical Suite

The correct care and handling of the feline surgical patient can greatly enhance the feline experience. This includes minimizing stressors before, during, and after surgery. Keeping the cat separate from other animals, along with providing comfortable, familiar bedding, can help create a calm environment both pre- and post-operatively. Minimize noise by speaking in low voices and keeping music at a low level in the area. Creating a treatment plan that includes multi-modal pain management perioperatively is important. Providing thermal support can be accomplished using heated towels, warm air, or warm water circulating devices. Maintaining a calm, quiet space in these areas away from other species and providing adequate pain management and thermal support are all ways to minimize stress for the surgical patient [7].

3.6 The Hospitalization Ward

Important considerations in a hospitalization ward for a feline patient include the following. Provide a safe space away from other species. Enclosures should not be facing any other animals. The enclosure should be made of material that is easy to clean and disinfect and should be large enough to accommodate places to hide and a litterbox away from food, water, and bedding. It should also include a shelf elevated off the cage floor. Many cats feel more comfortable on an elevated platform. Creative ideas for hiding spaces include cardboard boxes, plastic buckets, kitchen shelf organizers, or the cat's personal carrier. A towel can be placed in front of the box to provide a place for the cat to hide. Encourage clients to provide food and bedding from home. Smells from home can help the cat feel safer and comforted and can help reduce stress.

Providing thermal support in enclosures can be comforting. The enclosure should be large enough so that the patient can move off the heat source if needed. It is important that items used to provide thermal support be safe for the patient. Electric blankets are not recommended due to the risk of thermal burns. The use of synthetic feline pheromone diffusers in the room is also helpful. Feline-friendly music and lower lighting in wards are another way to enhance the feline experience. Feline-friendly music is also known as "cat specific music." It consists of a classical style with a tempo and pitch that is pleasing to cats. Speakers preloaded with feline-friendly music are commercially available (Figures 3.7, 3.8, 3.9, and 3.10). See Figure 3.11 for a detailed list of important feline-friendly ideas that can be implemented in hospital workflow and design.



Figure 3.7 Feline-friendly hospital design including single-facing enclosure banks to minimize ocular stimulation. *Source:* Jan Yaroslav.



Figure 3.8 Example of a feline-friendly enclosure. 1. Provide an elevated area in the enclosure. 2. Provide a hiding spot. 3. Provide a porthole to keep the litterbox separate from other areas. 4. Provide comfortable bedding. *Source:* Jan Yaroslav.



Figure 3.9 Example of providing comfortable bedding for the patient to hide. *Source:* Jan Yaroslav.



Figure 3.10 Example of using the patient's carrier in the enclosure to provide a safe space. *Source:* Jan Yaroslav.

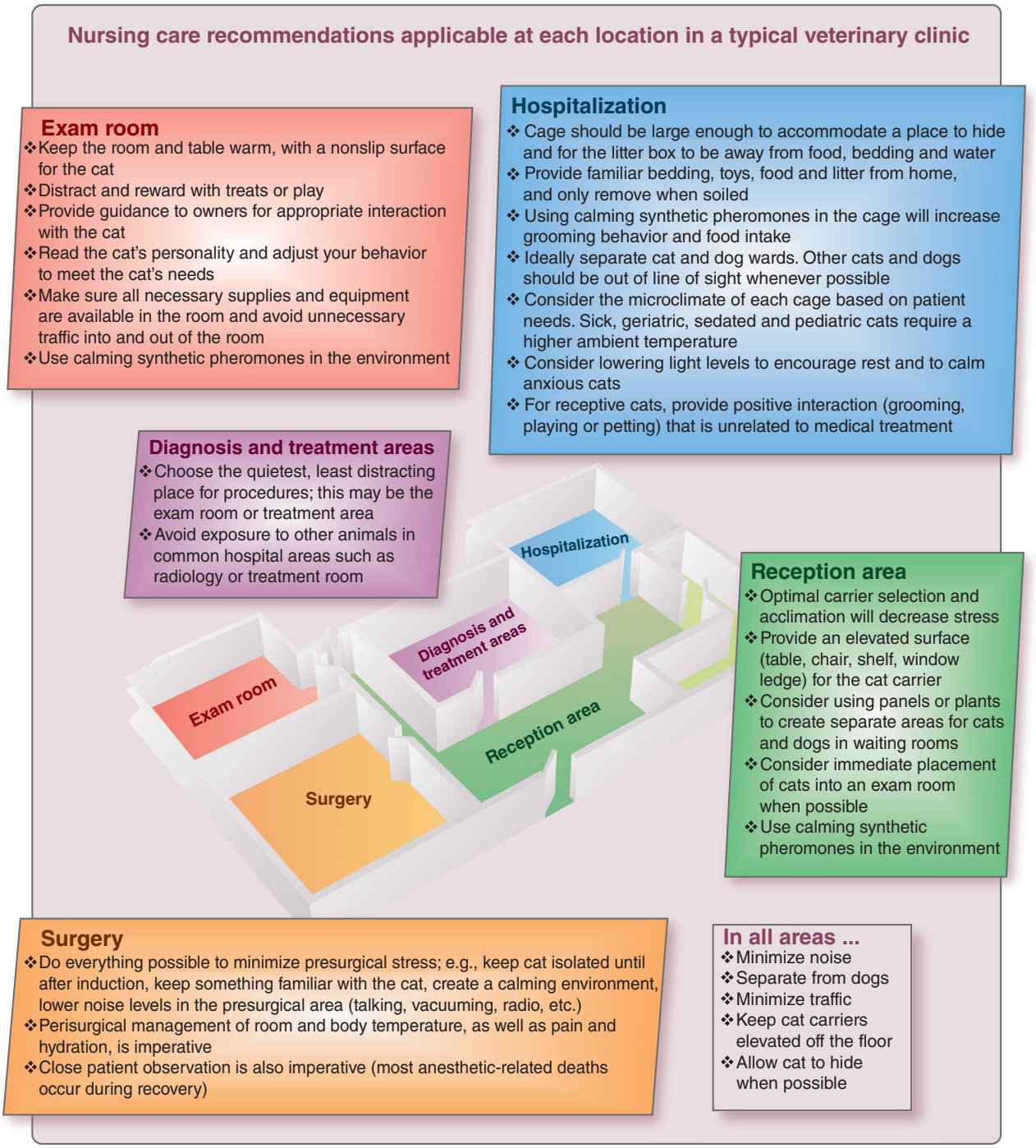


Figure 3.11 Nursing care recommendations at each location in the veterinary hospital. *Source:* Reprinted with permission from the Feline Veterinary Medical Association. AAFP and ISF Feline-friendly Nursing Care Guidelines.

3.7 Training the Team

Preparing the veterinary hospital for the feline patient is a team effort. It is helpful to identify the "cat whisperers" on your team when developing and implementing a feline-friendly training program. They enjoy working with feline patients and are cat advocates. These team members function in a leadership role and will participate in training others.

The customer care representative is the first point of contact for most clients when they call the hospital to schedule an appointment. This phone call sets the tone for the upcoming visit. This team member's duties include greeting the client with care and consideration and providing information on what to expect at the visit. It is important that they receive training in topics such as carrier acclimation and feline-friendly resources so that they can address any questions that the client may have. They are also responsible for the client–patient experience when they are in the reception area.

The veterinarian plays an integral role in the client–patient experience. They must possess good communication skills and feline medical expertise. It is also important that they be trained in feline behavior, handling, and environmental needs to support other team members.

The veterinary technician's role is key in providing a feline-friendly client–patient experience. Important traits for the feline veterinary technician include treating both patients and clients in a calm and caring manner. They possess a high level of veterinary medical expertise and mastery of many feline nursing care skills. It is important that they receive training in topics such as feline behavior, the environmental needs of cats, feline-friendly handling, nursing care skills, and client communication. They are responsible for the patient's experience while at the hospital and are an important resource for the client when they return home.

The veterinary assistant's duties include assisting the technician or doctor with handling the patient using feline-friendly handling techniques, patient care, and client communication. They may spend more time with the patient than other team members. It is important that they receive training in patient care in all areas of the hospital. Having sharp observation skills and knowing when to ask for help are imperative skills for the veterinary assistant. They often fill more than one role and are trained as customer care representatives as well.

3.8 How to Become a Cat Friendly Practice®

The Feline Veterinary Medical Association's Cat Friendly Practice® Program was launched in 2012 to support and educate veterinary professionals on the development and implementation of Cat Friendly techniques in their practices. The Cat Friendly Practice® Program provides two levels of practice designation consisting of silver for those achieving basic standards and gold for those achieving optimum standards. It is free to practice with at least one FeVMA member. The program was designed for any practice type whether it be companion animal, mixed animal, or feline only. The program provides guidance and creative solutions to help any practice achieve the standards for designation. It does not require massive remodeling of the facility. The process of becoming a Cat Friendly Practice® includes completing an application, a checklist for self-assessment, and submitting photographs of the facility. The checklist guides the applicant through the requirements for the veterinary premises, veterinary medicine standards, patient care and handling, and team training. Practices that achieve the Cat Friendly Practice® designation are required to re-apply every 3 years [8]. The FeVMA also offers three cat-friendly certificates with three different levels. The program is called the Cat Friendly Certificate Program and discounts are provided to FeVMA members. All team members can complete the certificate program. The categories are Cat Friendly Veterinarian® (CFV) for DVM's, Cat Friendly Veterinary Professional® (CFVP) for veterinary technicians, and the Cat Friendly Veterinary Advocate (CFVA) for assistants, front office staff, and practice managers. Each team member is required to complete an online course of modules to complete the certification. FeVMA student members within the FeVMA Student Chapter receive complimentary access to the certificate program [9].

3.9 Resources for Veterinary Professionals

- FeVMA Cat Friendly Recognition Program available from: https://catvets.com/cfp/cat-friendly-recognition-programs
- FeVMA Cat Friendly Certificate Program available from https://catvets.com/cfp/cat-friendly-certificate-program/
- ISFM/AAFP Cat Friendly Veterinary Environment Guidelines. JFMS. 2022; Vol 24: 1133–1163. Available from: https://journals.sagepub.com/doi/epdf/10.1177/1098612X221128763 AAFP Practice Guidelines supplemental information including videos and webinars available from: https://catvets.com/guidelines/practice-guidelines/cat-friendly-veterinary-environment-guidelines
- 2022 AAFP/ISFM Cat Friendly Veterinary Interaction Guidelines Approach and Handling Techniques. JFMS 2022; Vol 24: 1093–1132. Available from: https://journals.sagepub.com/doi/epdf/10.1177/1098612X221128760. AAFP Practice Guidelines supplemental information including videos and webinars available from: https://catvets.com/guidelines/practice-guidelines/cat-friendly-veterinary-interaction-guidelines

- AAFP and ISFM Feline-Friendly Nursing Care Guidelines. JFMS. 2012 Volume 14 Pages 337–349. Available from: https://journals.sagepub.com/doi/pdf/10.1177/1098612X12445002
- Client Brochures for Caregivers available from: https://catvets.com/guidelines/client-brochures

3.10 Resources for Clients

- https://catfriendly.com/cat-owner-resources/
- Getting Your Cat to the Veterinarian. https://catfriendly.com/be-a-cat-friendly-caregiver/getting-cat-veterinarian/

The goal of creating a feline-friendly hospital environment is a team effort that will reduce stress for the patient, client, and staff members. Excellent resources and support are available to any hospital that is striving to become feline-friendly. Implementing changes in hospital design, workflow, client communication, and team member training are easy and cost-effective ways to achieve this goal.

See companion website for further clinical references.

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9 AAFP Cat Friendly Certificate Program 2024 available from https://catvets.com/cfp/cat-friendly-certificate-program/.

4

Life Stage Considerations

Ann Wortinger BIS, LVT, VTS (ECC) (SAIM) (Nutrition), Elite FFCP

TECHNICIAN TIDBITS

- Primary socialization occurs between 2 and 7 weeks of age.
- All deciduous teeth are present by 6 weeks.
- All permanent teeth are present by 24 weeks.
- Training for cooperative care can begin as kittens.
- After neutering, a cat's energy needs decrease by 25%.
- Arthritic changes can be seen as early as 7 years of age.
- Seventy-four percent of cats older than 11 years show signs of degenerative joint disease.
- Pain scales can help to identify subtle signs of pain.
- Frailty scales can predict adverse clinical outcomes.
- The ideal body condition score is 3 of 5 or 4 of 9.

For many of us, we will see cats from their kittenhood through geriatric years. Some may even be involved with neonates and kittens who have yet to be weaned. This chapter will look at the different physiological and behavioral changes that occur as cat's transition from one life stage to another.

4.1 Kitten

The American Association of Feline Practitioners (AAFP) and the American Animal Hospital Association (AAHA) Feline Life stage Guidelines designate cats from the ages of birth to 6 months as kittens [1]. Most of us get our first glimpse of kittens around 8 weeks of age when they present for their first exams and vaccinations. However, there is a lot of growth and development occurs before we first see them.

Those who work in shelters, rescues, and with breeders will have exposure to younger kittens than are seen in general practice. From 0 to 2 weeks is seen as the neonatal period, where kittens are just learning to orientate to sounds, and competition for rank and territory begins. At the end of this period, the kitten's eyes will begin to open [2]. At this age, separation from their mother and littermates can lead to poor learning skills and aggression toward people and other pets, as they age [2]. A lot of early learning and acceptable behavior is beginning to be taught to each kitten in a litter at this age, and without this enforcement, we can see behavior problems. These can be seen most commonly in singletons who are hand-reared by humans and do not have their bad behaviors corrected by a mother or sibling.

From 2 to 7 weeks of age is the primary socialization for kittens. For kittens not raised around people or in quiet houses, this can pose problems later in life, when they have not had a varied number of experiences during this socialization period [3]. By the third week, their sense of smell is well developed, and they can see well enough to find their mother. By the fourth week, their sense of smell is fully mature, hearing is well developed, and their deciduous teeth will begin to erupt. They will start interacting with their littermates and are beginning to walk fairly well [2]. All of their deciduous teeth should be in by the end of week 6, making aging young kittens slightly easier [4]. Delayed tooth eruption can be related to malnutrition, disease, and stress and cannot be used as a hard and fast aging technique (Table 4.1). From the fifth to seventh weeks, they can right themselves, place their feet precisely, avoid obstacles, stalk, pounce, and play with toys. They will begin to groom themselves, and their littermates (Figure 4.1).

Table 4.1 Approximate eruption schedule for teeth in cats.

Teeth	Deciduous	Permanent
Incisors	3–4 weeks old	11–16 weeks old
Canine	3–4 weeks old	12–20 weeks old
Premolars	5–6 weeks old	16–20 weeks old
Molars	–	20–24 weeks old



Figure 4.1 Kevin, a 7-week-old foster kitten, who we had already had for 3 weeks. *Source:* Ann Wortinger.

The time period from 7 to 14 weeks is their most active play period. Play with objects and siblings increases as their physical coordination and motor skills increase. Social play with siblings and others can include belly-ups, hugging, ambushing, and licking. Object play can include scooping, tossing, pawing, mouthing, and holding. As they dash around their environments, there will be tail chasing, pounding, leaping, and dancing [3]. All of these activities serve to strengthen their muscles, coordination, and social bonds. This is usually the age at which kittens will leave their mothers and siblings and move into their forever homes.

Kitten vaccinations are timed to allow for two vaccines to occur after the decline in maternally derived antibodies (MDA). The vaccines given will depend on whether the kitten obtained MDA, their current exposure levels, and their living situation. The earliest age a kitten should be vaccinated is 4 weeks old, with vaccines administered every 2–4 weeks through 16–18 weeks old [5]. See Chapter 9: "Feline Immunology and Current Vaccination Guidelines," for further information.

Beginning around week 11, a kitten's deciduous teeth will start falling out, and their permanent, adult teeth will begin to appear. Typically, the incisor teeth are the first to fall out and be replaced, followed by the canines, premolars, and, finally the molars by about 6 months [4].

It is important to socialize kittens to the carrier and travel, as this will become a regular part of their lives as their routine vaccinations will require regular visits to the clinic [1]. The consequences of negative associations with the carrier, travel, and ultimately the veterinary clinic can last for the cat's entire life [6]. All it takes is one traumatic visit to set the tone for the rest of cat's life. The AAFP Feline Behavior Guidelines recommend the use of minimal restraint and distraction,



Figure 4.2 Jack, a foster failed at 4 months old. While Jack has the ticked coat consistent with an Abyssinian, his littermates were tabby, and black and white kittens. *Source:* Ann Wortinger.

preferably with toys or food, during veterinary visits. More information on fear-free and low-stress handling can be found at https://fearfreepets.com and https://cattledogpublishing.com/LSH, as well as in Chapter 1: "Feline Behavior" and Chapter 2: "Feline Friendly Interactions."

As kittens transition into their new homes, there will be many new experiences for them to learn from. This can include new people, new animals, and possibly even new food. If they have been well-socialized, they will transition through this period with ease. However, if they were not well socialized with a mother and siblings, were hand-reared, or raised outside with little human interaction, this transition can be rocky and may set the kitten up for behavioral problems in the future [2].

By 3–6 months, kittens will be most influenced by their siblings (if still present) or their household companions. They will begin to see and use ranking within the household, which may include humans (Figure 4.2).

For information on feeding kittens and when to transition to adult food, refer to Chapter 12: "General Feline Nutrition."

4.2 Junior

Junior cats are those between 7 months and 2 years of age. These cats will usually have been placed in a stable household, have received all of their kitten vaccines, may or may not be neutered, and all of their adult teeth should be in.

If neutering has not already been done, this is an excellent time to discuss the topic. With males, the strong urine smell as they mature will usually persuade owners to neuter their pets. With females, if desired, and able to control access to intact cats, the owners may want to wait until after the first heat cycle. Those owners who have not experienced a female cat in heat may change their minds once their pet goes through their first heat cycle [1]. Remember, that caloric requirements decrease by ~25% immediately after neutering, and we need to remind owners that the amount that they are feeding will need to be decreased, to help prevent future obesity [1]. When figuring out daily energy requirements (DER), refer to Chapter 12: "General Feline Nutrition," for the formulas to use. Often, the Life Stage Factor will decrease from 1.2 to 1.0 after neutering.

This is an excellent age to begin training for cooperative care, including basic handling and commands [1, 6]. Ensuring that kittens and ultimately adult cats will willingly allow owners to perform toenail trims, and basic grooming tasks, as well as making them comfortable with basic handling such as looking in the mouth, the ears, and full body exams, can help keep the cat comfortable and ensure a higher level of compliance from their owners, as they will not be dealing with a fearful cat [6].

Because these cats are close to or at their full adult size, this is a good opportunity to discuss the proper sizing for litter boxes with owners. The current recommendation is, at a minimum, 1.5–2 times the size of the largest cat, with one litter box per cat in the house, plus one [1, 7]. Many commercially available litter boxes are too small to comfortably accommodate a full-grown adult cat. Good options include large storage containers, commonly available at hardware stores. An opening can be cut into a side to allow easy entry and exit from the box [7]. A utility knife, small hand saw, or jigsaw can be used for this purpose (Figure 4.3).

With the wide variety of litter available commercially, remember that the ultimate choice lies with the cat, not the owner. Most cats prefer unscented, clumping litter that is cleaned daily [1]. The box should be located in an accessible location that does not receive a lot of traffic. Many owners will opt for a basement location. As long as the cat can access the stairs and the box is cleaned frequently, this is not usually a problem, though this is an unrealistic expectation for very young and older cats with size and mobility issues [1].

The AAHA/AAFP recommends booster vaccines between 6 months and 1 year, though boosters can be given sooner if the cat is entering a high-risk or stressful situation, such as boarding or traveling [5].



Figure 4.3 A converted storage tote used in the author's foster kitten room. Typically, by the time the kittens are 7 weeks old, they can easily access the litter box. Notice the pheromone diffuser is also located in this room. *Source:* Ann Wortinger.

4.3 Prime

Cats in their prime life stage are between 3 and 6 years of age. They are fully grown adults, usually neutered, and have settled into their lives [1]. Often, we will only see these cats when they need routine preventative care or when they are sick.

As the current AAHA/AAFP vaccine recommendations are for every 3 years after their first booster, we will likely not see these cats for vaccines. However, it is still important for clients to bring in their healthy, stable, well-vaccinated cats to ensure we have a baseline for weight, BCS, and blood work for these cats [1].

For cats with the potential for routine exposure to FeLV through their living situations, or for those who are allowed outdoors unsupervised, revaccination is recommended every 2 years [5].

As cats mature, it is important to ensure they have adequate environmental enrichment that will accommodate their full adult size and weight [1, 7]. Lots of climbing and perching structures, which allow for free movement without competition for space, are important, especially in multi-cat households. Cats will have individual preferences for where they want to stretch and sharpen their claws. To ensure that the cat uses the preferred structures over less desirable ones, ensure that the type of material is available for the cat [7]. While scratching posts and climbing structures may not have the aesthetic the owners want, these must be located in an area where the cat frequents, such as family and living rooms [7]. Figures 4.4 and 4.5 are in the author's family room and show multiple climbing structures connected by walking platforms. All cats in the house regularly use these runways, including the author's blind cat.



Figure 4.4 A carpet-covered climbing structure was placed to allow easy access to the walking platforms. The uppermost platform extends over the French door and around to another resting structure. *Source:* Ann Wortinger.



Figure 4.5 The walking platform ends at another resting area, with a 6-foot-tall, sisal-wrapped pole for climbing and clawing. *Source:* Ann Wortinger.

Routine dental care and routine dental assessments are extremely important in preventing painful gingivitis and other oral diseases [1]. Often, the only indication that there is a problem is either an offensive smell from the mouth that the owner is concerned about or an unexpected weight loss due to pain while eating. Including routine oral care and teaching clients how to perform a basic oral exam during their cooperative care routines can help prevent bigger problems from occurring in the future [1].

4.4 Mature

Mature cats are healthy cats aged 7–10 years [1]. As with those prime-aged cats, routine health care and feeding need to be continued. Some arthritic changes may start to be seen at this age [8]. Changes related to chronic pain can be difficult to differentiate from behavioral changes as a result of aging [9]. There is no gold standard method for assessing pain in cats; however, there are multiple pain-scoring tools for both chronic and acute pain. The use of these pain-scoring tools can decrease subjectivity and bias by owners and the veterinary team, which ultimately leads to better patient care [8]. As cats are nonverbal, especially regarding pain, it is safe to assume that if a condition found in a cat would be painful to a human, it is also painful for the cat, regardless of whether the cat is indicating signs of pain [9]. Doing a trial of analgesic medications to assess the cat's response is appropriate and will often yield dramatic results [9].

Multimodal pain management is the best option and can involve the use of stairs and stools to make accessing favorite spots easier. Figure 4.6 shows the stairs provided to the resident cats by the author's desk. This help save the author's shoulder from lifting cats who want onto the desk or lap, but also allow the older cats access where it may not have been possible before.

If pain is suspected or confirmed, it may be helpful to reassess the litter box location and access. Using a storage tote can help lower the opening so that there is easier access [1].

With the increased incidence of arthritis, weight management becomes even more important at this age. Switching from a maintenance diet to a lower-calorie, lower-fat food can help prevent obesity related to decreased activity [1] (see Figure 4.7).



Figure 4.6 Poppy, 11 years old, using the stairs located in the author's office for easier access to the desk and lap. *Source:* Ann Wortinger.



Figure 4.7 Gimli was adopted at 7 years old and weighed over 20#. We were able to get him down to 15#. Here, he is 10 years old. *Source:* Ann Wortinger.

Starting disease screening tests as cats age can help find diseases in their earlier stages when interventions are easier and may be more effective. We know that older cats are more susceptible to diabetes mellitus, hyperthyroidism, chronic renal failure, and arthritis [1]. Refer to Section 3 of this book for individual disease management.

4.5 Senior

Our senior cats are those between 11 and 14 years old [1]. At this stage, we are looking at increased disease screening tests, more frequent assessments for chronic pain, and potentially more living condition adjustments to accommodate age- and disease-related limitations [1].

Degenerative joint disease affects up to 74% of cats over the age of 12 years. [11] This disease is multifaceted, and peripheral and central changes can result in maladaptive pain. Many cats go undiagnosed and are therefore left untreated. Asking the client specific questions about mobility and activity can help identify a lot of these cats. Once identified, this is a lifelong condition, with no cure. Treatment is multimodal and can be complicated by the existence of other disease processes [11]. Refer to Chapter 7: "Analgesic Considerations for the Feline Patient," for additional information on analgesics.

We will have begun educating clients about what to look for with age- and disease-related changes so that they can be brought to our attention sooner rather than later. Weight loss, specifically related to cachexia, is important to monitor. For more specifics on cachexia, refer to Chapter 12: "General Feline Nutrition."

Continuing to monitor oral health is important, along with the additional evaluation for the presence of oral tumors [1]. We may see these cats more often for disease management than we would with our mature cats. Continuing to offer cooperative care and fear-free handling can make future management easier on both the cat, but also the owner, and the veterinary team. If the disease process allows, the use of previsit prophylactic medications may be helpful [10].

4.6 Geriatric

With improvements in veterinary care, indoor lifestyle, and nutrition, we are seeing more geriatric cats than ever before [11]. These are cats over 15 years old. Many of the changes that are seen in our geriatric cats are subtle, we need to enlist the owner's help in noticing these and bringing them to our attention. Signs include decreased grooming, or an increase in an unkempt appearance, especially in a cat who had previously been fastidious in their grooming, increased or unusual vocalizations, and changes in interactions with other animals and people, especially those in the family [11]. Changes in sleeping behaviors and locations, particularly when a cat is not using their favored spots. Changes in responses to visual and auditory cues, such as the sound of the cat food can opening, or the owner's arrival at the door [11] (Figures 4.8 and 4.9).

Cachexia has been mentioned above but can become a bigger concern as the cat ages, especially when multiple disease processes are involved. While there are no diets developed to address cachexia specifically, the use of therapeutic recovery diets can increase the number of calories the cat can consume daily, as can some of the over-the-counter diets for older cats. The calorie content of the diets must be checked, because not all senior or geriatric diets have the same calorie density.

When handling geriatric cats, it is especially important to be gentle, as there may be many sources of arthritis, and rough handling or even placing them in an uncomfortable position can exacerbate the pain [11]. In addition to the pain and body condition scores previously introduced, we now have one more scale to use: the Frailty scale [11]. These scales can be used to identify frail geriatric cats and, in humans, can reliably predict adverse clinical outcomes and patient response to therapy and stressors [11]. With increased identification of frailty, we can establish treatment plans, both physiologically and psychologically, for these older cats. There are phenotype fragility scales and an index fragility scale. Both can be helpful, easy to use, and can be used with serial assessments. The Phenotype scale looks at areas, such as unintentional weight loss, muscle weakness, endurance, slowness, and low activity. The Index Frailty Scale looks at physiological deficits, psychological (emotional) deficits, cognitive (task-oriented) deficits, and deficits in social function [11] (Table 4.2).

Slower gastrointestinal transit times may predispose geriatric cats to dehydration and constipation. Asking owners about litter box habits and stool consistency may help to prevent an obstipation visit to the clinic if we can intervene before the problem becomes worse [11]. Chronic dehydration can also predispose the elderly cat to CKD.

Increased or excessive vocalization, altered social interactions, or house-soiling can be associated with cognitive dysfunction syndrome (CDS). In over 25% of cats over 11 years of age, these changes have no recognized medical cause [11]. CDS is a diagnosis of exclusion of medical and environmental causes for the behavior. Treatment can involve environmental changes,



Figure 4.8 Lily in her prime at 7 years old. *Source:* Ann Wortinger.



Figure 4.9 Lily, at 18 years old, had been treated for hyperthyroidism with I131 and has degenerative joint disease and Stage 2 chronic renal failure CRF. Her heated bed helped with the arthritis. *Source:* Ann Wortinger.

Table 4.2 Fragility scales examples.

Phenotype Frailty Scale		
Medical conditions/problems present	**Yes**	**No**
Unintentional weight loss		
Weakness		
Poor endurance, early exhaustion		
Slowness and low activity		
Prefrail: "yes" to 2 of 4	**Frail**: "yes" to 3 or 4 of 4	
Index Frailty Scale		
Medical conditions/problems present	**Yes**	**No**
Physiologic deficits		
Psychological (emotional) deficits		
Cognitive (task-oriented) deficits		
Deficits in social function		
Prefrail: "yes" to 2 of 4	**Frail**: "yes" to 3 or 4 of 4	

supplements, pheromones, and medications. Individualized combination therapy is most effective and can improve brain function, longevity, and owner peace of mind [11].

Ultimately, as the number of concurrent disease conditions increases, we need to look at the related decrease in health-related quality of life concerns. This can be an extremely challenging conversation to have, but if we have been working with the client, hopefully, this will come as no surprise. The occurrence of multiple disease processes, their treatments, as well as physical challenges, need to all be considered. Just because we can do something does not mean it is in the best interest of our patients. When dealing with multiple terminal conditions, setting endpoints ahead of time can guide clients who are unsure of when it is appropriate or desired to stop [11].

Working with the veterinary team, the client will select 2–3 endpoints at which point care will no longer be pursued. These can include anorexia unresponsive to appetite stimulants, pain that cannot be managed at home, in the case of bone cancers, a pathologic fracture, or if the owner is unable to complete the required treatments. Every client will have different skills and conditions, and even though we are there to help, we are not able to perform all of the treatments their cat may require.

It is helpful to discuss hospice and end-of-life options before the actual day arrives. This gives clients time to do research and ask questions. Unfortunately, not all cats allow us time to think and consider before a final decision needs to be made. Ensuring that we have general information available on euthanasia options, cremation places, and burial requirements in your area can help distraught clients.

4.7 Body Condition Scoring

Body condition scoring (BCS) is a subjective assessment of a cat's body fat and to a lesser extent protein stores [12]. As this is subjective, it would be entered under the S portion of a SOAP format medical information. The scoring system considers the cat's frame size independent of its weight. BCS involves both visual and physical assessment through palpation to assess body fat over the rib, abdomen, lumbar area, and tail base [13].

There are two main scoring systems, the 5-point scale and the 9-point scale. Both systems use defined criteria to help make the subjective process of body evaluation more objective, but all subjectivity cannot be removed when assigning a score to a cat. For this reason, the same person must try to assign the score each time the cat is evaluated. The 5-point scale scores the cats to the nearest half score, and the 9-point scale scores to the nearest whole score [12] (Figure 4.10).



Figure 4.10 WSAVA body condition score for cats [14]/World Small Animal Veterinary Association (WSAVA).



Figure 4.11 Daisy, in stage 3 cachexia secondary to cancer. Despite nutritional support with an esophagostomy tube, she continued to lose weight. Her BCS is 2/5. *Source:* Ann Wortinger.

For cats, a mid-range score would be consistent with a body fat percentage of 25–30% [13]. On a 5-point scale, the change in body fat for each increment change is ~10–15% [13]. When trying to detect small changes in body fat, the use of BCS scores would probably not be your best choice, but for monitoring and routine care, it is quick, easy, and painless. BCS are ideally used with body weight measurement, not in place of weighing the animal at every visit. Figure 4.11 shows a cat with a BCS of 2/5. This 12-year-old cat has cancer cachexia. You can easily visualize her prominent hip bones and the spinous processes of the vertebrae. Figure 4.12 is of a cat with a BCS of 5/5+. Her owners were resistant to weight loss attempts, and this cat did develop diabetes before her death.



Figure 4.12 Bootsie, after years of obesity, developed diabetes. Her BCS is 5/5+. *Source:* Ann Wortinger.

4.8 Body Condition Score Uses

A BCS should be recorded with the weight each time a cat is examined. Body weight alone does not indicate how appropriate the weight is for that individual cat. The BCS puts in perspective what an individual animal should weigh [12] (Figure 4.10).

In general, cats with an optimal body condition have:

1. Normal body contours and silhouettes.
2. Bony prominences that are easily palpated but not seen or felt above the skin surface.
3. Intra-abdominal fat that is insufficient to obscure or interfere with abdominal palpation.

Normal BCSs are 3/5 or 4–5/9. When scores are below 2/5 or 3/9, or above 4/5 or 7/9 action should be taken to bring the animal into a more normal BCS [12]. Best practice would dictate that the weight be recorded at every visit to the clinic, a BCS be done at every physical exam and a discussion be done with the client regarding any abnormalities at every visit [13].

Just because an animal scores a 5/5 or a 9/9 does not mean that this is the maximum size or weight that this animal can attain. Animals can be scored as a 5/5+ or 9/9+ if morbid obesity is present. There is no "maximum" amount of body fat compatible with life [12].

Using BCS is an effective means of monitoring an animal's condition as well as its' weight and is something that can be easily learned by most pet owners and done at home. By teaching clients how to do this, our assessment should come as less of a surprise to them and make them involved in maintaining a healthy weight for their cats. This should be instituted early on in the client/patient/veterinary team relationship so that we can prevent obesity and all of the associated problems.

4.9 Diagnostic Techniques

With our kittens and younger adult cats, testing for retroviral diseases (i.e., feline leukemia virus and feline immunodeficiency virus) is routine, and may need to be done repeatedly, if discordant results are obtained. If housed indoors without the chance of repeated exposures, once tested negative, they may not require additional testing. These tests are routinely done in-house but may require additional testing at a reference lab. See Chapter 24: "Infectious Diseases," for further information regarding retroviral diagnostic methods.

For kittens, young adults, and cats with routine access to either the outdoors or prey, routine fecal testing is required. While still routinely done in-house, many clinics will send these to a reference lab.

Being comfortable with and able to perform the various evaluation scales is important to ensure they are being utilized correctly. We have discussed the use of pain scales, which can be used at any age, as can BCSs. The Frailty scales are usually reserved for our geriatric cats but may be utilized, if necessary, on any age of the cat.

Depending on the life stage of the cat that we are working on, we may need to consider their growth and development as well as enrichment needs, or we may need to consider environmental adjustments to ensure the cat and the owner can age comfortably in place. We are extremely lucky in that we can often see our patients from their first kitten visit to their final visit and have the opportunity to continue to work with our clients through multiple pets. The more we learn about cats and aging, the more we can offer to our cats and our patients.

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5

Client Education and Communication Topics for the Feline Owner

Christina M. Daigle, LVT, VTS (CP-C/F)

TECHNICIAN TIDBITS

- Using direct eye contact, speaking in a positive tone, and empathetic listening will provide owners with the confidence that you care about their pet.
- When obtaining a medical history use open-ended questions to prevent information being missed.
- Communicating educational material and resources to owners in the form of verbal, written, and audio-visual materials will set owners up for success when managing their cat's condition.
- Encouraging an owner to keep a log of their cat's daily routine can be a tool to use when evaluating disease management at home.
- Providing frequent communication with an owner will provide them with the support needed to successfully manage their cats' needs at home.

Veterinary technicians have an important role to provide owners with the resources and knowledge to manage their cat's health during its lifetime [1]. Educating and communicating effectively builds relationships with pet owners and provides a positive veterinary experience [2].

Skills required include observing and listening, reinforcing and encouraging, questioning and responding, and relaying the appropriate required information when communicating. A veterinary practice can be a busy environment, so having the ability to actively listen to a concern is vital when working with pet owners [3]. Applying these skills will provide the best education and veterinary care for their pet [2].

Veterinary technicians provide owners with realistic goals when handling their cat's medical needs at home. Client education can include recognizing changes with a disorder, care that can be provided at home, and answering common questions about a pet's condition. Owners having access to a skilled veterinary technician that can answer questions about their cat's health will provide great value to their veterinary experience [4].

5.1 Types of Communication

When medical recommendations are made for the benefit of a pet, it must be communicated in a way it can be comprehended and understood. Building a relationship with an owner begins with that first phone call made for the appointment and continues in the examination room. During an exam, provide owners the opportunity to reveal their story at the beginning of every appointment. If a story is not told, simply asking questions before any recommendation is given to create a connection and increase trust. Providing verbal, nonverbal, and paraverbal communication along with reflective and empathetic listening will play an essential role when communicating with a pet owner [2].

5.1.1 Nonverbal Communication

Nonverbal communication can be conveyed through our body language in a negative and positive manner. Avoiding eye contact, leaning away, arms crossed, frowning, and yawning can be perceived to pet owners negatively and being disengaged in the conversation. Providing occasional eye contact, leaning forward slightly, smiling, arms uncrossed, and empathically listening creates a positive interaction with being engaged with the pet and owner [2].



Figure 5.1 A positive interaction can be conveyed through the use of body language. Providing eye contact, leaning forward, smiling, and engaging with their pet while communicating will be perceived as being engaged with the conversation. *Source:* Christina Daigle.

5.1.2 Paraverbal Communication

Fluctuations with your tone of voice can have a positive or negative effect on a conversation with a pet owner. It is important to communicate words not jumbled and spoken clearly. Speaking abrupt and short with your tone can be considered rude and received negatively. Being monotone in your message can portray being bored and detached from the conversation, and the pet owner will likely be distracted by something more stimulating in their environment [3]. Having an energetic tone of voice proves being competent and confident. It demonstrates to owners that you have an attentive attitude and really have their cat's best interest in mind [2].

5.1.3 Reflective and Empathic Listening

Active and reflective listening skills make up the majority of the communication process. It offers reassurance by providing direct eye contact and acknowledgment. When in a conversation, allow the owner to finish talking. Reflecting back what was mentioned will acknowledge that you understand the information provided about their pet. When reflectively listening, important details to a pet's medical history can be obtained when you understand what was communicated [4].

How much you care about a situation is expressed when using empathetic listening skills. You may not necessarily agree with what is said by a specific individual, but you recognize that they have an opinion. When acknowledged, they feel appreciated for their views being understood. Only after this has happened, will recommendations be able to be provided for their specific needs and wants. Understanding each situation owners are experiencing with their pet will allow you to provide the best medicine and service [3] (Figure 5.1).

5.2 Obtaining a Medical History

Wellness exams are customized based on behavioral and physical changes during each feline life stage. Early identification of medical or behavioral concerns can be detected when using "open-ended" questions when obtaining a medical history [5]. A treatment or wellness plan is compiled from many factors from a patient's life stage. Preventative wellness care and treatment requirements change as a cat ages. The "AAHA/AAFP Feline Life Stage Guidelines" offer considerations for each life stage to ensure a cat lives a long healthy life [1]. Questions are customized based on each life stage, so the appropriate care recommendations and client education topics are discussed at the time of the exam [1] (Table 5.1).

Table 5.1 General topics of discussion for all feline life stages during wellness exams.

Wellness Exams Recommended Yearly (Birth to 7 years) **Every 6 months for senior cats (>10 years)**
• Discuss normal behavior and how to identify changes.
• Spay and neutering.
• Acknowledging signs of discomfort, illness, and anxiety.
• Discuss other cats in the household, interactions, and possible changes in behavior, resources.
• Nail care, scratching behaviors, and declawing alternatives.
• Housing (indoor/outdoor/partial outdoor access).
• Exposure to children or other pets.
• Financial planning for medical care and pet insurance.
• Disaster preparedness.
• Environmental enrichment (e.g. scratch posts, toys, play, and resting locations).
• Carrier acclimation and significance of preventive care.
• Review medications, supplements, surgical, and medical history.
• Microchipping and other identification options.
• Consult about diet, feeding regimen, and other diet recommendations.
• Inquire about daily food and water consumption.
• Management of unwanted behaviors and positive reinforcement.
• Assess temperament and character, review considerations for upcoming veterinary exams.
• Elimination behaviors and address house-soiling issues.
• Vaccine protocols dependent on age when initially vaccinated, state regulations, individual risks and benefits, and current vaccination guidelines.
• Review core vaccinations (feline herpesvirus-1, feline calicivirus. feline panleukopenia virus, rabies virus).
• Evaluate quality of life when applicable.

Considerations based on various feline life stages direct specific attention on physical, behavioral, and medical changes that progress over a cat's life. It is important that veterinary team members can recognize variances in each feline life stage. Using a detailed question template as a guide during an appointment may be helpful, so specific questions are addressed [1]. Using open-ended questions like, "Do you have any concerns with [cat name] today?" or "I understand that [cat name] activity level has decreased, when did you notice the change?" will ensure no applicable information was missed about their cat's health. Providing education on each life stage and what is considered to be normal behavior will inspire cat owners to be aware of changes in their cat's overall health and pursue medical care to address the issue [1] (Table 5.2).

Feline life stages should be reviewed at every veterinary visit to educate owners on important health-related issues that may arise as their cat ages. Providing current recommendations will improve overall compliance of care and strengthen the veterinary–client–patient relationship [1] (see Chapter 4: "Life Stage Considerations," for further reading).

5.3 Home Environmental Factors

Addressing a cat's environmental needs at the time of a wellness exam can prevent environmental stressors that may create undesirable behaviors in future. A cat's behavior needs change during various life stages and should be reviewed frequently with owners [5] (Table 5.3).

5.3.1 Feline Enrichment

Resources such as scratch posts, cat trees, and perches allow cats to exhibit normal behavior by increasing the overall space and encouraging climbing and resting in their home environment. Multicat households should provide various hiding spots and litter box locations. Toys that encourage hunting games can prevent boredom and provide additional environmental enrichment. Client communication on enrichment should be provided verbally, written in the form of handouts, and educational media. Desired behavior should be reinforced with a reward in the form of a treat or play and unwanted behaviors should be redirected [5].

Table 5.2 Topics of discussion based on feline life stage (0 to >10 years) [1, 5].

Topics of discussion for feline life stages (0–6 years)

	Kitten (0–1 yr)	Young Adult (1–6 yr)
Medical history	• Congenital and genetic concerns • Specific breed health and predispositions	• Changes in grooming habits and behavior • Vomiting/diarrhea
Nutrition and weight management	• Review quantity fed, type of diet, and amount consumed. • A variety of textures and flavors introduced. • Offer food puzzles. • Regular assessment of weight and body condition.	• Discuss environmental enrichment to encourage exercise and play. • How to assess weight changes and the risks of obesity
Behavior and environment	• Socialization period – introduce to other people and pets. • Carrier acclimation and positive veterinary visits. • Review handling (nail trimming, grooming, medicating) • Positive reinforcement and training. • Prevent the risk of aggression by discouraging the use of feet and hands during play.	• Any change in human/cat relationships due to possible stressful events. • Touching and manipulating ears, mouth, and feet with gentle handling to aid in acceptance. • Discussion on the possible decline of intercat interactions.
Elimination	• Litter box location, set up, and cleaning regiment. • Offer a variety of litter types to allow kittens to choose their preference. • Normal elimination behaviors. • Ask about elimination habits and marking behaviors. • Differentiate if urination or defecation occurs outside the litter box.	• Verify litter box size (height and length) to allow for growth. • Cleaning regiment, litter type, location, and number of litter boxes. • Ask about elimination habits and marking behaviors. • Differentiate if urination or defecation occurs outside the litter box.
Oral health	• Preventative care and dental prophylaxis. • Discuss dental home care (toothbrushing). • Familiarize kitten to mouth handling for toothbrushing and teeth wiping. • Dental disease and treatment.	• Dental diet if indicated. • Preventative care and dental prophylaxis. • Discuss dental home care (toothbrushing). • Dental disease and treatment.
Parasite control	• Exposure evaluated by geographic location, travel, and lifestyle. • Educated owners regardless of housing status (indoor/outdoor) broad-spectrum antiparasitic recommended yearly. Review effectiveness against fleas, heartworms, intestinal parasites. • Review zoonotic risks. • Discuss the importance of fecal exams and frequency dependent of lifestyle factors.	
Vaccination	• Review vaccination protocols and continue or complete the series. • FeLV vaccine considered core future lifestyle unknown.	• Discuss vaccination history. • Review vaccination protocols and continue or complete the series. • Ongoing FeLV vaccine-based risk exposure.

Topics of discussion for feline life stages (7 years and older)

	Mature adult (7–10 years)	Senior (>10 years)
Medical history	• Discuss current grooming habits, behavior, mobility, and activity. • Polyuria/polydipsia/vomiting/diarrhea • Changes in appetite or water consumption.	• Discuss current grooming habits, behavior, mobility, activity, vision, and vocalization. • Polyuria/polydipsia/vomiting/diarrhea • Changes in appetite or water consumption. • Review cognitive dysfunction. • Presence of masses

Topics of discussion for feline life stages (7 years and older)		
Nutrition and weight management	• Monitor weight and body condition (weight loss or gain). • Discuss therapeutic diets if suitable. • Review appetite and weight changes that may be correlated to disease.	• Monitor weight and body condition (weight loss or gain). • Discuss therapeutic diets if suitable. • Review appetite and weight changes that may be correlated to disease.
Behavior and Environment	• Easy accessibility to food, water, soft bedding, and litter box. • Provide client education on recognizing behavior changes.	• Easy accessibility to food, water, soft bedding, and litter box. • Provide client education on recognizing behavior changes. • Review quality of life issues.
Elimination	• Verify litter box size (height and length) so the cat can enter easily. • Review litter box cleaning regiment. • Ask about elimination habits. • Differentiate if urination or defecation occurs outside the litter box. • Review locations of the litter box (avoid stairs for cats with decreased mobility).	• Verify litter box size (height and length) so the cat can enter easily. • Review litter box cleaning regiment. • Ask about elimination habits. • Differentiate if urination or defecation occurs outside the litter box. • Review locations of the litter box (avoid stairs for cats with decreased mobility).
Oral Health	• Preventative care and dental prophylaxis. • Discuss dental home care (toothbrushing). • Dental disease and treatment. • Assess for oral tumors, inability to eat due to dental disease, changes to quality of life	• Preventative care and dental prophylaxis. • Discuss dental home care (toothbrushing). • Dental disease and treatment. • Assessing for oral tumors, inability to eat due to dental disease, changes to quality of life.
Parasite control	• Exposure evaluated by geographic location, travel, and lifestyle. • Educated owners regardless of housing status (indoor/outdoor) broad-spectrum antiparasitic recommended yearly. Review effectiveness against fleas, heartworms, intestinal parasites. • Review zoonotic risks. • Discuss the importance of fecal exams and frequency dependent of lifestyle factors.	
Vaccination	• Resume core vaccination regimen to current guidelines. • Consider risks and benefits when vaccinating senior cats due to overall health status.	• Resume core vaccination regimen to current guidelines. • Consider risks and benefits when vaccinating senior cats due to overall health status.

5.3.2 Nail Care

Cats use their claws to mark their territory, stretch, transfer their scent, and condition nails. Coarse fabric, wood, and sisal rope are materials often favored for scratching. A variety of scratching surfaces and textures should be offered. Tall and sturdy vertical surfaces are preferred because it allows cats to fully stretch while scratching. Horizontal surfaces should be provided for cats that enjoy scratching carpeting. Toys, treats, and catnip placed around designated scratching areas will encourage it to occur in the appropriate locations. Unappealing, textured covers or double-sided sticky tape placed on undesirable areas can prevent unwanted scratching. Nail trims should be performed with cats in a calm environment. Demonstrating proper nail trimming and providing educational materials at wellness visits will provide owners with the confidence to perform nail trims in their own home [5].

5.3.3 Grooming

Many skin and coat problems can be identified appropriately when education is provided on proper grooming. Combing the hair helps maintain undercoat, prevent matting, and reduce consumption of fur. Bathing is often not needed, but some medical conditions may require frequent grooming [5]. Cats with oral pain from severe dental disease may have difficulty

Table 5.3 Feline behavior needs depending on feline life stage (0 > 10 years) [5].

Life stage: kitten (0–6 months of Age)
• Intercat social play most prevalent at 12 weeks of age. • Strong play drive. • Normal predatory behavior can be expressed through play by offering toys to avoid play biting. • Main socialization period to be introduced to humans should occur at 3–9 weeks of age. • Expose to various stimuli and handling methods that may be experienced during their lifespan. • Provide positive experiences to car rides, carrier exposure, nail trims, dogs, toothbrushing, children, and veterinary visits. • Reinforced positive behaviors with food or other suitable rewards. • Punishment should never be used to correct inappropriate behavior because it can lead to defensive aggression.
Life stage: junior (7 months to 2 years of age)
• Various handling methods by manipulating feet, mouth, and ears should be continued. • At 1–2 years, intercat connections may change and aggression may progress. • Inappropriate urination or spraying can develop due to stress related to a change with intercat relationships. • To improve intercat relations and reduce stress and anxiety, synthetic feline pheromones should be used.
Life stage: adult (3–10 years of age)
• Prone to weight gain due to decreased activity. • Provide interactive sessions of play for 10–15 min three times a day to improve activity and assist in preventing weight gain.
Life stage: senior (11–14 years of age)
• Changes in behavior should be evaluated for possible medical reasons. • Examples of behavior changes can include litter box usage, inappetence, social avoidance, and vocalization. • Education should be provided to cat owners to be aware of behavior variations. • Placement of additional soft bedding, ramps, and other modifications to the cat's environment can significantly increase overall quality of life.
Life stage: geriatric (15 years of age and over)
• Decrease in cognitive function, mobility, vision, and hearing may be present. • Education should be provided to assess for signs of discomfort. • Locations of bedding, food, water, and litter box access should be reviewed with cat owners to ensure accessibility due to possible osteoarthritis.

grooming. Bacterial salvia dispersed with grooming can create a smelly dull coat that will need additional attention. Overweight cats are unable to groom themselves appropriately and will need further care of their hind end to prevent fecal and urine scalding from occurring. Dull coats often matt due to oily buildup and may require frequent sanitary trims and bathing. Cats with arthritis and hyperesthesia will require extra upkeep around their joints and skin. Long-haired cats require excess fur to be removed and hairless breeds need bathing on a regular basis to reduce oil build up on skin. Conversations on the importance of grooming and coat health should be started at the first kitten exam and reviewed yearly [6].

5.3.4 Dental Care

Education on preventative dental care is vital for understanding how dental disease can affect overall wellbeing. Inappetence, oral pain, and other systemic diseases can occur when untreated. Reviewing tooth brushing and its benefits with owners will improve their cat's health. Providing dental care education early in a cat's life will create overall client compliance and become part of their cat's daily routine [5]. Toothbrushing at home can be performed by using positive reinforcement and providing cat owners with the appropriate training to become successful at home [7] (Box 5.1).

Box 5.1 Techniques for feline tooth brushing for feline owners.

- Offer a variety of flavored toothpastes to encourage interest.
- The cat should be positioned with their back toward the owner. This technique is less confrontational and if movement occurs during toothbrushing, the appropriate support can be provided.
- Utilize a blanket or towel for additional support and prevent front limbs from pawing at the toothbrush or owner's hand.
- Place the palm of the hand gently on top of the head with the thumb and second index finger placed around the cheekbone. Caution is taken to not cover eyes with fingers.
- Gently tilt head upward while using thumb to retract upper lip.
- Use the thumb or finger on the other hand to access one side of the cat's mouth.
- This motion should be performed for several days to get the cat acclimated to the sensation of being restrained and mouth manipulated.
- Toothpaste can be placed on a finger or cotton tip applicator and applied to teeth in a circular motion.
- Apply toothpaste moving from the back to front (molars to canines).
- This should be performed numerous times to increase the cat's comfort with the procedure.
- Toothbrush may be introduced.
- Brushing should be performed in 10 s intervals and gradually increased to 30–45 s for each dental arcade.

Educational material on feline toothbrushing in the form of written handouts and multimedia videos will aid in the owner's success with dental home care. Products approved by the Veterinary Oral Health Council (VOHC) should be reviewed as well. VOHC products in the form of chews and dental diets that are effective for plaque or calculus removal can provide additional benefit. Although not as effective as toothbrushing, these products can be another resource offered to owners who are unwilling to attempt brushing their cats' teeth [5].

5.4 Preparing for the Veterinary Visit

A trip to the veterinary clinic can be considered a stressful experience. Challenges that may be faced: difficulty placing cat in the carrier, level of stress experienced during travel, behavior during the veterinary visit, and how other cats may react to their return home. Owners may consider unpleasant experiences their cat may encounter during a veterinary visit to be more harmful than the lack of veterinary care received. By providing educational resources and a supportive plan, it will reduce their anxiety about the upcoming experience and minimize their cat's stress [8].

5.4.1 Cat Carrier Education

Cats more familiar with their carriers will significantly reduce their stress. Pet carriers are frequently kept in basements, garages, and only taken out when needed. Carriers incorporated in areas of the house will encourage them to use it as a place of relaxation. The space is recognized as a place of comfort that has a familiar smell and can be used instantly if an emergency were to arise. Placing a comfortable blanket and offering treats in the carrier make it an enjoyable place for them to be. It should be relayed that it takes time and patience for a cat to accept a carrier, so owners do not get discouraged in their cat's progress [9]. Carriers should be easy to clean, strong, and supportive. The top should be easily removed for exams and well ventilated [10]. Carriers that are made out of fabric or in the shape of a backpack should be avoided. Fabric carriers can also be difficult to clean. They can easily collapse on a cat when opened that can create discomfort and distress. Backpack carriers provide inadequate ventilation, restricted space, swaying movement, and result in the cat being openly exposed. Multicat households should have a carrier for each cat to be transported separately. This will prevent unwanted behaviors that may occur due to stress and confinement during transport [9].

Carriers should be picked up from underneath and not just from the handle. This will keep the carrier supported, stabilized, and reduce movement during transport. Cats should have the capability to stand up and turn around comfortably in a carrier. It should not be overly large to prevent sliding or rolling from occurring during travel. A carrier's size will need to be reevaluated as the cat grows from a kitten to an adult. Successful carrier training will reduce stress

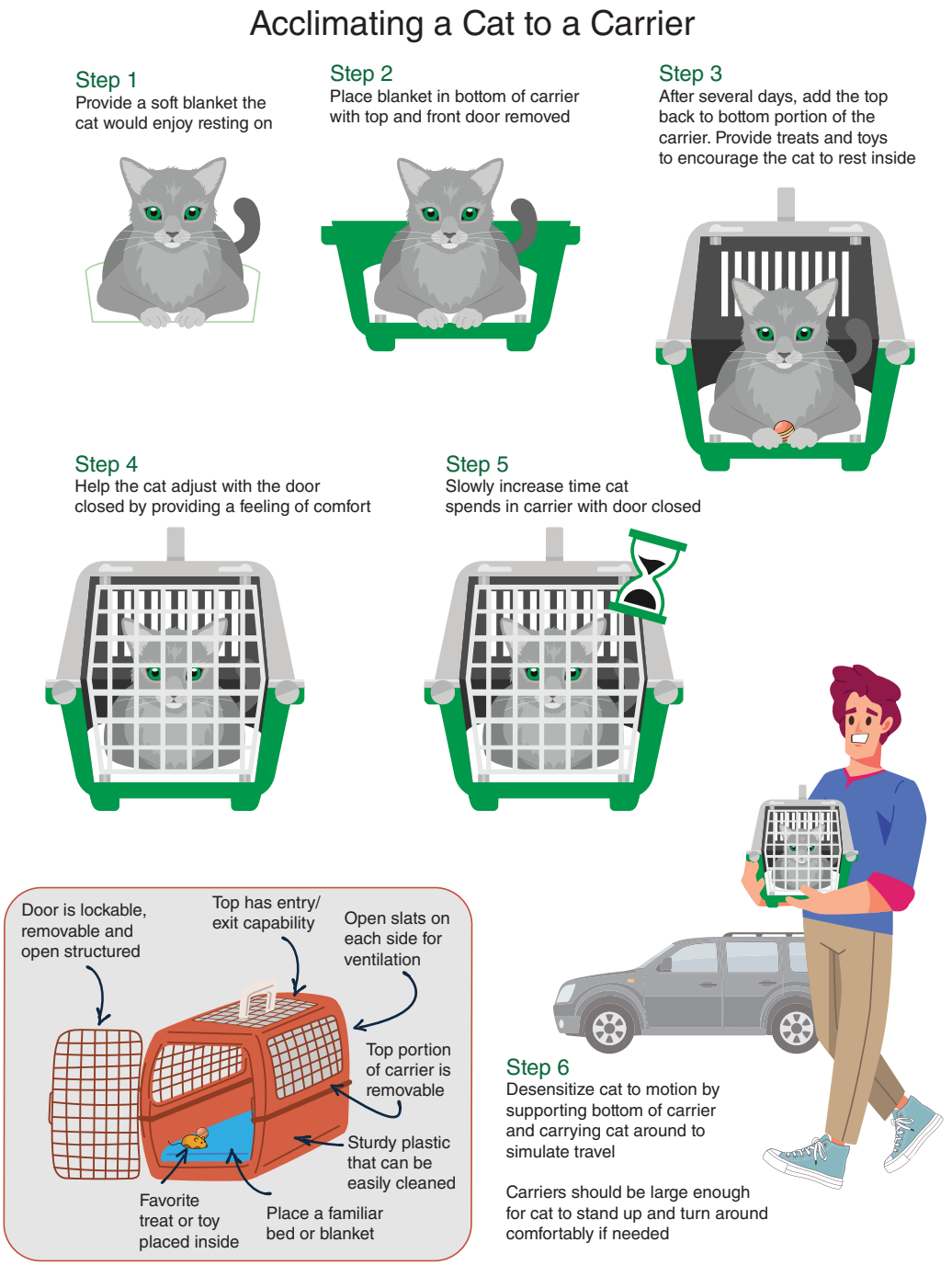


Figure 5.2 Acclimating a cat to a carrier. *Source:* Adapted from [9]; Erica Koch.

during travel for veterinary exams or to other locations in the future [9]. Effective carrier training can be encouraged by using a step system (Figure 5.2).

5.4.2 Traveling

When exposed to various smells, sights, and sounds, traveling can be stressful for a cat. Covering the carrier with a towel or blanket can help reduce stress that may be experienced. The appropriate airflow and surrounding temperature will need to be evaluated to prevent overheating with a covered carrier. Applying synthetic feline hormones to a blanket or towel

15 minutes prior to travel can help reduce anxiety. Carriers should be secured in the vehicle with absorbent material placed on the bottom if travel is longer than expected. The vehicle should also be ventilated and at a suitable temperature. A carrier should never be opened during transport to prevent injury from occurring [10].

5.4.3 Anxiolytics

Pharmacotherapy can be used for cats with a fearful disposition to reduce anxiety and provide a more enjoyable experience for both owner and cat. Anxiolytics are best given prior to a stress-induced event, and owners should be advised on how to appropriately medicate at home. Whenever any type of anxiolytic is prescribed prior to a veterinary visit, clear instructions should be given on what will be prescribed. A trial run prior to the stress-induced event may be recommended. The owner can understand its effectiveness and be aware of any side effects that may occur while their cat is medicated. Any adverse events that occur can be relayed to the veterinary team so medication modifications can be made and communicated prior to the next veterinary exam [11] (see Chapter 8: "Introduction to Feline Pharmacology," for further information on anxiolytics).

5.4.4 Returning to the Household

Some considerations may need to be addressed to ensure a smooth transition when their cat returns home. A multicat household may not be willingly accepting when a cat returns with unfamiliar scents from the veterinary hospital. The returning cat should remain in their carrier until all other cats in the household are calm. Hissing and growling should be ignored and positive interactions that occur between cats are to be rewarded. Wiping down each cat in the household to transfer their scent can help with a smoother re-introduction. Spraying synthetic feline hormones on a piece of material placed in the carrier can also reduce stress during travel. In some instances, a re-introduction phase may be needed despite measures previously taken. This can be achieved by following the same process that is used when a new cat is introduced into a multicat household. It may be recommended for all cats in the household to attend exams to prevent any severe problems from occurring when returned to their home environment [8].

5.5 Nutrition

Educating clients on the AAHA Nutrition and Weight Management Guidelines and the WSAVA Body Condition Score (BCS) Chart can give them the tools to monitor their cats' body condition at home and communicate the changes with the veterinary team. These scales provided to clients as a handout will provide a valuable resource to understand the description of each BCS scale and how it can relate to their own cat's body weight and fat. Teaching clients how to weigh their cats at home will give them the opportunity to monitor their cats' weight and be involved with their progress [12] (Box 5.2). (Refer to Chapter 12: "General Feline Nutrition," for other nutritional guidance in the feline patient).

5.5.1 Diet Change Recommendations

Reviewing daily feeding requirements will provide an understanding of the specific diets being recommended. Weighing the food to control the amount that is fed can result in a more accurate approach and should be suggested. If a diet needs to be changed, education is to be provided how to accomplish correctly. A gradual transition will prevent gastrointestinal

Box 5.2 Techniques for owners to weigh cats at home [12].

- Cat can be placed directly on a digital scale.
- To reduce stress placed in a carrier and placed on digital scale.
- A digital luggage scale can be used as another alternative.
- Weigh empty carrier and subtract from total weight of cat and carrier combined.
- Encourages owners' involvement with cat's weight process.
- Frequent reporting can occur to veterinary team.

upset from occurring. The transition should occur over 7–10 days, slowly mixing and increasing the new food in their diet. This transition can be done by starting to use 75% of their cat's current diet to 25% of the new diet for about 3 days, then 50% of the previous diet mixed with 50% of the new diet for an additional 3 days, followed by increasing to 75% of the new diet mixed with 25% of the previous diet for an additional 3 days [12]. If no gastrointestinal signs occur (vomiting, diarrhea, inappetence) during the transition period, they can be fully transitioned over to the new diet. If any gastrointestinal signs occur during the transition period, they should return to their original diet and inform the veterinary team [12]. Communicating frequently on the patient's nutritional progress will ensure that progress is evaluated often, adjustments can be made if needed, and owners can ask additional questions on their cat's diet recommendations. Providing client education on a nutritional plan will confirm their understanding of proper feline nutrition and guarantee a successful outcome [12].

5.6 Nursing Care for the Feline Pet Owner

Providing the appropriate education, guidance, and support can lead to the successful management of their cat's illness at home. Medication formulation should be considered depending on a cat's temperament and an owner's possible physical limitations. If an owner has limitations with administering a tablet or capsule, medications can be formulated as a flavored liquid (Figure 5.3). Various techniques for medication administration should be reviewed and demonstrated to pet owners [13] (Box 5.3).



Figure 5.3 Utilizing a towel placed around the neck can prevent front leg movement and be helpful when administering medications. *Source:* Christina Daigle.

Box 5.3 Oral medication administration techniques for cat owners [13, 14].

- Create an enclosed space for administering medications such as using a bathroom sink lined with a soft blanket or nonslip table or floor.
- Positioned cat sitting upright facing away from caretaker.
- Apply even gentle pressure by each side of the cat by holding front legs above elbow.
- Additional restraint can be performed by using a medium sized towel.
- Towel placed around cats' neck in a swooping motion can prevent front leg movement.
- Tablet/capsule should be held between thumb and index finger of caretakers dominate hand.
- Other hand is placed on head by placing thumb and index fingers to either side of the cat's mouth.
- Tilt head upwards, with finger of hand holding tablet/capsule to retract mouth.
- Place tablet/capsule on back of tongue and hold mouth closed gently for few seconds.
- Rub under chin to encourage swallowing.
- A small amount of warmed water placed in a syringe can be given to tablet/capsule was consumed.
- A pill plunger can be utilized to hold tablet/capsule to assist in successful administration.

5.6.1 Subcutaneous Fluids

Administering subcutaneous fluids can be used to treat various mild illnesses in cats at home. These fluids get slowly absorbed in the bloodstream so it is inappropriate for use in cats with severe illness and dehydration [15].

Equipment includes the fluid bag, intravenous administration sets, and needles. Needles are color-coded depending on needle size. Larger gauge needles used will result in a faster administration time. Cats with puncture sensitivities may require a smaller needle size to be used. Owners are trained how to remove needles from the protective needle casing and maintain sterility by using a new needle with each fluid treatment. Medical waste containers should be provided for needle disposal [16].

A 10–15 drop/ml administration set is often preferred to be utilized [16]. It should be reviewed how to connect a fluid line to a bag and where a clamp is located on a fluid line to start and stop the fluid flow. To prevent contamination, the point near the drip chamber should not be touched when attaching to the fluid bag. Priming of the drip chamber and removing kinks and air in the fluid line should be discussed with the owner [17].

Fluid bags are removed from the protective plastic seal prior to attaching the fluid line and can be placed in a warm water bath to decrease any additional irritation during fluid treatment [17]. The interscapular region is the preferred location for administration to reduce discomfort to the patient. Typically, a total amount of 50–150 ml of fluid is administered but can vary depending on the patient's needs. Fluid is typically absorbed in a few hours and may move ventrally from the original injection site [18]. Techniques on subcutaneous fluid administration should be provided (Box 5.4).

Box 5.4 Techniques for subcutaneous fluid administration at home [17].

- Cat is placed in a comfortable location such as a couch or blanket.
- Subcutaneous fluid administration set should be primed and suspended above location cat will receive treatment.
- A subcutaneous space is created by lifting the skin with one hand around the interscapular region around the scruff area.
- Without breaking sterility, removed protective casing from the needle with the other hand.
- Hub of needle facing upward is inserted in the subcutaneous space that's created by lifting the skin in area of the scruff.
- Lifted scruff area can be released once needle is secured subcutaneously.
- Steady fluid flow rate is started when fluid line clamp is opened.
- Needle can be slightly redirected under the skin to increase fluid rate.
- After total volume administered, clamp is closed to stop flow rate.
- Needle is removed, placed in protective casing, and disposed in medical waste container.
- New needle is placed on administration set in preparation for next treatment.
- Gentle pressure applied to injection site with expectation slight discharge of fluid may occur.

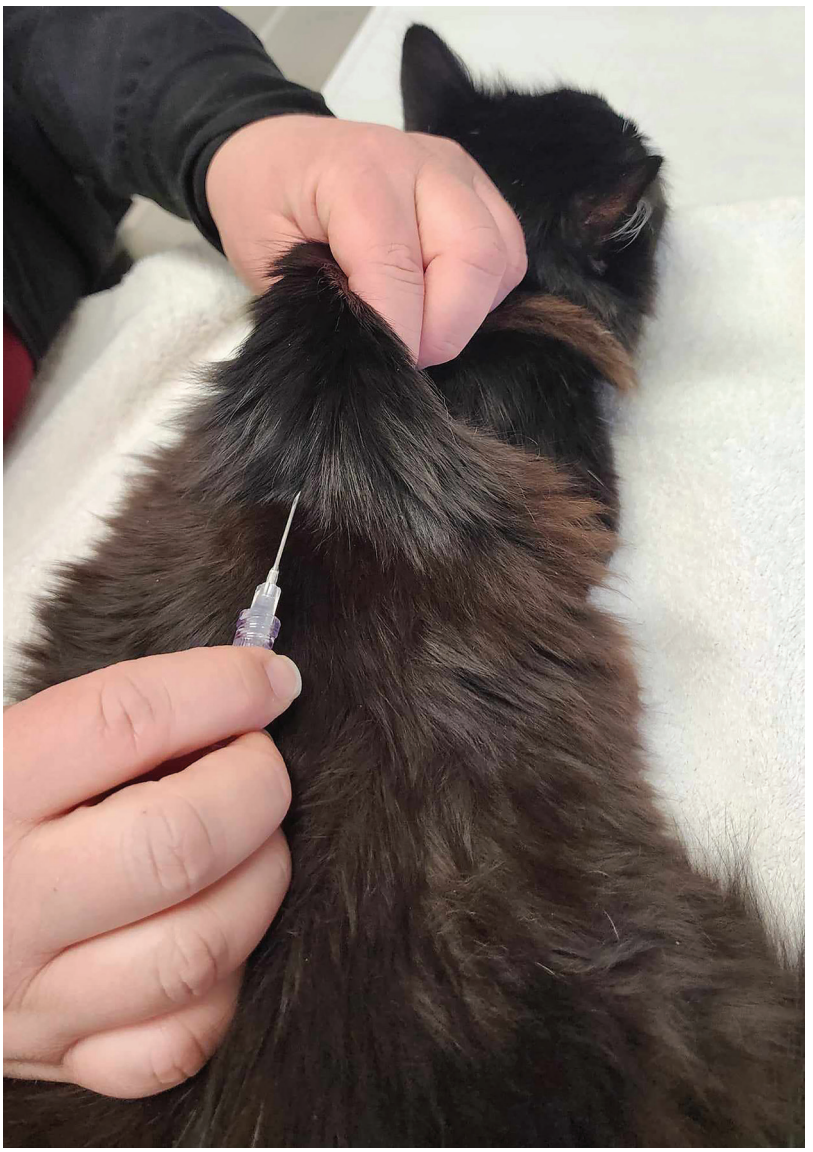


Figure 5.4 The subcutaneous space is created around the interscapular region by lifting the skin upward in the scruff area with one hand. *Source:* Christina Daigle.

Grooming, interacting, normal appetite, and elimination behaviors can all be signs of recovery in a cat. Education that is provided should give owners the ability to recognize problems during their cat's treatment. This will make them aware to seek additional medical care if it is needed. Resources in the form of written and verbal instructions, along with audiovisual aids should be provided. Follow-up communication on the wellbeing of their cat should occur frequently, so they have the resources needed to provide continuum of care at home [19] (Figure 5.4).

5.6.2 Reproductive Care

When a pregnant queen is being evaluated, owners should be informed on the general care, normal labor, and delivery expectations, and recognize complications if they occur. They should understand the gestational period of a queen is 65–67 days, but it can vary [20]. The nutritional needs of a queen are increased during pregnancy, and they must be fed an appropriate diet during that time. A diet for pregnancy and lactating cats should follow the Association of American Feed Control Officials (AAFCO) standards [21]. A pregnant queen does not need their activity restricted, but exposure to new or sick cats during this time should be prevented. To reduce stress, the queen should be isolated from other cats in the

household during the last 2 weeks of gestation. A nesting box lined with towels or blankets will provide a safe and quiet area for delivery to occur. The time the queen spends in the nesting box should increase 1 week prior to the delivery [20].

5.6.2.1 Labor and Kitten Delivery

Around day 61 of the gestational period, a rectal temperature can be monitored twice daily on the queen. When the body temperature drops one full degree (99.0 °F), the labor signs can be present within 12–24 hours. If milk is present in mammary glands, labor can begin within 24–48 hours. Inappetence may be seen 24 hours prior to labor. The queen may also display signs of restlessness, panting, pacing, and overgrooming herself. A kitten is delivered after 60 minutes of active labor in the queen. A kitten should be produced every 30–60 minutes after the initial delivery occurs. If no kitten is produced when a queen is in active labor for 2 hours, owners should be made aware to seek veterinary intervention at that time [20].

An owner may need to intervene to remove amniotic membranes from kittens during delivery if they are born in quick succession. Removing the amniotic membrane during this time will prevent injury and increase their survival. Kittens should be kept warm, cleaned, dried, and umbilical cords should be tied 1 inch away from the body wall. A strong suckle should be present and kittens kneading the mammary gland will encourage milk let down so nursing can occur. Within 24 hours post-delivery, a queen should start eating and be offered a diet AAFCO approved for pregnancy and lactating females. Owners should be made aware to observe for signs of fever, anorexia, discharge from mammary or vulva area, or if the queen is disinterested in her kittens. If any of these signs are observed, veterinary evaluation on the queen should be performed [20] (see Chapter 20: "Gestation, Lactation and Pediatrics," for further information).

5.6.3 Neonate Care

Providing care to an orphan kitten can be a common conversation that may occur with a pet owner. Education must be provided on nutrition, warmth, social stimulation, elimination, and sanitation requirements. Owners having the ability to recognize a problem and correct it quickly will aid in the success of their overall survival [22].

Enclosure education should include kittens being in a warm, quiet, clean area, soft absorbent bedding being provided, and being located away from other pets and children. Hand washing should be discussed prior to any neonate handling. Hypothermia frequently causes illness and death and the environmental temperature and humidity maintenance for the kitten should be reviewed. Owners should be aware that a heat source is to be provided while also giving kittens the capability to move away from warm locations if needed. A heat source can be in the form of a hot water bottle wrapped in a towel or a circulating hot water blanket [22].

It is important to inform owners how to monitor a kitten's overall health at home by observing their weight, behavior, and daily food intake. If excessive crying, restlessness, and poor muscle tone is observed, veterinary intervention will be needed [22].

If a foster queen is not available to provide nutrition to the kittens, commercial formulas will have to be fed. Daily nutritional requirements and frequency of feedings will need to be outlined and reviewed with the owner. Instructions should be provided on calculated feeding amounts, the quality of the formula, and how to properly store it. Proper neonate feeding techniques should be demonstrated to the owner before it is attempted on their own at home. The kitten's head should be elevated in a sternal recumbency position during feedings, and the nursing bottle should never be squeezed to prevent aspiration from occurring. Preparation of the formula should be discussed so special care is taken not to feed cold formula, overfeed, or feed too quickly [22].

A kitten that is less than 3 weeks of age will be unable to eliminate on their own. After each feeding, the process of stimulating the anogenital area to encourage defecation and urination will need to be demonstrated to the owner as well. It should be relayed that a kitten that is fed formula may develop diarrhea or constipation, and owners may need to seek veterinary care at that time [22].

At 4 weeks of age, nonclumping or paper litter should be provided in a low-sided litter box. Educate owners to place kittens in the litter box after each feeding to encourage elimination in the appropriate designated area to aid with litter box training [22].

It will need to be reviewed that kittens can be trained to drink formula out of a shallow dish at 3–4 weeks of age. Canned food can be mixed with formula, which is offered several times a day. The food that is offered is to be formulated for kitten growth. At 5–6 weeks of age, 30% of their daily nutritional requirement should include solid foods and fresh water that is provided in a shallow dish. At 6–9 weeks of age, weaning should be completed and the appropriate AAFCO kitten life stage diet should be reviewed with the owner [22].

5.6.4 Postoperative Care

Aftercare of a cat that has undergone sedation or general anesthesia will need to be reviewed with the owner at the time of discharge [23]. A recovery plan may include a patient's medications, surgical wound care, restrictions, and a nutritional plan [24]. Verbal and written instructions are to be provided to all routine, nonroutine, and medical procedures. All discharge instructions should also be reviewed in a quiet location of the hospital to attain the dedicated attention of the owner [23].

The class of medications (e.g. antiemetic, antibiotic), frequency, route of administration, and possible side effects should be discussed [23]. The type of sutures placed, what is expected for wound healing, and management of the surgical site during recovery should also be reviewed at the time of discharge. Drains placed in a body cavity or wound to remove excessive gas or fluid should be cleaned frequently to prevent a blockage from occurring. Individual, customized postoperative instructions should be provided to each owner about their pet. There will be an understanding from the owner of what is expected for a normal recovery to occur or if additional follow-up may be needed [23] (Box 5.5).

Box 5.5 General postoperative care topics for veterinary technicians [23].

Confinement
- May be beneficial to confine in a crate or room.
- Remain indoors.
- Separation from other pets in the household temporarily.

Feeding
- Water to be offered first.
- Small frequent meals introduced with warming or adding water to increase palatability.
- Therapeutic diets prescribed should be transitioned over a 7–10-day period.
- Possibility of nausea post sedation or general anesthesia.

Medications
- Class of medication, frequency, and route of administration.
- Administered with or without food.
- Possible side effects.

Generalized postanesthetic side effects
- Inappetence, constipation, bloating, ileus, or vomiting.
- Depression, ataxia, and lethargy can be signs of extended anesthetic recovery.

Surgical Site
- Surgical site to be assessed daily.
- Normal pictures of surgical healing should be reviewed with owners.
- Excessive swelling, discharge, and redness present should be evaluated.
- Reduce handling during recovery to minimize discomfort.
- Use of Elizabethan collars or recovery suits reviewed to prevent incision licking.
- Follow-up for incision recheck, suture, or drain removal addressed and scheduled.
- Communicate 24 h post discharge to assess progress and address additional questions.

Drain care
- Review cleaning drain site with warm soaks to prevent blockage and remain effective.
- Suggest confining patient to a crate or room to prevent discharge on furniture or carpeting.
- Form a protective barrier with petroleum jelly drain site to prevent skin dermatitis.
- Prevent excessive licking around drain site with an Elizabethan collar worn.
- Follow-up for drain removal.
- Accidental removal will need to be evaluated if parts of drain are still present in wound.
- Delayed healing will occur if pieces of the drain remain in wound.



Figure 5.5 Evaluating a bandage can be done by assessing the toes for the presence of excessive swelling, moisture, discharge, and odor. *Source:* Christina Daigle.

5.6.5 Bandage Care

Detailed directions on how to upkeep a cast, bandage, or splint applied to an extremity should be carefully reviewed with the owner. Great care should be taken to keep it dry and clean by keeping cats indoors. Litter boxes should be maintained, and paper litter can be suggested for use to prevent debris sticking to the inside and outside of the bandage. Owners should assess toes daily for color, odor, and swelling. A tight-fitted bandage may create excessive swelling and prevent circulation causing the toes to become pale or cyanotic. Odor may be present due to moisture or tissue damage located under the bandage. Rechecks should be performed weekly for bandage reassessment and owners should be made aware if any abnormalities are seen to seek veterinary care [23] (Figure 5.5).

5.7 Client Communication and Feline Disease Management

Communication is an essential skill required as a veterinary technician to achieve a higher level of patient care. Clinical signs, the diagnostic process, treatment possibilities, and the long-term management of a feline disease are crucial when communicating with pet owners. The advantages of treatment and possible complications that may arise should be reviewed as well. Providing the most up-to-date information will give owners the support and assurance needed when

deciding on a treatment option for their pet. Overall compliance for veterinary care and owner happiness occurs when great communication is delivered between veterinary professionals and pet owners [25].

5.7.1 Inappetence in Cats

Communicating reasons why a cat may experience anorexia will educate owners to notice signs of inappetence quickly [26]. Aversion to food can commonly be seen if change in the environment has occurred. Owners should be provided suggestions to encourage their cat to resume a normal appetite at home [27] (Box 5.6). The longer a cat does not eat the more difficult it can be to manage. It should be advised if recommendations have been unsuccessful, the cat should be reevaluated [27].

5.7.2 Enteral Feeding for Cat Owners

In cats, esophagostomy and gastrostomy tubes give owners the capability to manage their cat's inappetence at home. Feeding a cat with a feeding tube can be anxiety provoking for the pet owner. The veterinary team has a crucial role to ensure the owner is comfortable with the task [26]. With a feeding tube placed, cats can still eat normally and should be offered small meals to encourage eating. Changing the bandage around the feeding tube insertion site should be reviewed and assessed for swelling, discharge, and redness. Daily maintenance of the feeding tube includes cleaning around the insertion site and evaluating the sutures to reassure there was appropriate placement. Marking the placement for the owner will certify the positioning has remained intact when the bandage is changed. Slight discharge or fluid around the insertion site can be normal but if there is concern a photograph can be submitted to be evaluated by the veterinary team. Demonstration should be performed with owners on troubleshooting placement, diet recommendations, and tube-feeding techniques [28] (Table 5.4).

Cats experiencing prolonged anorexia have a smaller stomach capacity and may need to receive reduced feedings. They should be fed 1/3 of their total resting energy requirement (RER) day one and increased to 100% of the total RER by day 3 of assisted feeding [27].

Medications administered through the feeding tube can result in a more pleasant experience for both the cat and owner. Tablets, capsules, and liquid medications can be dissolved in warm water and placed in a syringe for easier administration. All medications placed through a feeding tube should be flushed with warm water to confirm all contents will enter the stomach. Be aware not all medications are labeled to be dissolved or crushed and this should be verified prior to administration [28].

Possible complications that could occur during tube feeding should be reviewed with the owner. This will give them the ability to recognize complications and notify the veterinary team when they arise. Blockages are reduced when warm water is flushed to dislodge food that is left after feeding [28]. Flushing the feeding tube with a small amount of nondiet soda followed by a warm water flush may also be beneficial in dissolving a blockage as well [29]. Routine rechecks should be performed to reevaluate the tube placement, insertion site, owner concerns, and patient progress with the feedings [28] (Figure 5.6).

Box 5.6 Techniques to encourage feline appetite to return [27].

- Offer small portions of food that is usually offered.
- Place food in wide shallow bowls to prevent whisker fatigue (touching side of dish).
- Remove environmental stressors during feeding times (e.g. loud noises).
- Increase food palatability by adding flavors, textures, consistencies, and warming food.
- Place food in a quiet location (e.g. covered kennel).
- Food bowls are to be placed in a different location of the litter box.
- To stimulate licking, place food on paws and face.
- Handfeeding and petting cat may encourage increased appetite.

Table 5.4 Esophagostomy and gastrostomy tube guidelines for feline owners [28].

Techniques for troubleshooting placement
• Prepare to have two 6 ml syringes - one empty and another with 3 ml of warmed water. • Pinch tubing to prevent air/fluid entering or escaping. • While pinching, remove feeding tube protective cap. • Attach empty syringe to end of tube and pull back plunger slightly. • Prior to negative pressure being reached slight amount of fluid/air enter syringe. • Negative pressure is achieved when the syringe plunger returns to its original position. • Proper placement verified when negative pressure is reached. • Syringe with 3 ml warmed water attached and flushed slowly with no resistance. • No vomiting, discomfort, or coughing seen can proceed with feeding. • If resistance present with flushing do not proceed with feeding.
Enteral feeding at home
• Feeding should occur in a comfortable location in the home for both cat and owner. • Hands or gloves are to be worn to prevent infection at insertion site. • All supplies such as syringes, bandage material, and other tube feeding equipment are prepared prior to feeding. • Food should be prepared in single or multiple syringes depending on the volume being administered. • Water and food administered is to be warmed to body temperature (temperature can be assessed by placing a drop from syringe on back of hand). • Cat's head is advised to be elevated when feeding to ensure food travels to stomach. • Feeding is started by flushing 3 ml of warmed water and if no resistance present can attach the food syringe and continue feeding regiment. • Feeding tube should be pinched in between syringe changes to prevent leaking occurring. • Warmed food is administered slowly (1 ml every 10 s) to prevent discomfort. • Mild swallowing may be seen during feedings with no sign of discomfort or distress. • Additional 3 ml of warmed water should be flushed when feeding is complete to prevent a blockage from occurring.

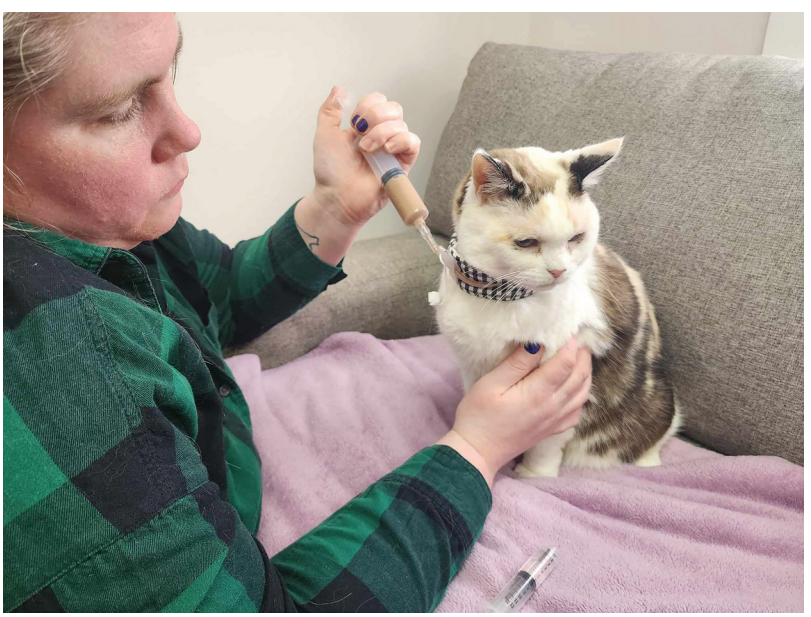


Figure 5.6 Enteral feedings should occur in a comfortable location in the home for both cat and owner. *Source:* Christina Daigle.

5.7.3 Inhaler Management

Training a cat to use an inhaler can be challenging but imperative for the success of the therapy. Using delivery systems with an inhalant chamber can be used to improve medication distribution. This specific device uses a pressurized metered-dose (pMDI) inhaler along with a spacer or valved holding chamber (VHC) that is attached to a fitting mask that is then applied to the cat's face. Suggestions should be provided to acclimate cats with the process [30] (Box 5.7).

Nebulizers can turn liquids into an aerosolized mist that can be delivered with or without a face mask. Flow-by inhalation is provided to the cat without a mask and can be a more appealing technique to be used. There can be significant drug loss into the environment and efficacy with its use has not been studied [30].

Device care should be reviewed with owners to reduce contaminants that may accumulate with the frequent use of the inhaler. Counseling should also be provided on how to reduce irritants located in the environment such as dustless cat litter, reduce the use of sprays, no cigarette smoke, and replace air filters in the home regularly. Providing additional resources on inhalant device use in the form of videos and brochures will also assist owners with the capability to improve their cat's quality of life (QOL) at home [30] (Figure 5.7).

5.7.4 Diabetes Management

Diabetes mellitus (DM) is a common endocrine disorder in cats, with a good prognosis when it is well managed. An effective way to manage glycemic control is using insulin. Educating on the type of insulin that will be administered, the appropriate dosing syringe, administration techniques, and proper storage of the bottle will help owners with being successful

Box 5.7 Techniques used for inhalation therapy training [29].

- Place inhaler on floor in same location of the cat.
- Positive reinforcement (e.g. treats and petting) will reassure cat to be in the same area.
- Desensitize to the sound of inhaler when depressed additional positive reinforcement.
- Place food through opening of face mask to encourage cat to place face on mask.
- Clicker training can be utilized to accustom cat to keep face on mask for longer periods.
- Increase frequency of clicks will encourage longer wait time for cat to acquire a treat.
- One-way valve of VHC is used to visualize each breath taken when device used.



Figure 5.7 Using positive reinforcement with food placed around or through the face mask can be a technique used to desensitize a cat to the inhaler. *Source:* Christina Daigle.

with DM management. Clinical signs of hypoglycemia should be reviewed. Signs include seizures, ataxia, disorientation, agitation, lethargy, and a coma. When hypoglycemia is present, prepare owners to administer high glucose syrup orally or on the oral mucosa if the swallow reflex is not present. Owners should be aware that they will need to seek out additional veterinary guidance when this occurs and discontinue insulin therapy until they are further instructed [31].

Education DM management with the owner should include understanding how to read the bottle label, how to deliver the appropriate dose, how to recognize the differences between a U-40 and U-100 syringe, and how to administer the insulin correctly. Owners should demonstrate at the time of the exam how they would withdraw the insulin from the vial and administer it to their cat. Medications dispensed, their indication for use, and the administration routes should all be reviewed at the same time as well. Written materials and educational videos will provide additional guidance. Frequent communication with an owner will build a professional client–veterinary relationship and offer the support to be successful with diabetic management at home [31].

5.7.4.1 Monitoring Blood Glucose Levels

The use of handheld glucometers to obtain blood glucose (BG) values is a great tool for the management of DM at home. Many handheld veterinary glucometers available are calibrated for feline blood, require a small blood sample, and provide a BG value quickly. The pinnae and metacarpal pads are sites that are well tolerated to obtain a BG blood sample in cats. The ear is warmed by rubbing the area or is shaved to give a better visualization of the marginal ear vein for the owner. A 25-gauge needle or lancet is used to puncture near the marginal ear vein to obtain a drop of blood. Touching the glucometer strip to the area will uptake the blood sample. Pressure should be gently applied to the ear to stop bleeding while the sample is being processed. A 25-gauge needle or lancet can also be used to obtain a sample from the metacarpal pad using the same collection process [32] (Figure 5.8).

A continuous monitoring system (CGM) can be used to monitor interstitial glucose levels. The device is usually placed subcutaneously around the dorsal area of the neck. These sensors measure interstitial glucose concentrations and are kept on by an adhesive patch. BG values are obtained by scanning with a CGM reader or using a mobile device. A soft collar or bandage dressing can be placed around the CGM to protect the area [32]. This device can be used to monitor BG levels at home if the owner feels they will be unable to obtain a sample by using a handheld BG monitor.

5.7.4.2 Long-term Diabetic Management for Cat Owners

Owners should be encouraged to keep a log of their cat's daily routine to assist with their overall DM management. Monitoring water and food intake, urine production, the time and dosage of insulin administered, and their cat's overall wellbeing should be logged on a daily basis. Limiting dietary carbohydrates can improve DM management and monitoring water intake can indicate how well they respond to insulin therapy. Weights should be obtained weekly to monitor weight loss and help improve glycemic control. A urine dipstick can be applied to a urine sample to monitor the presence of urine glucose. The presence of glucosuria or ketones in urine demonstrates a poor glycemic control and the veterinary team should be notified of the changes immediately [32].

5.7.5 House Soiling

Feline house-soiling is a multifaceted problem that can lead to an owner surrendering or euthanizing their cat. Educating owners how to maintain their cat's social, physical, and medical needs will prevent this unwanted behavior from occurring. Common reasons for house soiling include litter box avoidance in high-traffic areas, lack of clean acceptable locations to eliminate (e.g. multicat household), negative experiences that may occur near a litter box (e.g. located near a loud washing machine), and the presence of another dominate cat near the litter box area resulting in seeking another location to eliminate [33].

Marking is a normal feline behavior that occurs when urine is sprayed to leave a scent. Marking can be caused when there is a stress-related change in the environment (e.g. play and sleep areas) and unfamiliar smells (e.g. clothes and shoes). Sexual behavior due to unaltered male or females can lead to urine spraying and marking around entry areas (e.g. doors and windows). Diabetes, urinary infections, arthritis, kidney disease, cystitis, along with other medical conditions can lead to house-soiling behaviors. An inflammatory condition aggravated with stress is known as feline idiopathic cystitis (FIC). Hematuria, discomfort, straining, and the frequency to urinate can occur with FIC. Owners should seek medical evaluation (e.g. urinalysis, abdominal radiograph and ultrasound, chemistry profile) to rule out the possibility of medical factors for the house-soiling occurring [33].

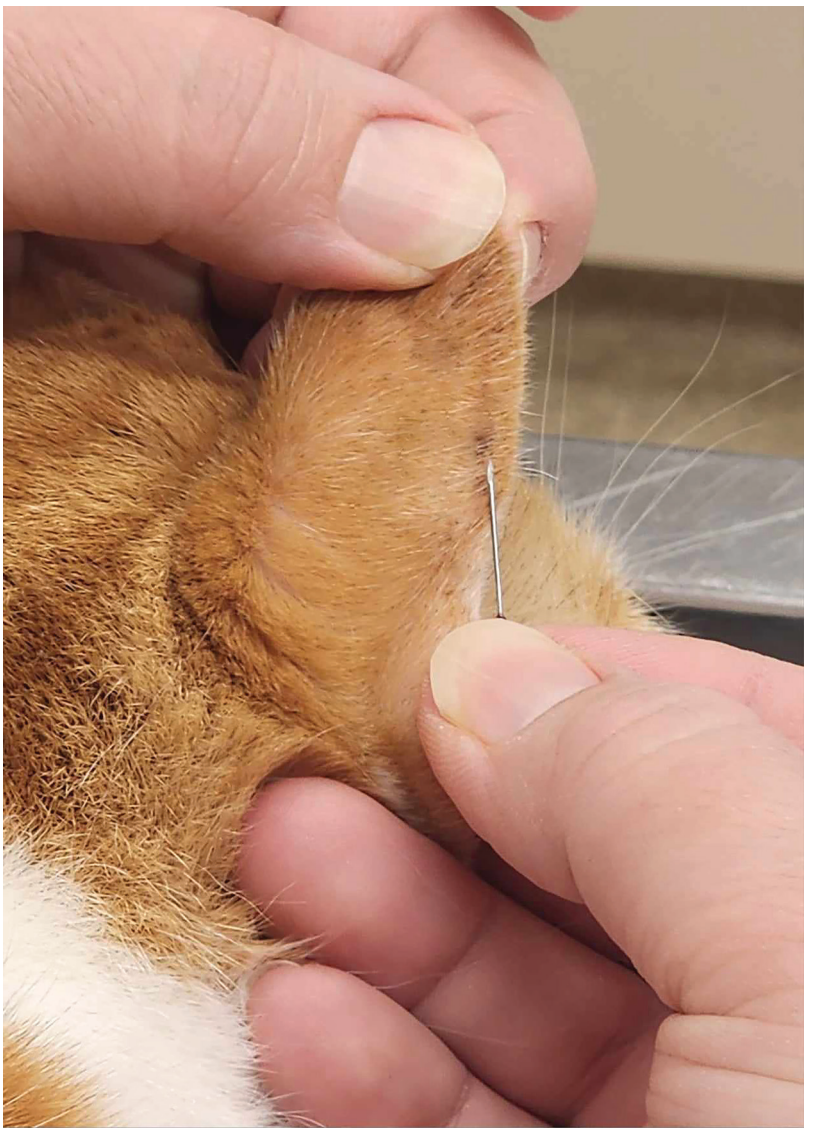


Figure 5.8 A 25-gauge needle can be used to puncture the marginal ear vein to obtain a small blood sample for a BG measurement. *Source:* Christina Daigle.

Reviewing ideal litter box management is important when evaluating reasons for inappropriate urination occurring in the household [33] (Box 5.8). Cleaning with a urine odor eliminator product and using a synthetic feline hormone in the area will reduce marking behavior. Inappropriate urination can be frustrating for a cat owner to manage. Addressing the problem in a timely manner will prevent future unwanted house-soiling behaviors to occur and increase the success for the issue to be resolved [33] (Figure 5.9).

5.7.6 Chemotherapy Safety

When cats undergo chemotherapy treatments, providing communication on general and palliative care as well as the owner's safety are important topics for discussion. After chemotherapy treatment, owners should be aware of the safe handling of excrement, how to safely administer hazardous drugs if needed, and potential contact risks. This should be provided as verbal and written instructions at the time of the patient discharge [34] (Box 5.9).

Box 5.8 Suggestions for ideal litter box management [32].

- Each cat in the household has a litter box plus an additional box.
- Litter box placed in variety of locations in the home.
- Avoid placement need food and water and in quiet private areas.
- Keep litter boxes apart from one another.
- Litter boxes should be placed on each level of a multi-level home.
- The size of the litter box should be 1.5 times length of cat (nose to base of tail).
- Low-entry boxes may be needed for senior cats.
- Various types of litter should be utilized to evaluate a cat's preference.
- Cats favor unscented clumping litter and often dislike dusty and deodorizer type litters.
- Waste to be removed from litter box daily.
- Litter box should be washed every 1–4 wk with soap and hot water (avoid ammonia-based products).
- Punishment for inappropriate urination should never be used as it can lead to fear aggression and lead to further marking in other unknown locations.

Box 5.9 Chemotherapy safety techniques for owners [33].

- Chemotherapy-rated gloves should be dispensed when hazardous drugs (HD) prescribed.
- Chemotherapy gloves are to be worn when each administration of HD is given.
- Hands are to be washed when gloves are removed.
- Avoid direct contact with contaminated excrement and litter box placed in low-traffic area.
- Excrement should be cleaned daily and double bagged with impermeable waste bags.
- Waste bags can be disposed with household trash.
- If contact with excrement on skin occurs, wash hands for 5 min with dishwashing detergent.
- Use caution with cat interacting with children to minimize exposure.
- Individuals pregnant or lactating should not administer HD or clean excrement.
- Medications should be stored in child-proof containers and cannot be crushed or split.
- Soiled towels, blankets, and other fabric materials should be washed twice, separately, and bleached.

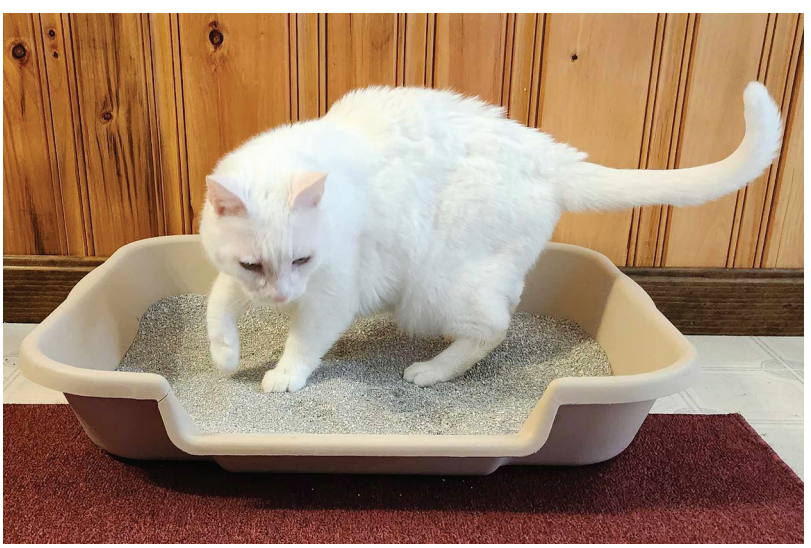


Figure 5.9 Senior cats suffering from arthritis may need a low entry litter box to eliminate properly. *Source:* Christina Daigle.

Providing education to an owner on chemotherapy can help improve their cat's overall QOL and minimize their discomfort. It is recommended that owners keep a log of their cat's appetite, behavior, comfort level, and other abnormalities that can occur during treatment. When the log is reviewed, it can help with adjusting the treatment plan and assessing the patient's QOL. Supporting owners managing their cat's cancer will provide them with the capability to manage aftercare treatment at home [35].

5.7.7 Feline Hyperthyroidism Care and Management

The most common endocrinopathy that is often diagnosed in general practice is feline hyperthyroidism (FH) [25] (see Chapter 18: "Endocrinology," for further information). Many cat owners may associate clinical signs of FH with age-related changes; so, it is important owners understand how to identify illness and behavior changes that may be seen in their senior cat [25].

Medical, dietary, and surgical management, along with radioactive iodine (I^{131}) therapy are many of the options available for the treatment of FH. There are many considerations owners should take when they are deciding on the best treatment plan for their pet. This includes their ability to medicate daily, the cost and accessibility to treatment, and their pet's overall temperament [25].

The most commonly used drug for the medical management for FH is methimazole [36]. Methimazole treatment is often considered the most cost effective for owners. It is important when reviewing treatment that owners understand it will not cure FH. Lifelong management will be necessary, leading to increased costs for treatment. Benign tumors can also persist to grow and potentially become malignant over time. Owners should be aware that repeated blood chemistry and thyroid panels will need to be performed to monitor their cat's response to treatment [25]. Success of FH management relies on the ability to administer the medications twice daily. Methimazole can be in the form of a pill, oral solution, and a transdermal ointment. Administration techniques and medication formulations should be reviewed at the time of discharge to improve overall owner compliance and success with the management of treatment at home [25].

5.7.7.1 Dietary Management

T4 levels can be stabilized and maintained when a cat is fed a restricted iodine diet. The clinical signs of tachycardia and weight loss usually do not improve with the feeding of this type of diet. If the decision is made to feed a restricted iodine diet at home, it is important owners understand no other commercial diets can be fed at the same time. These specific diets do not treat the cause of FH, and benign tumors can continue to occur with an increased risk of malignant growth [25]. When considering dietary management, reviewing daily feeding requirements will ensure owners understand the diet that is being recommended. Providing education on how to accomplish a diet transition will also need to be reviewed to prevent any gastrointestinal signs to occur [12] (see above section in this chapter for client education on diet change recommendations).

5.7.7.2 Surgical Management

The possible advantages and complications of a thyroidectomy should be reviewed with owners. Prior to the surgical removal, treatment (e.g. methimazole) is preferred to establish euthyroidism to reduce the cardiac effects and potential anesthetic risks [36]. Postoperatively, owners should be made aware that hypocalcemia can be a postsurgical complication that can occur if there is damage to the parathyroid glands during removal. This may result in additional lab testing to monitor for hypocalcemia and assess renal function [36].

When recovering at home, the surgical site should be monitored daily and observed for any additional swelling, discharge, and redness. Any rechecks should be addressed and scheduled prior to the patient's release [23]. Serum total T4 levels will need to be rechecked at 1 month, 6 months, and yearly postoperatively to assess for the return of FH. The possibility of FH reoccurrence should be reviewed, and owners are to be informed their cat will need to be reevaluated by a veterinarian if clinical signs return [25] (see above section in this chapter for client education recommendations for post-operative care).

5.7.7.3 Radioactive Iodine Therapy

The gold standard of FH therapy in cats is considered to be radioactive iodine (I^{131}) and it can be administered orally or subcutaneously. Treatment is safe, effective, and eliminates the need for life-long management. I^{131} concentrates in and destroys hyperactive thyroid tissue, but once it is administered owners should be made aware their cat will need to remain

hospitalized in isolation for 7–10 days. It should be reviewed that visitation is not allowed during the isolation period and it may not be a recommended treatment option for cats that have a concurrent medical condition [35].

When a cat that has received I^{131} therapy returns home, they can still release residual radiation for several weeks post treatment through their urine and feces. Home care post-treatment should be reviewed with owners at the time of discharge [35] (Box 5.10).

Box 5.10 Home care two weeks post radioactive iodine therapy [35].

- Limit close contact with for no more than a 30-min period per day.
- Cats should remain indoors.
- Gloves are to be worn at all times when in contact with urine and feces.
- Litter box should be lined with flushable litter and waste removed twice daily.
- Dispose waste in sewer system and use caution to avoid splashing.
- Any gloves or objects that have been in contact with excrement are placed in a double lined disposable bag kept away in an isolated location.
- Prohibit contact with children and pregnant woman.

After the 2-week period, the excrement no longer needs to be flushed and the cat can return to its normal home routine. Owners should be made aware that clinical signs of FH may take several months to resolve. A relapse post I^{131} treatment is infrequent, but due to the possibility of an occurrence, owners should be aware it is recommended to recheck serum T4 levels yearly [35].

5.7.8 Chronic Kidney Disease Management

Chronic kidney disease (CKD) is a frequently diagnosed disease in senior cats that will progress over time and requires regular assessment to address complications that may arise. Providing owners with the proper education and support on how to manage the disease can improve their cat's overall QOL [37].

Owners should be made aware of the clinical signs of CKD. This can include a dull coat, muscle wasting, delayed skin turgor, lethargy, inappetence, and polyuria [38]. At home, they may first notice their cat having an increase in urine production (polyuria) and an increase in water consumption (polydipsia). Cats often do not drink all the water they are offered, so it can be more difficult for owners to notice a change in their daily water consumption. Polyuria is often the first clinical sign noticed by owners when they see an increased amount of urine located in their cat's litter box. When signs of polyuria and polydipsia are observed, around two-thirds of kidney function has already been lost. If medical treatment is started in the earlier stages of the disease, it can slow down the progression [39].

Advanced stages of CKD can also include inappetence, poor hair coat, weight loss, vomiting, and lethargy. Severe dehydration will occur with the presence of inappetence, decrease water consumption, polyuria, and vomiting. Owners should be aware when these conditions occur it can cause chemical imbalances and their pet can deteriorate rapidly. This can be life threatening and veterinary intervention should be sought out quickly. Owners understanding the progression of CKD will provide them with the knowledge they need to recognize signs earlier and perhaps the chance to delay the progression of the disease [39], see Chapter 27: "Urinary and Renal," for further information.

5.7.8.1 Hydration Maintenance at Home

Fresh water should be provided at all times in a cat's environment. Owners should be encouraged to provide multiple water sources. This includes offering multiple bowls in a variety of depths and sizes, flowing water fountains, or flavored water to increase water consumption. A canned food diet will also increase water intake and water may be added for increased hydration. Careful consideration must be taken when adding water due to the calorie–volume ratio to ensure the body weight is being maintained [40]. A feeding tube can be used as well to maintain long-term hydration and provide nutritional support if it is needed [41].

In advanced stages of CKD, subcutaneous fluids can be used to maintain hydration (see above section in this chapter for recommendations on client education for subcutaneous fluid administration techniques). Owners can administer fluids at home as prescribed by their veterinarian [40].

Constipation can be an increased risk to occur in cats with CKD due to medications that have administered dehydration and reduced gastrointestinal motility. Fecal material should not be in small firm pieces but be moist and logged shaped [38]. Signs of constipation can include frequent trips to the litter box, straining, production of dry fecal material, and vomiting. Owners should monitor for constipation at home, and if signs are observed they should seek veterinary intervention [42]. It may be advantageous to increase soluble fiber to their diet by providing laxatives, stool softeners, as well as increasing their hydration for the management of chronic constipation [40].

5.7.8.2 Nutritional Requirements

Nutritional requirements are important client education topics that should be reviewed with every CKD cat owner. Cats with CKD should be fed small frequent meals in a day to maintain their daily energy requirements. Kidney diets tend to limit both protein and phosphorus content and be more calorie dense. These diets also have reduced sodium content and have supplementation omega-3 fatty acids, potassium, B vitamins, and antioxidants. Use of these diets has increased longevity in cats with CKD. Limiting protein can reduce signs of uremia being present and the severeness of renal pathology when phosphates are reduced. Cats demonstrating signs of azotemia are recommended to start a kidney diet. A canned diet is preferred over a dry formulation to increase water consumption. Due to the restricted protein content, these diets tend to be less palatable and may lead to inappetence in advanced CKD cases. Owners should be made aware of the benefits of feeding a kidney diet, and that a slow transition needs to occur over 4–8 weeks to improve the acceptance. Medications should not be mixed with the diet to prevent additional aversions to the change. Homemade diets can be fed if a commercial diet has not been a success, but they must be formulated by a veterinary nutritionist to ensure they are nutritionally balanced [41].

5.7.9 Providing Support to Cat Owners

One of the key roles of a veterinary technician is being an advocate to our patients. Taking the initiative to provide education on how owners can deliver the very best care to their animals will help with overall compliance and success [43]. Many owners can feel overwhelmed when they hear about a diagnosis their cat has recently received. There can be concern about the specific diagnosis and the various treatment options available to them. Following up with a phone call a few days after options are presented can provide owners with emotional support and the opportunity to answer other additional questions about a treatment or diagnosis [40].

Educational materials presented in a written format will provide owners with accurate information about their pet's diagnosis. This will prevent the risks of owners finding uneducated or misleading information from an online source [43]. After verbal or written instruction is given, offer the opportunity for the owner to ask any questions about the material they have received. Any client communication that is provided needs to be documented in the patient's medical record. This will ensure everyone on the veterinary team is aware of the recommendations offered to the owner and what treatments were performed on the patient [43].

Diseases that require lifelong management can be challenging for both the veterinary team and cat owner. Planning a routine for medical rechecks, treatments, home care recommendations, and educational materials will provide the owner with reassurance and reduce their stress. Nobody is prepared when they hear their pet's diagnosis, but if frequent communication and resources are provided it will ensure owners that the veterinary team is looking to provide their pet with the very best QOL [40].

5.7.10 End-of-life Care

When a cat is diagnosed with the advanced stages of an illness, the objective for the patient changes. The efforts move from treating a disorder to maintaining their comfort level and QOL. One of the main goals with end-of-life care is to protect the connection between the owner and the pet so it does not place strain on the human-animal bond. Communicating about end-of-life care will provide owners with the guidance they need when making decisions for their pet. Taking the time to explain the disorder, prognosis, treatment options, and understanding the owner's values with the process will be the support needed to make reasoned decisions around end-of-life care [44].

A cat's personality and temperament should be taken into consideration when discussing QOL with an owner. If a fear-anxiety emotional response occurs when treatments are administered, it can sever the human-animal bond between cat and owner. Identifying the reason for fear or discomfort occurring should be reviewed and prevented (e.g. medication

administration). This may essentially outweigh the benefits of treatment and should be considered when discussing QOL with pet owners. As veterinary team members, it is crucial that we attempt to make the interaction positive to alleviate the owner's distress. Understanding the potential wants, beliefs, financial budgets, and goals for end-of-life care for the owner will continue to develop the veterinary–client–patient relationship. Providing continuous communication about the care for their cat will increase their overall confidence and respect of the veterinary team [44].

Providing education that can be easily followed and understood through the use of verbal, written, and visual (e.g. videos) directions will aid in home end of life comfort care. This will ensure owners have realistic expectations and understand the treatment options that are available to them. Demonstrating how to handle their pet and administer treatments safely will aid in the success of management at home. It is important their environment is discussed and that modifications may need to be made to improve QOL. This can include easier access to the litter box, the design of the box, food, water, and comfortable bedding. Frequent communication should be continued regularly so owners can feel reassured and comforted when making decision with their cat's end of life care [44].

When a cat has entered the final stages of its life, the entire veterinary team has the responsibility to provide emotional support and empathy to owners. It is important that the veterinary team and owners work together when discussing end-of-life care and assessing their QOL. Owners do know their pet best and by working with the veterinary team, realistic outcomes and the patient's best interest can be reviewed and evaluated. It is important for owners to understand that it is all right to feel the emotions they are experiencing. Resources should be provided to grieving owners (e.g. pet loss support group), so they get emotional assistance and not feel they have to go through this grief alone. Providing exceptional communication during end-of-life care will ensure that their pet's overall wellbeing is in the best interest of the whole veterinary team [44].

Veterinary technicians are the communication link between veterinarians and pet owners. Speaking in a clear and simple manner, being engaged, actively listening, and being attentive to an owner's concerns will result in effective communication being provided. Supplying educational materials and resources for an owner to understand their cats' needs will improve overall compliance with care. It will demonstrate you have their pet's best interest in mind and continue to strengthen the veterinary–client–pet relationship during each feline life stage they experience.

See the companion website for further clinical references.

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6

Anesthetic Considerations for the Feline Patient

Lanette Jordan, BS, LVT, VTS (Anesthesia and Analgesia)

TECHNICIAN TIDBITS

- Minimum recommended anesthesia supplies
  - Intravenous (IV) catheter
  - Cuffed endotracheal tube with Murphy eye
  - Laryngoscope
  - Anesthesia machine
  - Nonrebreathing (NRB) circuit with pressure manometer
  - Capnography machine
  - Stethoscope
  - Thermometer
  - Blood pressure monitor
  - Pulse oximeter with waveform
- Airway obstruction
  - Cats have a higher incidence of airway obstruction either due to laryngeal spasm, mucus blockade, or kinking of the endotracheal tube.
    - Monitor the patient during induction and recovery for laryngeal spasm.
    - Apply lidocaine preemptively after induction, before intubation.
    - Have more injectable induction agents, lidocaine, and re-intubation supplies during recovery.
    - Use capnography to monitor for partial or complete occlusions.
    - Have airway suction catheters and re-intubation supplies available.
- Anesthesia machine
  - To maintain the integrity of the machine, performing safety checks and servicing of the individual parts should be part of every clinic's routine.
  - Add a temporary occlusion valve (spring-loaded pop-off valve) to the anesthesia machine to reduce human error from forgetting to open the pop-off valve.
  - Add a positive pressure relief valve (e.g., EMD valve®) that will release pressure within the system around 25 cm H_2O, reducing the instance of barotrauma should the pop-off valve be accidentally closed.
  - If your patient has inspired carbon dioxide (CO_2) on an NRB system, increase your oxygen flow rate.
- Bradycardia
  - Bradycardia is a common complication during anesthesia, which is usually less than 100 bpm in most cats.
    - Causes may include, but are not limited to anesthetic and analgesic agents, vagal tone, hypertension, hyperkalemia, hypothermia, and increased intracranial pressure.
    - Treatment: treat the cause/source and use anticholinergic.
- Electrocardiogram
  - Crocodile clips with serrated teeth can cause damage to the skin. Use atraumatic clips and move them frequently during the procedure to reduce clamp trauma to the skin, or use adhesive electrode pads instead.
  - Conductive gel is preferred over alcohol when using clips because it is nonflammable and does not evaporate as quickly.
  - When using Lead II, the white and red electrodes need to transect the heart.

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- Hypotension
  - Hypotension is a common complication during anesthesia. In small animals, the mean arterial blood pressure should be kept >60 mmHg [1].
  - If hypotension is encountered, discuss the following options with your veterinarian:
    - Decrease anesthetic depth, if possible, without the patient becoming too light.
    - If the patient is bradycardic, consider an anticholinergic.
    - If the patient is hypovolemic or vasodilated, consider a fluid bolus.
    - If the patient is normovolemic and not bradycardic, consider a positive inotrope or vasopressor.
- Indirect blood pressure
  - A blood pressure cuff that is too large will produce lower than actual values.
  - A blood pressure cuff that is too small will produce higher than actual values.
  - Electrical interference may occur in the Doppler from other equipment, even cellular devices making it difficult to hear the pulse.
  - Oscillometric devices may have trouble reading during periods of bradycardia, tachycardia, dysrhythmias, vasoconstriction, or movement.
  - When purchasing an oscillometric device, make sure it conforms to the American College of Veterinary Internal Medicine Consensus Statement for validation.
- Capnography
  - Talk to manufacturing companies to ensure that the capnography sampling is appropriate for your practice.
  - Check for cracks in the capnography adaptors.
  - Check the sampling lines, filter, and water traps for condensation or water occlusions and replace them as needed.
  - Trim the endotracheal tube and use low-dead-space capnography adaptors when available to reduce mechanical dead space.
- Pulse Oximetry
  - If the transmittance probe is having trouble reading due to tissue bed occlusion from the spring-loaded clamp.
  - Try to use a thicker tissue bed or create one by folding the tongue and attaching the clip to the folded area.
  - Try a reflective probe taped to the ventral aspect of the tail base.
- Hypothermia
  - Hypothermia is a common anesthetic complication. Small patients are at the greatest risk due to the increased surface area-to-body mass ratio. Active warming and passive insulation should be used in combination for the best results in maintaining temperature.
    - Active warming examples: convection-type warm air devices (BAIR Huggers™), electrically conductive fabric warmers (HotDog® Warming Device), circulating warm water blankets (Gaymar T/Pump®), chemically activated warm packs (TransWarmer®), and continuous fluid warmers (Astoflo Plus eco).
    - Passive warming examples: reflective emergency rescue blanket, bubble wrap, blankets, and socks.
- Fluid administration
  - Cats are at an increased risk of fluid overload.
    - Cats have a lower blood volume per kilogram than dogs (40–60 ml/kg)
    - Cats are small and therefore care must be taken to ensure that administering drugs and flushing the IV catheter do not exceed the patient's fluid rate.
    - Cats may have a higher incidence of undiagnosed cardiac disease.
  - Ways to ensure accurate fluid administration:
    - Use a fluid pump or syringe pump.
    - If using a drip rate, use a burette and only fill it with a volume that is a set amount (the author likes to fill the burette with 1 hour's amount of fluid and refill it every hour as needed for the procedure).

The goal of anesthesia is to allow loss of consciousness, muscle relaxation, and amnesia to facilitate a procedure. Any species can have inherent complications with anesthesia; however, cats continue to have an increased risk compared to dogs [2–7]. These anesthetic challenges may be attributed to the small size of the species, the variation in some drug metabolism and elimination, undiagnosed or underlying diseases, and increased fear and stress that may be present when the patients are brought into the hospital setting. This chapter will discuss ways that the veterinary technician can contribute to the veterinary team by performing a comprehensive patient evaluation and creating an individualized anesthetic plan to maintain adequate anesthetic depth, reduce anesthetic complications, and support normal homeostatic physiologic processes through the four phases of anesthesia: preanesthetic, induction, maintenance, and recovery.

6.1 Preanesthetic Phase

The preanesthetic phase is the time before the patient is induced and includes the preanesthetic assessment, anesthetic protocol, premedication, and intravenous (IV) catheterization. Since the veterinary technician is often one of the first people with whom a client and patient interact in a clinical setting, veterinary technicians are vital in obtaining information about the patient that can be used to impact decisions in developing the anesthetic protocol. The anesthesia technician should also be knowledgeable about equipment and drug availability to ensure the viability of the plan.

6.1.1 Preanesthetic Assessment

The preanesthetic assessment allows the veterinary team to assess the overall risk anesthesia and the procedure pose to the patient. Based on the preanesthetic assessment potential risks and complications can be identified and planning implemented to prevent or reduce those potential risks. This information will help assign a rating of anesthetic risk called an ASA status as originally developed by the American Society of Anesthesiologists.

6.1.1.1 Patient History

The first step of the preanesthetic assessment is determining the patient's signalment, which includes the patient's species, breed, age, and reproductive status. The next step is obtaining a thorough history, which consists of obtaining the chief complaint, current medical conditions, and current medications. It is well known that obtaining a complete and accurate patient history can often be difficult, especially for feline patients, due to various factors. Many cats may spend time outdoors or live in multi-cat households, which limits the owner's knowledge of their eating, drinking, urinating, and defecating habits. Cats also often do not show obvious clinical signs of disease, or the owner assumes the subtle signs are normal for the animal. Therefore, a history questionnaire, as well as educational handouts for the owners on signs and symptoms of common diseases in cats, can help to provide a more comprehensive history. The AAFP/AAHA Feline Life Stage Guidelines can aide in developing a patient assessment based on a variety of factors [8]. For further information, see Chapter 4: "Life Stage Considerations."

6.1.1.2 Physical Examination

After obtaining the patient's history, the veterinary technician should participate in a physical examination with the veterinarian. The physical examination findings (Tables 6.1 and 6.2) can be used not only to identify underlying conditions that may not have been apparent to the owner but also to create a baseline of values [3]. Any changes in those values during the hospital stay could alert the veterinary staff to changes in the patient's condition that may influence patient management. However, cats may experience anxiety or stress during their hospital visit and therefore require special consideration. For further information on interactions, refer to Chapter 2: "Feline Friendly Interactions" or the FeVMA and ISFM offer Feline-friendly Nursing Care and Feline-friendly Handling Guidelines to aid in educating the veterinary team on ways to mitigate the stress of the hospital stay [9, 10]. Fear and stress can cause catecholamine release, which can cause tachycardia, tachypnea, and hypertension, all of which may augment the baseline values obtained during the examination and should be noted when considering patient management and protocol development. Fear and stress can also increase the risk of anesthesia. Therefore, the veterinary team should always be mindful of reducing fear and anxiety to create an overall safer anesthetic experience [2].

Table 6.1 Anesthetic physical exam. A minimum physical assessment to aid in creating an anesthetic plan.

Body weight
Body condition score
Mentation/temperament
Pain score
Hydration status
Heart rate, character, ECG, and pulse rate
Respiratory rate and character
Temperature

Table 6.2 Range of normal values.

Temperature: 100–102 °F (rectal)
Heart rate/pulse rate: 120–200 beats/min
Respiratory rate: 20–30 breaths/min

Adapted from [2]. Normal ranges in a feline patient for temperature, heart rate, and respiratory rate. Patients may differ slightly from the range.

6.1.1.3 Diagnostic Testing

The veterinary technician should be able to identify risk factors during the history or physical examination to help determine the best diagnostic testing for the patient [2]. Blood sampling is usually the first step in identifying underlying diseases that could increase anesthetic risk. Minimal blood testing could consist of a packed cell volume (PCV), total solids, blood glucose, and renal status, such as an Azo-Stick® for blood urea nitrogen. These four markers could help identify anemia, dehydration, hypoproteinemia, azotemia, hypoglycemia, or hyperglycemia. If any of these values were abnormal then further diagnostic testing could be performed. If the patient is at risk of having a coexisting disease, such as hepatic lipidosis, kidney disease, hyperthyroidism, or cardiomyopathies, or if the patient had previous abnormalities on bloodwork, it would be beneficial to go ahead and obtain more diagnostics like a complete blood count (CBC), blood chemistry, T4, and NT-proBNP [2]. Other diagnostic testing like coagulation, blood typing, and/or cross-matching, may be warranted depending on the risk of bleeding during the procedure. See Chapter 11: "Interpretation of Common Diagnostic Test Results," for further reading.

Patient handling for blood sampling can be accomplished in many ways. The crucial factor is that the technician be well-prepared before handling the patient, including gathering and organizing the supplies for efficient use, as well as communicating each step of the process if an assistant is required. Common sites of blood collection include the medial saphenous, cephalic, and jugular veins. The selection of the vein will depend on several factors, such as sample size requirements and patient considerations like the location of future catheter placement or comorbidities, such as coagulopathies or increased intracranial or intraocular pressures [3]. The need for blood sampling will also have to be balanced with the stress induced by the patient. If the bloodwork findings will not alter the anesthetic plan or the procedure in an emergency, then blood sampling could occur after the patient is immobilized or anesthetized.

Other diagnostic tests may include, but are not limited to, diagnostic imaging, urinalysis, noninvasive blood pressure, electrocardiogram (ECG), cytology, and histology. Again, the amount of other diagnostic testing will depend on the findings from the history and physical examination.

6.1.1.4 ASA Status

Once all the information has been collected from the history, physical examination, and diagnostic testing, an anesthetic risk classification can be determined. The American Society of Anesthesiologists created the ASA status to assess and classify a patient's preanesthetic risk based on comorbidities present (Table 6.3). When combined with the known perioperative risks involved with the type of procedure, the ASA status can help predict the overall risk of anesthesia and help shape the anesthetic protocol that the veterinary team develops [11].

Table 6.3 ASA classification system.

1: Normal healthy patient.
2: Mild systemic disease.
3: Severe systemic disease.
4: Severe systemic disease that is a constant threat to life.
5: Moribund, not expected to survive.
E: Denotes emergency procedure (delay may lead to increased threat to the patient's life or body part).

Adapted from [11]. An ASA classification allows a patient to be categorized into a level of anesthetic risk.

6.2 Anesthetic Phase

The anesthetic phase will include premedication, induction, maintenance, and perioperative pain management drugs, as well as monitoring equipment and plans for supportive techniques, such as fluid therapy, warming devices, and emergency drug calculations. It is important that the veterinary technician play an active role in helping develop the anesthetic protocol, as they are generally the ones that are monitoring the patient throughout the procedure. Anesthesia technicians should be knowledgeable about the use and effects of the drugs in the protocol, as well as be able to troubleshoot the anesthetic equipment available at the facility. This will allow the veterinary technician to communicate with the rest of the veterinary team effectively and efficiently about any changes occurring during the anesthetic event.

6.2.1 Premedication

Once the anesthetic protocol has been created and all the supplies and equipment for the anesthetic event have been prepared, the patient can be premedicated. Premedication is the administration of sedatives or tranquilizers, and usually an analgesic, if there is a risk of pain, before general anesthesia. This combination is called neuroleptanalgesia. The two agents have a synergistic effect, which means they increase the intensity of each other. The synergistic effect allows the use of lower dosages of each agent to achieve the desired sedation and analgesia [12]. The goals of premedication are to provide chemical restraint, muscle relaxation, anxiolysis, analgesia, and reduction of induction and maintenance anesthetics.

The intramuscular (IM) route is commonly preferred for premedication when an IV catheter is not present due to its more reliable uptake within the body [12]. Any skeletal muscle can be used, but the epaxial muscles and muscles of the cranial and caudal thigh are common choices (Figure 6.1). Be aware that it is easy to miss the muscle in the caudal thigh and inject inadvertently in the fascia between the muscles, thus reducing or prolonging absorption of the premedication. Buccal or oral transmucosal (OTM) can be an option for cats exhibiting protective emotions when other routes are not feasible, depending on the drug. However, the anesthesia technician needs to ensure that the drugs are administered within the cheek pouch rather than swallowed to prevent first-pass hepatic metabolism [12, 13]. The subcutaneous route has shown unreliable uptake and should not be used, if possible, except for drugs specifically labeled for only the subcutaneous route, such as nonsteroidal inflammatory drugs [12].

6.2.1.1 Premedication Agents

When selecting premedication drugs, the benefits of each agent must outweigh the disadvantages. A list of drugs commonly used for premedication is provided in Table 6.4. Not only does the veterinary technician need to consider which



Figure 6.1 Premedication in the caudal thigh. A patient receiving premedication via intramuscular injection in a caudal thigh muscle. *Source:* Lanette Jordan.

Table 6.4 Premedication options. Examples of premedication options with suggested dose ranges, estimated durations, advantages, and disadvantages. These drugs can be used alone or in combinations depending on the procedure, patient, and discretion of the veterinarian [12, 14, 15].

Drug	Dose	Use	Other benefits	Duration	Disadvantages
Acepromazine	0.01–0.05 mg/kg IM or IV (lower end of dose range recommended for IV)	Mild sedation	• Antiemetic • Antihistamine	4–6 h (variable)	• Slow onset (~15 min IV or ~30 min IM) • No analgesia • No anxiolysis • Vasodilation (contraindicated if patients are at high risk for hypotension or hypovolemia • Antihistaminic effect (contraindicated if a patient undergoing allergy testing)
Dexmedetomidine	1–20 mcg/kg IM or IV (lower end of dose range recommended for IV)	• Reliable sedation • Mild-to-moderate analgesia • Muscle relaxation • Reduction in the amount of injectable or inhaled anesthetics required to maintain anesthesia	• Synergistic with opioids • Shorter onset (10–20 min)	2–3 h	• Peripheral vasoconstriction increases systemic vascular resistance causing hypertension and reflex bradycardia • Centrally mediated bradycardia • Inhibition of insulin release leading to hyperglycemia • Inhibition of antidiuretic hormone leading to increased urine production • Vomiting from stimulation of the chemoreceptor trigger zone
Alfaxalone	2–3 mg/kg IM or IV (lower end of dose range recommended for IV)	• Sedation • Induction • Maintenance of anesthesia	Minimal cardiovascular effects	Dependent on dose 5–30 min IV 15 min–2 h	• Large volume to administer IM • May lead to immobilization, the patient may require intubation, especially at higher doses or when administered IV • Shivering, twitching, muscle rigidity, agitation, and noise sensitivity may be seen in recovery

Ketamine	3–10 mg/kg IM or IV (lower end of dose range recommended for IV)	• Sedation • Immobilization • Induction • Analgesia	Increases sympathetic tone.	IM IV 15 min	• Contraindicated in patients with HCM • Contraindicated in patients with significant renal insufficiency • Contraindicated in patients with uncontrolled hyperthyroidism • May lead to immobilization, the patient may require intubation, especially at higher doses or when administered IV • Muscle rigidity • Pain on injection • Emergence delirium may occur on recovery • May increase ICP and IOP • May result in hyperthermia due to increased muscle tone when inhalant is not used • May result in apneustic breathing pattern • Eyes may remain central
Tiletamine/ zolazepam	2–10 mg/kg IM or IV (lower end of dose range recommended for IV)	• Sedation • Immobilization • Anesthesia		Surgical anesthesia may last up to 30 min. But sedation may last up to 4 h	• May have a longer recovery due to zolazepam lasting longer than tiletamine in a cat • Contraindicated in patients with HCM, significant renal insufficiency, and uncontrolled hyperthyroidism • May lead to immobilization, the patient may require intubation, especially at higher doses or when administered IV • Muscle rigidity • Pain on injection • Emergence delirium may occur on recovery • May increase ICP and IOP • May result in hyperthermia due to increased muscle tone when inhalant is not used • May result in apneustic breathing pattern • Eyes may remain central
Methadone	0.3–0.5 mg/kg IM or IV (lower end of dose range recommended for IV)	• Analgesia • Anesthetic-sparing • NMDA antagonist properties	No vomiting	4–6 h	• Bradycardia • Hyperthermia

(Continued)

Table 6.4 (*Continued*)

Drug	Dose	Use	Other benefits	Duration	Disadvantages
Hydromorphone	0.025–0.1 mg/kg IM or IV (lower end of dose range recommended for IV)	• Analgesia • Anesthetic- sparing		4–6 h	• Bradycardia • Vomiting • Hyperthermia (almost 40% of postoperative cats)
Morphine	0.2–0.5 mg/kg IM or IV (lower end of dose range recommended for IV)	• Analgesia • Anesthetic- sparing		4–6 h	• Bradycardia • Vomiting • Hyperthermia • Histamine release
Butorphanol	0.2–0.4 mg/kg IM or IV (lower end of dose range recommended for IV)	• Sedation • Can antagonize (reverse) mu agonist opioids		1–2 h May last up to 5 h	• Bradycardia • Vomiting • Hyperthermia
Buprenorphine	0.02–0.04 mg/kg IM or IV (lower end of dose range recommended for IV)	Mild-to-moderate analgesia	• Minimal cardiovascular effects • Available in various concentrations for varying durations • Can be administered via OTM although IM or IV has been shown to provide better analgesia	4–8 h	• Delayed onset of 30–45 min after IM or IV • Has a higher affinity for the mu receptor than other opioids (hard to override) • Bradycardia • Vomiting • Hyperthermia • Euphoria
Midazolam	0.1–0.5 mg/kg	• Reduction of induction agent dosage when used as an adjunct to induction • Reduction of MAC of inhalant • Skeletal muscle relaxation • Anticonvulsant activity	Minimal cardiopulmonary effects	Unpredictable pharmacokinetics	• May cause dysphoria, agitation, and/or excitatory reaction • No clinically relevant analgesia • Caution in patients with hepatic disease

ICP, intracranial pressure; IOP, intraocular pressure.



Figure 6.2 Intravenous catheterization. A patient receiving an IV catheter in the cephalic vein. *Source:* Lanette Jordan.

agents to use for premedication, but also the location of the patient before and after premedication to reduce patient stress and ensure a greater premedication effect. For example, providing separate areas for dogs and cats before and after premedication may offer the ability to provide a quiet, dark room with minimal stimulation, which will reduce fear and stress and allow more profound sedation.

6.2.1.2 Intravenous Catheterization

Usually, after the premedication phase, when the patient is adequately sedated, an IV catheter is placed, if not already present, in the patient. Intravenous over-the-needle catheters come in a variety of types and are usually the preference of the practice or veterinary professional. Common sites of peripheral IV catheterization are the cephalic or medial saphenous veins, with the location depending on the procedure being performed. For example, procedures involving the head, such as intraocular procedures, would benefit from a catheter in the hindlimb to allow for easier accessibility during the procedure. See Figure 6.2 for an example of a catheter placed in the cephalic vein of the front limb for a patient undergoing an abdominal procedure. IV catheters are recommended for general anesthesia because they allow safe and easy drug titration during anesthetic induction as well as intraoperative fluid or medication administration. See Table 6.5 for step-by-step instructions. The author recommends that any critical patient have an IV catheter placed in case emergency drug intervention is required.

6.2.2 Induction Phase

After an IV catheter is secured, general anesthesia is induced. During induction, the patient will transition from consciousness to unconsciousness with the goal of that transition to be as smooth as possible. The transition is divided into stages and planes of anesthesia (Table 6.6). Ideal induction agents would work rapidly to move the patient from stage I to stage III and avoid excitement or undue stress.

6.2.2.1 Induction Agents

6.2.2.1.1 Intravenous

The author's preferred method of induction for felines is with an IV agent through an IV catheter (Table 6.7). This method allows the drug to be titrated to achieve the desired level of unconsciousness in the patient and reduces the risk of administering more agents than is necessary which would increase the likelihood of having adverse side effects from the induction agent(s). "Off-the-needle" injections are not recommended due to the increased risk of perivascular injection. The choice of induction anesthetic used should be made on a case-by-case basis as there are advantages and disadvantages to each agent.

Table 6.5 Steps of intravenous catheterization. Suggested materials and steps to place an IV catheter.

Materials

1. Over-the-needle catheter
2. Aseptic prep
3. Tape
4. Clippers
5. Syringe of normal saline
6. T-port or injection cap

Technique

1. Select the size of the catheter (most adult cats take a 22–20G)
2. Flush the T-port extension line
3. Tear tape to secure the catheter to the limb based on preference
4. Have an assistant restrain the patient and occlude the desired vessel
5. Clip and aseptically prepare the desired site of catheterization
6. Nick the skin with a hypodermic needle to reduce skin drag on the catheter at the desired site of puncture (preference)
7. Insert the catheter at 30–45° angle and advance toward the vessel
8. Once a flash of blood is seen in the stylet, advance the catheter and stylet slightly farther into the vessel to ensure that the catheter is in the lumen of the vessel then slide the catheter off the stylet while keeping the stylet still to help guide the catheter
9. Once the catheter has been fed completely to the skin, the stylet can be removed, and the T-port or injection cap placed on the catheter
10. Secure the catheter with tape
11. Flush the catheter to check for patency

Table 6.6 Guedel's stages of anesthesia.

Stage	Plane	Description
I (Disorientation)		Amnesia/disorientation
II (Excitement)		Excitement/delirium Loss of consciousness May struggle, paddle, or vocalize
III (Surgical)	1 (Light)	Loss of motion Decreased response to stimulus The eye position is central or slightly rotated Palpebral reflex is present Cough or swallow may be present
	2 (Medium)	Loss of motion Decreased response to stimulus Eye position is rotated ventromedial Palpebral reflex is weak or absent Cough or swallow is absent
	3 (Deep)	Loss of motion Decreased response to stimulus Eye position is slightly rotated back to central Palpebral reflex is absent Cough or swallow is absent
	4 (Very deep)	Loss of motion Decreased response to stimulus Eye position is central Palpebral reflex is absent Cough or swallow is absent

Adapted from [16]. Descriptions that can allow the classification of the stages and planes of anesthesia in a patient.

Table 6.7 Injectable induction agents. Examples of induction options with suggested dose ranges, advantages, and disadvantages. These drugs can be used alone, in combination, or with other adjuncts depending on the procedure, patient, and discretion of the veterinarian [17–19].

Drug	Dose	Advantages	Disadvantages
Propofol	4–8 mg/kg IV	Fast onset Short duration Smooth induction Decreases cerebral metabolic oxygen consumption, cerebral blood flow, and intracranial pressure Antiepileptic activity Partial extrahepatic elimination	No analgesia dose-dependent cardiopulmonary depression The preservative-free formulation needs to be discarded 6–8 h after being punctured to reduce instances of bacterial growth The benzyl alcohol used in some formulations of propofol does not cause toxic effects in cats when used in normal clinical protocols Myoclonus or excitatory movements may occasionally occur May predispose the patient to gastroesophageal reflux May cause oxidative injury (Heinz body formation) with repeated exposure Prolonged recovery due to prolonged infusions or repeated exposures due to slow clearance
Alfaxalone	2–5 mg/kg IV	Fast onset Short duration Smooth induction Decreases cerebral metabolic oxygen consumption, cerebral blood flow, and intracranial pressure Can be given intramuscularly (off-label) Less apnea and vasodilation than propofol Does not cause oxidative injury of red blood cells	No analgesia Dose-dependent cardiopulmonary depression Poor recovery was noted in short procedures or without other sedatives (shivering, twitching, muscle rigidity, agitation, and noise sensitivity) This may predispose the patient to gastroesophageal reflux
Etomidate	1–3 mg/kg IV	Fast onset Short duration Minimal cardiovascular and respiratory effects Decreases cerebral metabolic oxygen consumption, cerebral blood flow, and intracranial pressure Decreases intraocular pressure Antiepileptic activity	No analgesia Rough induction if not well premedicated or without adjunct (myoclonus, excitatory movements, vomiting, salivation) Myoclonus Adrenocortical suppression May predispose patients to gastroesophageal reflux May cause hemolysis

(Continued)

Table 6.7 (*Continued*)

Drug	Dose	Advantages	Disadvantages
Ketamine	5–6 mg/kg IV	Minimal respiratory depression Sympathetic stimulation (increases heart rate, and blood pressure) Antihyperalgesic/analgesic Does not significantly change gastroesophageal sphincter pressure Can be given intramuscularly	Muscle rigidity (tip: combine with benzodiazepine, alpha-2-agonist, or propofol) Patients may retain cough or swallow reflexes Sympathetic effect (increases heart rate, and blood pressure) which may be contraindicated in patients with hypertrophic cardiomyopathy or hyperthyroidism Cats primarily excrete ketamine unchanged through their kidneys so it may be contraindicated in patients with significant renal insufficiency May increase intracranial pressure and intraocular pressure Emergence delirium may occur in recovery May result in hyperthermia due to increased muscle tone if inhalant is not used This may result in an apneustic breathing pattern Eyes may remain in a central location which may alter the assessment of depth and increase the risk of corneal abrasion
Tiletamine/ Zolazepam (Telazol)	1–4 mg/kg IV	Minimal respiratory depression Sympathetic stimulation (increases heart rate, and blood pressure) Antihyperalgesic/analgesic Can be given intramuscularly May have a smoother recovery than using ketamine due to zolazepam lasting longer than tiletamine in a cat	Requires reconstitution Limited shelf-life after reconstitution Cats may have a slow recovery due to the prolonged duration of zolazepam Patients may retain cough or swallow reflexes Sympathetic effect (increases heart rate, and blood pressure) which may be contraindicated in patients with hypertrophic cardiomyopathy or hyperthyroidism May increase intracranial pressure and intraocular pressure Emergence delirium may occur in recovery This may result in an apneustic breathing pattern Eyes may remain in a central location

Preoxygenation via a face mask for 3–5 minutes prior to induction is beneficial to many patients to reduce the instances of hypoxemia during induction; however, the veterinary staff may need to assess the pros and cons if the process of preoxygenation would cause undue stress to the patient.

6.2.2.1.2 Inhaled

Although a mask or chamber induction is possible with an inhalant anesthetic, these methods often have more risks for the patient and veterinary staff. Inhalant induction usually takes longer for the patient to reach the appropriate level of unconsciousness and often allows the patient to go through the excitatory phase, which could lead to injury themselves or to the veterinary staff [20]. For example, during the process, the patient may become apneic, or vomit, and not yet be at a point where they can be intubated to protect the airway from aspiration and provide ventilation.

Mask and chamber inductions also often require high levels of inhalant, which puts the patient at risk for cardiovascular and respiratory depression and increases the exposure of veterinary staff to waste anesthetic gas.

6.2.2.1.3 Intramuscular

IM induction can also be an alternative route of general anesthesia and can be achieved via a combination of drugs that include ketamine, Telazol®, or alfaxalone, which can be useful in the immobilization of aggressive animals. Feline population control is one field where injectable-only protocols may be beneficial. The Association of Shelter Veterinarians has guidelines and considerations for such anesthetic protocols [21].

However, this induction method also has risks. With IM induction, the drugs are not titratable; therefore, the dose may result in a patient who is not at the appropriate level of unconsciousness, leading to either an excitatory phase or a very deep plane of anesthesia, and requiring cardiovascular or ventilatory support. It is recommended that any time a sedation protocol or IM induction protocol is administered, veterinary staff be prepared to intubate the patient to protect the airway from aspiration and have the capability to provide ventilatory support should the patient become apneic.

6.2.2.2 Airway Management

Intubation with an endotracheal tube or supraglottic device has many benefits, including the ability to administer oxygen and inhalant anesthetics with no exposure to veterinary personnel, to administer emergency or aerosolized drugs like albuterol, to provide positive pressure ventilation, and to protect the airway from aspiration of orogastric material.

6.2.2.2.1 Endotracheal Tube

The largest endotracheal tube that can fit down the patient's larynx and trachea with minimal resistance should be used to reduce resistance to breathing during spontaneous ventilation due to the decreased diameter of the endotracheal tube. The most reliable method to determine the appropriate size of the endotracheal tube is to palpate the trachea through the neck at the thoracic inlet. The author usually selects one size below and above the predicted tube size to allow for three tubes to choose from during intubation. Most cats will take endotracheal tubes with an internal diameter between 3.5 and 5.5 mm. To reduce mechanical dead space and the risk of endobronchial intubation, the length of the endotracheal tube should be premeasured with the beveled end at the level of the thoracic inlet and the circuit adapter end at the level of the incisors. The circuit adapter end should be trimmed if trimming does not cut the pilot line to the cuff. The process of intubation is listed in Table 6.8.

The most common type of endotracheal tube used in cats is a cuffed Murphy tube (Figure 6.3). With this type of endotracheal tube, there is a balloon that connected via a pilot line to the cuff, with a one-way valve that allows inflation of the cuff with a syringe. The cuff can either be high volume-low pressure or low volume-high pressure with the first being the safest due to a more even distribution of pressure across the cuff if it is not overly inflated. The cuff creates a seal within the trachea to protect the lower airway from aspiration, as well as providing a closed system to reduce exposure of veterinary personnel to waste anesthetic gas. Trauma can occur if the cuff is overinflated, such as ischemic injury to the tracheal mucosa or tracheal rupture [24]. If the patient is going to be repositioned or moved during the procedure, the circuit should be disconnected from the endotracheal tube to prevent the endotracheal tube from becoming displaced or trauma occurring to the trachea. This endotracheal tube also has a secondary outlet at the beveled end called Murphy's eye, which provides a secondary pathway for air to enter the lungs should the beveled end of the endotracheal tube become occluded, such as by a mucus plug. If a mucus plug is suspected, an airway suction catheter can be used to attempt to clear the endotracheal tube. If the suction catheter does not alleviate the occlusion, the patient may need to be extubated and reintubated with a new endotracheal tube (Figures 6.4 and 6.5).

Table 6.8 Intubation. Suggested materials and steps to place an intravenous catheter [22, 23].

Materials:

1. Laryngoscope
2. Three endotracheal tubes
3. Water soluble lubricant
4. Lidocaine
5. Tie to secure the endotracheal tube
6. Tie to allow the assistant to hold the mouth open
7. Gauze to hold the tongue
8. Guide (8fr polypropylene urinary catheter) if guided intubation is preferred
9. Stylet (nylon coated wire), if increased rigidity and dexterity to tube, is required (silicone tubes)

The end of the stylet should not stick out past the distal beveled end of the endotracheal tube

Technique:

1. Select the endotracheal tube
2. Pre-measure and trim to the desired length (Figure 6.4)
3. Check that the cuff inflates appropriately
4. Lubricate the cuff of the endotracheal tube which will enhance the seal of the cuff.
5. Place back in the package if using a new tube or wrap end in gauze to prevent foreign material like hair from sticking to the lubricant
6. Check the patency of the catheter
7. Administer induction agent until the patient has lost the righting reflex and the tongue and jaw are relaxed
8. The assistant will open the mouth by placing one hand over the rostrum just long enough for the tie to be placed in the mouth
9. The anesthetist will place the tie in the mouth behind the canine teeth for the assistant to use to hold the head
10. The anesthetist will place the laryngoscope blade on the tongue and gently drag it out of the mouth for the assistant to grab with the gauze
11. The assistant will extend the tongue between the mandibular canine teeth
12. The anesthetist will then place the laryngoscope blade on the tongue at the vallecula (the space between the tongue and base of the epiglottis) Applying pressure to the tongue until the epiglottis is displaced and the larynx can be visualized (Figure 6.5)
13. Apply a drop of lidocaine to arytenoids to reduce instances of laryngospasm and wait 30–60 s
14. Advance the endotracheal tube bevel between the arytenoids and rotate the tube in a clockwise motion to open the arytenoids a little wider and aid in the advancement of the endotracheal tube. Do not apply force as this could damage the laryngeal tissue. If resistance occurs a smaller tube may be required
15. Advance tube to desired premeasured location
16. Confirm intubation visually or with other monitor devices like a capnogram
17. Perform one throw of a knot on the endotracheal tube and push to the back of the mouth
18. Wrap the ends of the tie behind the head and secure with a bow or slip knot
19. Attached endotracheal tube to breathing circuit with appropriate oxygen flow rate
20. Perform the leak test using the minimal occlusive technique by inflating the cuff using the pilot balloon of the endotracheal tube in small increments (0.2–0.5 ml) until the pressure within the breathing system is holding positive pressure at 20 cm H_2O and no audible air leakages is heard at the mouth from around the cuff. Check that the cuff pressure is within appropriate range (20–30 cm H_2O) using a pressure manometer or digital pressure indicator (e.g., AG Cuffill) on the pilot balloon (62–63)

6.2.2.2.2 Supraglottic Airway Device

An alternative to using an endotracheal tube is using a supraglottic airway device (V-gel®). A supraglottic airway device may be beneficial in some cases where endotracheal intubation could pose more trauma to the larynx, or the veterinary personnel is inexperienced in cat intubation [25–27]. These devices do not actually enter the trachea but have an inflatable bladder that can provide a seal to protect the airway and reduce instances of aspiration as well as allow for positive pressure ventilation [25, 26]. The two main disadvantages of this product are that if the head is being manipulated, the seal is more likely to be disturbed creating a risk for aspiration or exposure to anesthetic gas than if using an endotracheal tube, and the cost of the devices is significantly more than an endotracheal tube.

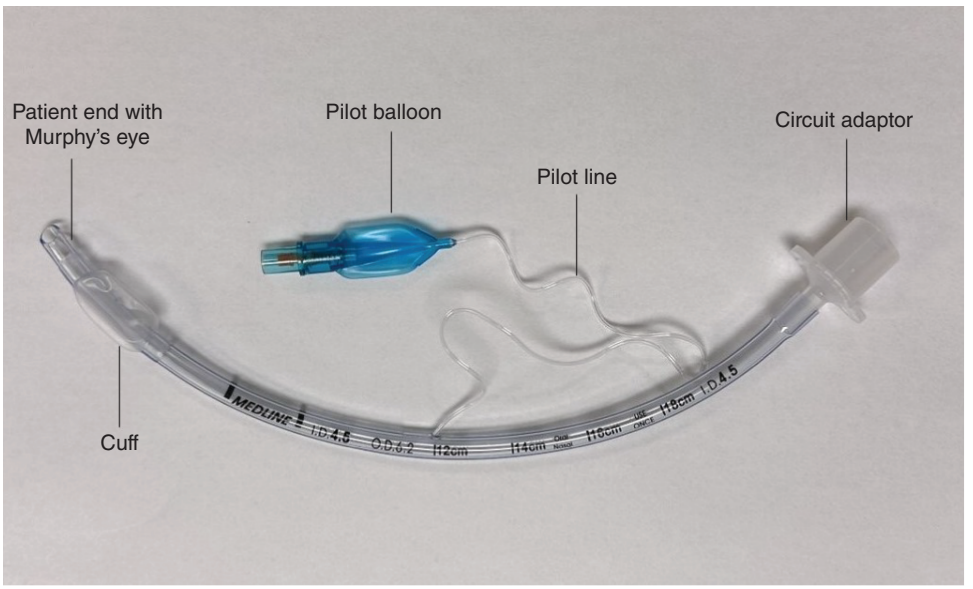


Figure 6.3 Parts of an endotracheal tube. A high-volume low-pressure cuffed Murphy endotracheal tube with labeled parts. *Source:* Lanette Jordan.

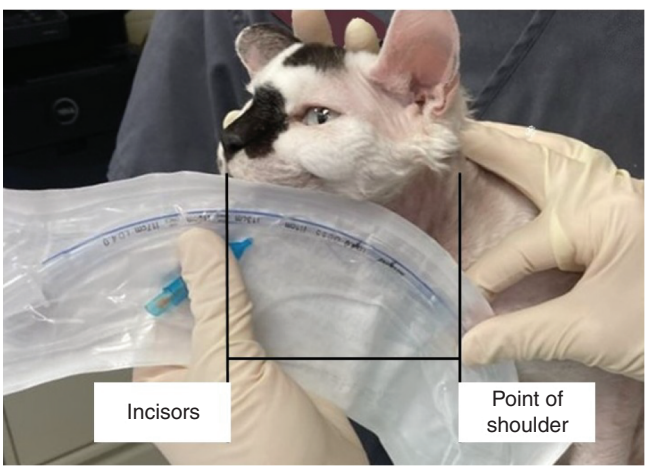


Figure 6.4 Premeasuring the endotracheal tube. Patient getting its endotracheal tube premeasured with the beveled end at the thoracic inlet and the adaptor end at the incisors. The endotracheal tube can then be trimmed at the adaptor end as long as the pilot line does not get cut in the process and the adaptor fits back into the lumen of the tube. *Source:* Lanette Jordan

6.2.3 Maintenance Phase

After induction and intubation, the patient will need some way to maintain a level of unconsciousness for general anesthesia. A common way to maintain general anesthesia is with an anesthesia machine.

6.2.3.1 Anesthesia Machine

The anesthesia machine is designed to deliver oxygen and inhalant anesthetics while also providing a means of eliminating carbon dioxide and waste anesthetic gas from the system. A checklist is an easy way to reduce human error and ensure that responsibility is being taken to check the anesthesia equipment before use (Table 6.9). Part of the checklist should always be performing a leak test to ensure that appropriate amounts of oxygen and inhalant are going to be delivered to the patient with minimal waste anesthetic gas exposure to the veterinary professionals (Table 6.10). If there is a leak, the veterinary technician can listen for air escaping through the leak or can look for bubbles escaping from the leak by spraying the circuit and machine with dilute soapy water. Common sites of a leak include parts of the equipment that get

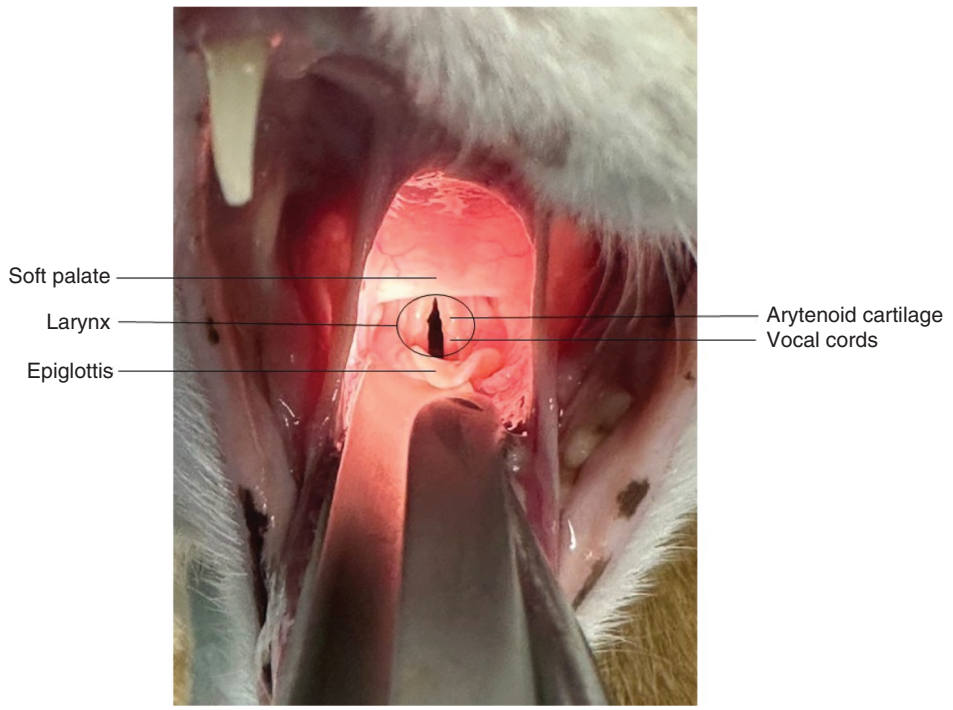


Figure 6.5 Inside a cat's mouth. The view in a patient's mouth with the laryngoscope on the tongue under the epiglottis. Identifiable structures for intubation are labeled. *Source:* Lanette Jordan.

Table 6.9 Equipment check. Suggestions to assess the endotracheal tube and anesthesia machine for appropriate function prior to anesthetizing a patient [28, 29].

Endotracheal tubes (ETT)

- Leak test cuff prior to each use by inflating the cuff with a predetermined amount of air, waiting 5 min, and then aspirating to check that the same amount of air is removed from the cuff.
- Use a bottle brush, and mild detergent to clean the inside of the ETT to prevent build-up and occlusions within the lumen of the ETT if the tube is going to be reused.*

Anesthesia machine

- Check the oxygen supply to ensure there is enough to last through the procedure.
- Check that the flowmeter turns on.
- Check that the vaporizer is filled appropriately.
  - Perform output checks and send off for recalibration as recommended by the manufacturer.
- Perform a leak test of the system, circuit, and bag (Table 6.10).
- Check that the breathing system manometer is functioning.
- Check that your unidirectional valves open appropriately and are dry.
- Check to see if the CO_2 absorbent needs to be changed.**
  - Create a system for recording the date that the absorbent was changed and the hours of use.
  - The author recommends changing the absorbent after 8 h of use or weekly to prevent the granules from drying out due to CO_2 absorption or exposure to air. Desiccated CO_2 absorbent can lead to noxious compound formation like Compound A or carbon monoxide when exposed to inhalant anesthetic.
- Check the scavenging system.
  - Check scavenging tubing for cracks.
  - Weigh the charcoal canister (F-air®) if using passive scavenging.
  - Check that the scavenging interface turns on if using active scavenging.

* Other cleaning protocols may be used. If disinfectants are used the appropriate dilution, contact time, and thorough rinsing must be done to ensure the product does not remain on the ETT and cause irritation to the respiratory tract.
** The appropriate time to change CO_2 absorbent is variable and depends on a variety of factors like the size of the patient, oxygen flow rate, size of the canister, and the humidity of the room, to ensure the product does not remain on the ETT and cause irritation to the respiratory tract.

Table 6.10 Leak checking a machine.

1: Turn on oxygen tank or connect to pipeline
2: Connect circuit
3: Connect reservoir bag
4: Close the adjustable pressure limiting valve (pop-off valve)
5: Occlude the patient end of the circuit
6: Fill the breathing system using the flowmeter or flush valve until the manometer at least reaches 20 cm H_2O
7: Turn down the oxygen flowmeter to 0.2 L/min
8: Watch the pressure manometer to ensure it maintains pressure for 10–20 s (if the manometer needle falls there is a leak that needs to be corrected)
9: Open the pop-off valve while keeping your hand on the patient end of the circuit

Suggested steps to test an anesthetic machine for leaks to ensure the patient is receiving the appropriate amount of anesthetic gas and oxygen as well as reduce veterinary personnel exposure to waste anesthetic gas.

manipulated frequently, such as the reservoir bag, circuit connections, seals around the carbon dioxide absorbent canister, and unidirectional valve domes.

The selection of a rebreathing (RB) system/circuit and an nonrebreathing (NRB) system/circuit depends on a variety of factors. NRB systems, also called Mapleson systems, offer less resistance to breathing than RB systems, which mainly comes from the carbon dioxide absorbent and unidirectional valves present in RB systems and offer less dead space than many RB circuits. Mechanical dead space is any area of anesthetic equipment that allows inspired and expired air to mix without performing gas exchange. Examples of mechanical dead space include the adaptor of the circuit that connects to the endotracheal tube, the adaptor of the endotracheal tube, any length of the endotracheal tube that is past the incisors, and any other adaptors used in between the breathing circuit and endotracheal tube-like capnograph adaptors. The more dead space that is present, the less effective your patient will be at performing gas exchange, because the volume they inhale (tidal volume) may not be enough to fill the dead space present and allow air into the alveoli for gas exchange. Cats are particularly at risk of being affected by dead space due to their small size. The amount of dead space present should be less than 20% of a patient's tidal volume, which, for a 5 kg cat, is around 10 ml [2]. Therefore, it is also important to not only select a circuit with minimal dead space and resistance, but also to try to reduce other sources of dead space. Two ways to reduce dead space are to select a capnograph adapter with the lowest dead space (if the diameter of the adapter still exceeds the internal diameter of the endotracheal tube to prevent increased resistance to breathing) and to trim the endotracheal tube to the point of the incisors.

Because NRB systems do not use carbon dioxide absorbents or unidirectional valves, they require higher oxygen flow rates of 200 ml/kg/min or higher to avoid any rebreathing of carbon dioxide. These higher oxygen flow rates also allow for faster changes in anesthetic depth. Technically, because the system uses more oxygen per kilogram, it means that they are slightly less economical than RB systems. In comparison, an RB system using a medium oxygen flow rate would be around 30 ml/kg/min [30]. However, to bring perspective a 3 kg cat on an NRB system like a Bain circuit may use an oxygen flow rate of 0.9 L/min. Now, technically, using medium flow on a rebreathing circuit the oxygen flow rate would be calculated to be 0.09 L/min. However, most vaporizers require oxygen flow rates much higher than that to maintain accurate output; therefore, the fact that NRB systems require a higher oxygen flow rate is generally not a determining factor in system selection.

There are some RB systems on anesthetic machines that offer low-resistance unidirectional valves and RB circuits with low dead space. Therefore, the selection of either system may depend on what the clinic has available. If an RB system is selected, it is important that the veterinary technician closely monitor the patient to ensure that the patient can adequately ventilate and/or that the veterinary technician is able to intervene and provide intermittent manual or mechanical ventilation.

Besides selecting a breathing system and circuit that are appropriate for your patient, a reservoir bag must also be selected. A reservoir bag acts as a holding tank for oxygen and inhalant to be inspired by the patient and allows for manual positive pressure ventilation. The recommendation for reservoir bag selection is to select a bag that is 5–6 times larger than the patient's tidal volume (Table 6.11). Rounding up to the closest available bag size is an acceptable practice.

Table 6.11 Selecting a reservoir bag. Suggested calculation to select a reservoir bag.

Vt = 10–20 ml/kg reservoir bag = Vt × 5–6
Example: 5 kg cat
Vt = 5 kg × 10 = 50 ml
Reservoir bag = 50 ml × 5 = 250 ml (Select a 0.25 L bag or a 0.5 L bag if available)

Table 6.12 Continuous rate of infusion of injectable anesthetics. Examples of drugs that can be used as a continuous rate infusion to provide general anesthesia. These drugs can be used alone, in combination, or with other adjuncts depending on the procedure, patient, and discretion of the veterinarian [18].

Alfaxalone: 0.2–0.3 mg/kg/min
Propofol: 0.2–0.4 mg/kg/min
Ketamine: 0.01–0.04 mg/kg/min

6.2.3.2 Maintenance Anesthetics

Inhalant anesthetics are commonly used to maintain anesthesia. They have many benefits, including the ability to quickly adjust the anesthetic depth, and are not largely dependent on liver metabolism or renal excretion. The most common inhalant anesthetics used in a clinical setting are isoflurane and sevoflurane. Both inhalants are delivered via precision vaporizers. Isoflurane has a minimum alveolar concentration (MAC) of about 1.6%, and sevoflurane has an MAC of about 2.6% in cats [20, 31]. Both inhalants can cause dose-dependent respiratory and cardiovascular depression. One benefit of sevoflurane is that, due to its lower blood: gas partition coefficient, induction and recovery are generally faster than with isoflurane. Another benefit is that sevoflurane has a more pleasant smell than isoflurane, which usually means that it is better tolerated for mask inductions. The main disadvantage is that sevoflurane is more expensive than isoflurane, and due to its lower potency, more milliliters are generally used during an anesthetic event.

In some cases, total intravenous anesthesia (TIVA) via injectable anesthetics or a combination of inhalant anesthetics and injectable agents (partial intravenous anesthesia, PIVA) may be preferred or necessary for the procedure. For example, if the patient seems to have too much cardiorespiratory depression on inhalant anesthetics alone or if the procedure would expose the veterinary personnel to waste anesthetic gas, TIVA or PIVA would be desired. Injectable anesthetics, like those mentioned in the induction section, can be administered either with intermittent boluses or as a continuous rate infusion in those instances either using single agents or a combination of agents (Table 6.12). If considering this route to maintain anesthesia, note that some anesthetics may accumulate and slow recovery.

6.2.4 Monitoring

It is important that, throughout the entire anesthetic process, the anesthesia technician monitors vital signs to support the maintenance of homeostasis, including circulation, oxygenation, ventilation, and temperature. The anesthesia technician should also remain ready to troubleshoot equipment for malfunction. The first step of monitoring involves the anesthesia technician using his or her own senses or using a "hands on" approach. This may include, but is not limited to, assessing reflexes, palpating a pulse, watching the chest for respiratory rate, or assessing the capillary refill time and mucous membrane color.

6.2.4.1 Circulation

6.2.4.1.1 Heart Rate

There are several ways to monitor circulation and perfusion, with the first assessment being heart rate. The patient's heart rate should ideally be maintained within its normal resting range. Since many patients present to the hospital with elevated heart rates, veterinary professionals often rely on species, breed, and age to help determine the appropriate resting heart rate should be for that patient. To assess the patient's heart rate various methods can be used.

6.2.4.1.2 Palpation

Direct palpation is a common method, with femoral pulses being a common location. The author also suggests using the lingual pulse, which can be located on the ventral aspect of the tongue toward the base or the dorsal pedal pulse, which can be located on the dorsomedial aspect of the hindlimb just distal to the tarsus, during anesthesia since the femoral pulse is rarely accessible during surgical procedures.

6.2.4.1.3 Auscultation

If palpating a pulse is unachievable due to the nature of the procedure, a stethoscope can provide an auditory assessment of the heart rate and respiratory rate. Esophageal stethoscopes can even be used during a procedure if access to the thoracic wall is not possible.

6.2.4.1.4 Electrocardiograph

An ECG machine that allows evaluation of the electrical function of the heart. It uses predefined positive and negative electrodes attached to the skin to detect electrical activity and voltage changes through a lead or axis. ECG machines can use anywhere from 2 to 10 electrodes [32]. During anesthetic monitoring, there are generally three electrodes (white, black, and red). These electrodes are generally placed with the white on the right thoracic region, the black on the left thoracic region, and the red on the left pelvic region. Self-adhesive electrode pads or clips can be placed in a variety of locations if there is adequate contact with the patient's skin. Commonly used under anesthesia are the axillary and inguinal regions or the metacarpal and metatarsal pads of the feet due to the lower level of hair coverage to improve skin contact. However, anesthesia technicians must be creative sometimes due to the nature of the surgical procedure. For example, during a bilateral elbow arthroscopy, the author has had to place the self-adhesive electrode pads on the inside of the ears for the white and black electrodes. These electrodes will be used for a bipolar lead system to view three leads of electrical activity (Leads I–III). The most common lead or axis recording in small animals is Lead II, where the white electrode is placed on the right and is the negative electrode, and the red electrode is placed on the left and is the positive electrode. Normal electrical conductivity within the heart starts at the sinoatrial node in the right atrium and moves down through the ventricles, which are slightly tilted to the left side of the body. Since the electrical activity is moving toward the positive electrode the voltage will be positive in deflection giving the anesthetist a view of the major pathway of electrical conductivity within the heart and the ability to see major arrhythmias. Although ECG is the only way to definitively diagnose an arrhythmia, it only measures electrical activity and does not provide information on mechanical function, such as cardiac output and tissue perfusion. Therefore, it should not be the only cardiovascular monitoring technique used during anesthesia. See Chapter 14: "Cardiology/Cardiovascular Diseases," for further reading on ECG.

6.2.4.1.5 Doppler

Doppler is generally associated with indirect blood pressure monitoring; however, when used alone it can be an auditory pulse detector. A Doppler uses a piezoelectric crystal, similar to those found in ultrasound probes, to produce waves that are transmitted into the tissues. When the waves encounter pulsatile flow, they are transmitted back to the receiver and relayed as an auditory sound. Any location can be used that has a superficial artery present, but common locations include the ventral tail, ventral metacarpus, or dorsomedial metatarsus. Once the pulse is detected, the probe can be secured in place via tape or wrap. To improve wave transmission, it is recommended that the fur be shaved at the location and that ultrasound gel be placed in between the probe and the patient's skin.

6.2.4.1.6 Pulse Oximetry

Pulse oximetry is primarily used as a non-invasive measurement of oxygen saturation. However, because the pulse oximeter is designed to measure the oxygen saturation of arterial blood, the machine can also be used as a pulse detector.

6.2.4.1.7 Blood Pressure

The next most common assessment of circulation and perfusion is blood pressure monitoring. Hypotension is a common effect of general anesthesia. In general, it is accepted to maintain a mean arterial blood pressure (MAP) above 60 mmHg. There are three main types of blood pressure monitoring: indirectly using a Doppler with a sphygmomanometer, indirectly using an oscillometric machine, or directly using an arterial catheter and transducer.

6.2.4.1.8 Indirect Blood Pressure

The indirect methods are the more common modalities seen in feline practice. Indirect techniques are often variable in accuracy, but direct monitoring is more difficult to perform and has an increased risk of tissue damage. When using the indirect modalities, it is often accepted to perform measurements every 3–5 minutes.

For Doppler indirect blood pressure monitoring, the Doppler ultrasound probe is placed distal to the placement of the blood pressure cuff. Once the pulsatile flow is heard on the Doppler ultrasound, a sphygmomanometer can be used to inflate the cuff to occlude flow (exceeding systolic pressure). Then, the air is slowly released via the sphygmomanometer until the audible pulsatile flow has returned. There is considerable variability with this method and can have a large margin of human error. In general, in cats the pressure on the sphygmomanometer when the signal returns is considered to be the MAP [31].

The second indirect method of blood pressure monitoring is using an oscillometric device which measures oscillations in the pressure cuff from the pulsatile flow during measurement. The pressure cuff width needs to be around 40% of the circumference of the limb. The device inflates to a pressure suspected to be greater than systolic pressure and then gradually decreases. Then as the pressure is gradually released the point of maximal amplitude of the oscillations is measured as the MAP. Each oscillometric device has an algorithm for calculating the systolic and diastolic pressure based on the measured MAP. In general, the most accurate measurement on these machines is the MAP. Common locations of the cuff include the forelimb proximal to the carpus (Figure 6.6), the tail base, and the hindlimb proximal to the tarsus.

6.2.4.1.9 Direct Blood Pressure

Direct monitoring is usually accomplished via the placement of an over-the-needle catheter in a peripheral artery. The most common sites in cats include the dorsal pedal artery located on the dorsal aspect of the metatarsals or the ventral tail artery close to the tail base. Once the catheter is secured, it is connected to a pressure transducer that measures the back pressure on a water column and membrane within the transducer. The transducer then quantifies the systolic and diastolic pressure and calculates the MAP based on those values. Each manufacturer will have their own algorithm for the calculation. This method of blood pressure monitoring is generally considered to be the most accurate method. However, peripheral arteries are very small in feline patients, making placement challenging. General risks of catheter placement include hematoma formation or infection. Feline patients also have less collateral circulation than their canine counterparts, making the risk of reduced perfusion distal to the arterial catheter greater. The duration of catheter placement has been shown to increase the incidence of complications. Therefore, it is recommended that the arterial catheter be removed when it is no longer needed [33].



Figure 6.6 Blood pressure cuff placement. Patient with a blood pressure cuff on the left forelimb proximal to the carpus used for noninvasive blood pressure monitoring. *Source:* Lanette Jordan.

6.2.4.2 Ventilation

The function of the respiratory system is to provide a means of gas exchange in the most efficient way possible to provide adequate tissue oxygenation and remove excessive carbon dioxide. The term ventilation refers to the mechanical movement of gas from the atmosphere to the lungs [34]. Respiration is the process of gas exchange of oxygen and carbon dioxide that occurs between the alveoli and blood vessels surrounding them, as well as at the cellular level.

Ventilation is primarily central nervous system (CNS) mediated. Central chemoreceptors detect even slight changes in the partial pressure of carbon dioxide, which can trigger alterations of alveolar minute ventilation. However, anesthesia may augment the chemoreceptor response leading to a decrease in response of ventilation. The second major player affecting ventilatory drive is the reticular activating system (RAS). General anesthesia can reduce traffic through the RAS, thus reducing ventilatory stimulation. Similarly, ventilation generally decreases during sleep. Anesthesia technicians may try to stimulate the RAS during recovery by increasing sensory stimulation by moving the patient's limbs or rubbing their body. Some other factors that can affect ventilatory drive can include heat regulation and low partial pressures of oxygen.

6.2.4.2.1 Respiratory Rate and Volume

Ventilation is commonly assessed by identifying a respiratory rate, either through visualization of reservoir bag or chest wall movement. However, ventilation is determined via minute ventilation, which is a combination of tidal volume and respiratory rate. During anesthesia, a patient's respiratory rate may be maintained, but the patient may still be hypoventilating due to an inadequate tidal volume. Therefore, it is recommended to use another method of measuring adequate ventilation be obtained.

6.2.4.2.1.1 *Capnography*

Capnography measures the partial pressure of CO_2 during the respiratory cycle, and the partial pressure of exhaled CO_2 at the end of expiration is displayed. There is an inverse relationship between alveolar ventilation and the partial pressure of CO_2; ventilation decreases, and the display value increases. A capnometer device will only display a value; however, more commonly, both a value and a graphical waveform called a capnogram will be displayed on the capnograph device. Both types of information can give insight into overall ventilation and ventilation complications, such as rebreathing of CO_2, partial or complete occlusions, and leaks within the breathing system or endotracheal tube.

Under normal circumstances, the alveolar and the arterial partial pressure of CO_2 should be similar, and therefore, $PETCO_2$ should approximate the $PaCO_2$ with normal values ranging from 35–45 mmHg. However, two factors can cause discrepancies in this relationship. The first is the breathing system selected. NRB systems require a higher fresh gas flow rate than RB systems, which can cause a dilution effect in $PETCO_2$. Combined with the low tidal volumes expected in feline patients, NRB systems can cause an erroneously low $PETCO_2$ value. The second factor that may alter the relationship between $PETCO_2$ and $PaCO_2$ is dead space. There are several types of dead space, including mechanical, anatomical, and alveolar. In patients at elevated risk of alveolar dead space, such as those patients with lung disease or are having significant hypotension, an arterial blood gas may be more beneficial for assessing adequate gas exchange. There are two main categories of capnographs on the market, mainstream and sidestream (Figure 6.7). Both describe the location of the measurement of the gaseous sample. There are advantages and disadvantages to both monitors, and the selection depends on a variety of factors.

6.2.4.2.1.2 *Mainstream*

Mainstream has the measurement chamber connected directly to the endotracheal tube. All of the patient's inhaled and exhaled gas passes through the chamber itself, which allows for a decreased lag time between a patient's breath and the capnogram wave appearing on the monitor. There is also the ability for portability [34]. The disadvantage of using a mainstream capnograph is the limited ability to reduce mechanical dead space. There are adult and pediatric adaptors, but both add dead space, as they must be connected to the endotracheal tube adaptor. The mainstream monitor is also heavier and bulkier than a sidestream adaptor. Caution is needed in the manipulation of small patients to avoid the weight of the analyzer bending and potentially obstructing the endotracheal tube or pulling it out of the patient. The mainstream capnography machine also has a higher risk of being damaged. It could get liquid or biological contaminants in the electrical aspect of the module due to the analyzer being close to the patient's mouth, or the analyzer could be dropped during patient transport.

6.2.4.2.1.3 *Sidestream*

Sidestream capnographs continuously aspirate gas from the airway through tubing to the monitor for analysis. The adaptor at the patient end is usually a lightweight plastic with small plastic tubing attached. Although it may add dead space, there

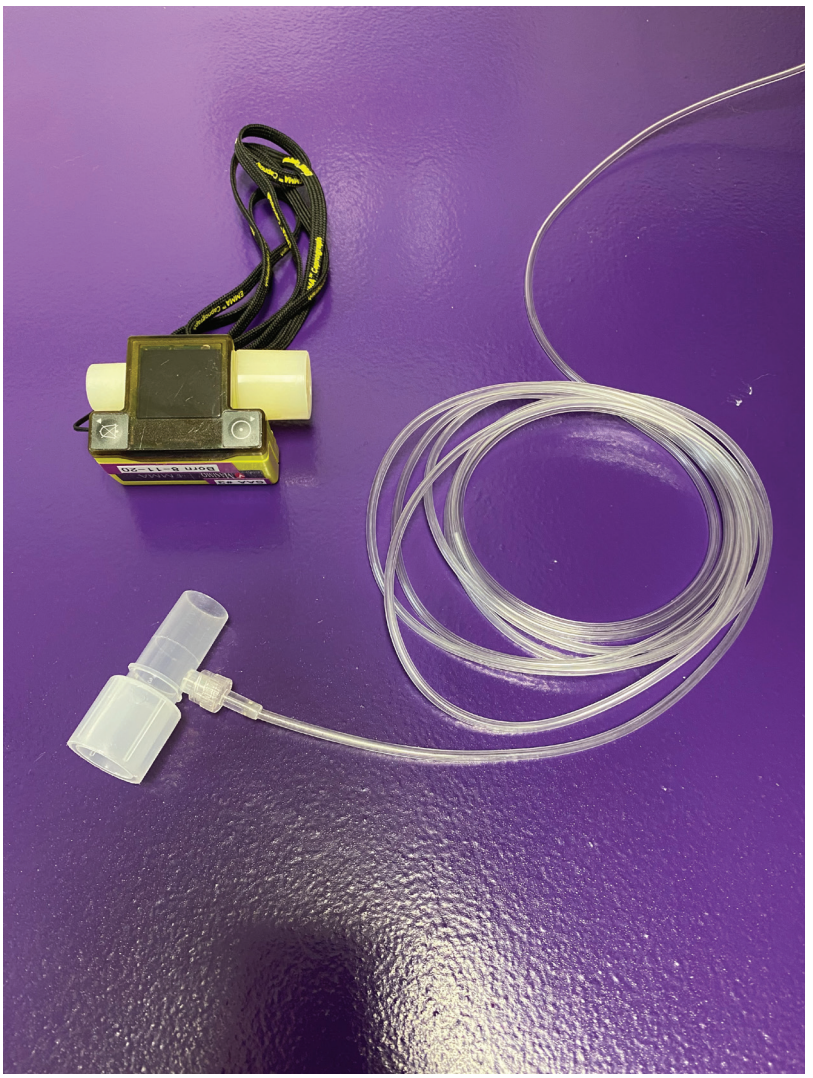


Figure 6.7 Capnographs. The top is the mainstream capnograph, and the bottom is the sidestream capnograph, the machine on the top is a mainstream capnograph while the plastic adaptor and plastic sampling line at the bottom are part of a side stream capnograph machine. *Source*: Lanette Jordan.

are accessories available called low dead-space adaptors (Figure 6.8) that allow the capnograph sidestream sampling line to be attached directly and take the place of the adaptor on the endotracheal tube [34]. Expiratory gases can also be sampled using nasal adaptors for sidestream monitors, allowing monitoring of non-intubated patients in a cage (e.g., Fairmont Medical, Capnography Nasal Cannula). A disadvantage of sidestream technology is that there may be an increased lag time between the patient's breath and the capnogram wave appearing on the monitor. This lag time will depend on the patient's respiratory rate, the sidestream sampling rate, and the length of the sidestream tubing. Most infrared spectroscopy usually requires a relatively large sample of gas mixture, meaning a sampling flow rate of around 150 ml/min. However, Microstream technology (Medtronic, Minneapolis, MN, USA) or molecular correlation spectroscopy uses a laser to generate the exact wavelength of infrared light that carbon dioxide absorbs to emit through the gaseous sample. This allows a lower sample flow, which could be beneficial for small patients by decreasing lag time or preventing falsely low measurements and distorted waveforms [35]. Another disadvantage of sidestream capnography is the potential for occlusions in the sampling line. Sidestream capnographs have filters or water traps to reduce interference of condensation and secretions. The lines, filters, and water traps will need to be maintained and replaced to avoid occlusions or false readings [34]. Finally, another disadvantage of sidestream capnography is the exposure to waste anesthetic gas. Since the machine is pulling a sample of the patient's breath, there will be some waste anesthetic gas in the sample. This gas will need to be diverted

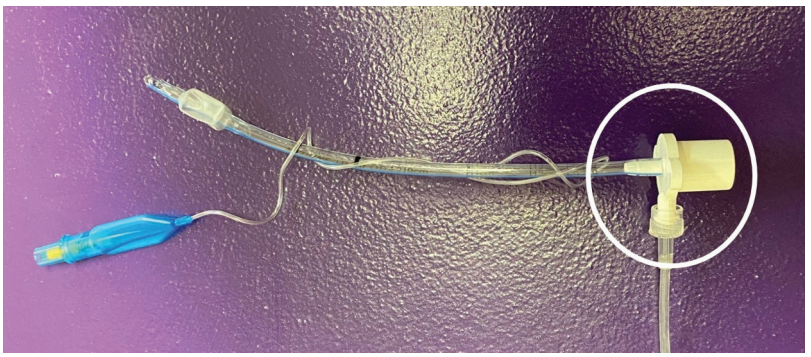


Figure 6.8 Low dead space adaptor. The circled portion of the image is a low dead space adaptor that can be used in place of the endotracheal tube adaptor with the side stream capnograph sampling line attached to the designated side port. *Source:* Lanette Jordan.

back into the breathing system to be scavenged or the capnography machine will need its own method for absorbing, or scavenging the inhalant. This adds another part of the machine that will also need to be maintained to prevent or reduce personnel exposure during use.

6.2.4.2.2 Oxygenation

In normal respiration, oxygen travels down a partial pressure gradient from the high levels within the atmosphere to the low levels within the blood vessels at the alveoli. Oxygen available for delivery to the tissues consists of free oxygen that is dissolved in the plasma, measured as partial pressure of dissolved oxygen and the oxygen bound to hemoglobin, which we measure via saturation (SaO_2) or (SpO_2 if using a pulse oximeter) (Table 6.13).

This formula indicates that most of the arterial oxygen content is dependent on the amount of hemoglobin present. Around 98% of total oxygen is bound to hemoglobin with the remainder dissolved in the plasma. Therefore, when assessing the oxygen delivery capabilities of a patient, the first thing an anesthesia technician should consider is the hematocrit level of the patient. An anemic patient may not be able to carry enough oxygen to deliver to the tissues, even if other factors like cardiac function, saturation, and partial pressure oxygen are normal. Saturation is the total amount of hemoglobin that has oxygen attached to the binding sites. For example, if the saturation is 98%, that means that out of all the hemoglobin being measured, 98% of them were completely saturated with oxygen. The oxyhemoglobin dissociation curve does show a relationship between saturation and the arterial partial pressure of oxygen. As the partial pressure decreases, saturation will eventually start to decrease. There are factors that affect the curve and shift the point at which saturation decreases, but, in general, hypoxemia is considered to be less than 80 mmHg partial pressure, which in a normal curve aligns with a saturation point of 95% [36]. Therefore, the goal should be to maintain an oxygen saturation of at least 95%. See Chapter 25: "Respiratory," for further information.

6.2.4.2.3 Pulse Oximetry

There are several methods for evaluating oxygenation with the gold standard being arterial blood gas analysis, especially for cases that are at high risk for poor oxygenation and perfusion. However, arterial blood gas analysis is invasive and requires technical expertise. Therefore, the more commonly used monitoring technique is via pulse oximetry. Conventional pulse oximeters function on the fact that oxygenated hemoglobin absorbs a specific wavelength of light that is different from hemoglobin, which does not have oxygen attached to it. This creates a linear relationship between the absorbance and concentration of oxyhemoglobin. The oximeter has a light-emitting electrode (LED) that emits specific wavelengths of light in pulses. This allows the machine to detect, via a photodiode/photodetector, variations in absorbance, thereby allowing the machine to detect periods of pulsatile flow when arterial blood has entered the tissue bed, and only measuring the

Table 6.13 Arterial oxygen content. This formula demonstrates the factors that affect the arterial oxygen content within arterial blood [36].

Arterial oxygen content = (% saturation × amount of hemoglobin × 1.39*) + (arterial partial pressure of oxygen × 0.003**)

* 1.39 is the maximum amount of oxygen binding capacity of hemoglobin.
** 0.003 is the solubility coefficient of oxygen in the plasma.

absorbance during those times and providing the saturation of arterial blood [37]. This feature also allows the machine to be used as a pulse detector to provide continuous visual and/or audible indication of the pulse rate. Of course, there are always limits to the accuracy of the machines and readings may become more unreliable if there is a loss or decrease in peripheral blood flow to the area being measured. There are two main types of pulse oximetry probes, transmittance or reflective. Chapter 25: "Respiratory," for further information.

6.2.4.2.3.1 *Transmittance*

A transmittance probe is the most used probe in clinics. This probe uses a clip with the LED on one side of the clip that will transmit the wavelengths of light through the tissue bed to the photodetector on the other side (Figure 6.9). Since the clip style usually relies on a spring-loaded action to keep the probe in place, sometimes the force of the clamp can start to occlude the tissue bed and provide falsely low saturation readings. Troubleshooting may include removing the clamp, massaging the tissue bed to re-perfuse the area, and repositioning the probe back onto the area.

6.2.4.2.3.2 *Reflective*

A reflective probe will have the LED and photodetector on the same side of the probe with a reflector in between. Although these probes are not as commonly used, reflective probes can be especially useful in cats because transmittance probes with



Figure 6.9 Transmittance pulse oximetry probe. A patient with a transmittance pulse oximetry probe on the tongue. *Source*: Lanette Jordan.

the spring load clamps often occlude the small capillary beds and result in a falsely low saturation reading. The reflective probes can easily be taped to the ventral aspect of the tail base where there is little hair coverage and provide saturation measurements throughout the procedure.

6.2.4.2.3.3 *Site Selection*

Site selection is important for both types of probes because both rely on adequate tissue perfusion and the ability for the light to travel through the tissue. Common placement sites would be the tongue, prepuce, vulva, ear, interdigital skin, ventral tail base, oral or rectal cavities, and esophagus. Ideally, the location selected will not have a dense hair coat, non-pigmented skin, and adequate perfusion. The location of the probe is dependent upon the type of probe used; however, in a study by Dörfelt et al. [38], the tongue was the most successful location for the transmittance probe.

6.2.4.2.3.4 *Interference*

Other factors that might interfere with accurate readings include movement like shivering during recovery as it will interfere with the machine being able to detect pulsatile flow, fluorescent lights which may emit some of the same wavelengths as the LED, and other forms of hemoglobin such as carboxyhemoglobin during carbon monoxide poisoning. A co-oximeter would be required to provide an accurate saturation if carbon monoxide poisoning is suspected.

6.2.4.2.4 Temperature

Although sometimes considered an afterthought, temperature can affect all organ systems and the ability to maintain homeostasis. Hypothermia, which is considered to be the core temperature of less than 99.5 °F [39], is very common in feline patients during anesthesia [40]. General anesthesia can cause hypothermia in a variety of ways, including reducing the body's ability to recognize and regulate body temperature, reducing heat production, and causing vasodilation which leads to increased loss of heat. Hypothermia can then lead to other adverse effects. Some of these are increased anesthetic recovery time, decreased drug metabolism, increased risk of bleeding, increased risk of infection, and reduced cardiac output and perfusion [41–46]. Therefore, monitoring temperature and implementing ways to reduce the instances of hypothermia should be paramount in the anesthetic monitoring plan. Monitoring of temperature is generally performed using a hand-held digital electronic thermometer called a thermistor [47]. Common sites under general anesthesia include the esophagus and rectum. Usually, hand-held digital thermometers are used for the rectum, while a temperature probe is used for the esophagus with ideal placement located in the distal third of the esophagus [47]. Gastric contents within the esophagus or feces in the rectum can cause falsely low readings. Therefore, close observation by the anesthesia technician is key. Axillary temperatures can be obtained and are usually more tolerated in awake patients but are generally less accurate due to the large gradient with the core temperature and other interfering factors like warming devices, regional vasoconstriction, and improper contact with the skin [31, 47].

There are several ways to help reduce temperature loss during anesthesia both using active warming and passive insulation. Active warming techniques are circulating warm water tables or blankets, forced warm air units, electrically conductive blankets, warmed IV fluids, warmed/humified inspired gas, and warm abdominal fluid lavage [47]. The use of fluid warmers to warm the IV fluids administered to the patient has also shown when used alone not to be effective in maintaining the patient's temperature. This is due to the low fluid rates and the distance they are positioned from the patient [48]. Passive insulation can include towels/blankets, socks, bubble wrap, and even reflective emergency blankets to provide insulation. Passive insulation has been shown to provide a cumulative difference in maintaining temperature; however, when used alone passive insulation did not significantly slow the rate of temperature loss [49]. Therefore, a combination of therapies is recommended. Caution should be used with other methods of warming like store-bought electric heating pads and microwavable products (fluid bags, rice bags, heating discs) due to the difficulty of obtaining a safe temperature and avoiding thermal burns.

6.2.4.2.5 Fluid Therapy

Although cats do seem to be at a higher risk for fluid overload, the benefits of fluid administration usually outweigh the risk. Fluid therapy under anesthesia should be individualized for each patient and procedure. There are several types of fluids available for use. In general, the most commonly used fluids during the maintenance phase of anesthesia are balanced, multi-electrolyte isotonic crystalloid solutions that can be used for replacement or maintenance, such as Lactated Ringer's solution, Normosol-R, and Plasmalyte-148. Fluid rates have historically been based on human data, which is difficult to extrapolate to feline patients. The AHAA/AAFP Fluid Therapy Guidelines for Dogs and Cats recommend a starting rate of

3ml/kg/h for cats for an anesthetic maintenance rate [50]. Research has been aimed at finding goal-directed therapy; however, it is unlikely at this time that the techniques used to calculate the ideal rate and response would be feasible in a routine clinical setting. Therefore, the specific rate used for every patient will need to be adjusted depending on the patient and procedure and reevaluated if significant changes occur during the anesthetic period. It is beyond the scope of this chapter to discuss all of the disturbances that can occur in relation to volume, distribution, or content and the treatments for those disturbances.

6.3 Recovery Phase

The recovery phase of anesthesia starts after the procedure has concluded and the maintenance anesthetic is stopped. The recovery phase concludes when the patient is responsive to external stimulation and is normothermic. During recovery, it is essential that constant observation and monitoring are continued by the anesthesia technician. The frequency and specific vitals obtained can vary depending on the ASA status of the patient and the procedure that was performed. Creating an environment appropriate for recovery can have a positive impact on recovery. Ideally, the recovery environment should be quiet with minimal foot traffic, and adjustable lighting, and contain all the required warming and monitoring devices for the patient. The patient is extubated when a strong swallow is observed. It is recommended that the cuff of the endotracheal tube remain inflated until that point to protect the patient's airway from aspiration of foreign or gastric material. Normal airflow should then be confirmed after extubation. It is also recommended that the IV catheter remain in place should adverse events occur requiring injectable medication [51]. Around 50–75% of anesthetic-related deaths occur in the postoperative period [7, 52, 53]. Of complications associated with recovery, airway obstructions are high in feline patients due to their small airways that are prone to laryngeal spasms. Cats should be monitored closely during the postoperative period to ensure that they can sit up and ventilate normally after extubation.

Another common occurrence during the recovery of felines is the emergence of delirium, dysphoria, excitement, and pain, which can lead patients to thrash and potentially injure themselves or the anesthesia technician. Although difficult to distinguish, the anesthesia technician should first try to assess the patient's pain and treat it as described in Chapter 7: "Analgesic Considerations," for the Feline Patient. If pain is not the reason for the difficult recovery, sedation may need to be considered to calm the patient and reduce further injury or complications. Prolonged recoveries are generally due to hypothermia but can be drug-induced. If suspecting the latter, reversing some agents can be considered, or providing supportive care to the patient until the drugs are metabolized, and the patient returns to appropriate consciousness.

Feline patients have a higher anesthetic risk than dogs, which may be attributed to a variety of factors, including but not limited to undiagnosed or underlying disease, fear and stress in the hospital setting, and their small size. The veterinary technician should be aware of the risks feline patients may have and try to reduce the risks as much as possible when developing an anesthetic plan with the veterinary team. During the patient assessment, the veterinary technician should advocate for and initiate feline-friendly practices whenever possible. The veterinary technician should research anesthetic supplies and equipment appropriate for the small size of feline patients and perform maintenance checks of those supplies and equipment to ensure proper functionality. The veterinary technician is generally the veterinary team member that will be monitoring the patient the most during the anesthetic event and therefore should be knowledgeable of the potential risks that are specific for that patient and procedure and have a plan for interventions should anesthetic complications arise through any of the phases of anesthesia.

See the companion website for further clinical references.

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7

Analgesic Considerations for the Feline Patient

Lanette Jordan BS, LVT, VTS (Anesthesia and Analgesia)

TECHNICIAN TIDBITS

- Definitions
  - Allodynia: A pain response from a stimulus that does not usually cause a pain response.
  - Analgesia: Absence of a pain response from a stimulus that usually causes pain.
  - Hyperalgesia: Increased pain response to a stimulus that normally causes pain.
  - Nociception: The physiological recognition of a noxious (tissue-damaging) stimulus.
  - Pain: A conscious physiological and emotional experience with actual or potential tissue damage.
  - Peripheral sensitization: This occurs when peripheral nerves become more responsive to pain.
  - Central sensitization: This occurs when the central nervous system becomes more responsive to pain.
- Drug metabolism and excretion [1–6]
  - Cats have a lower ability to metabolize certain phenolic compounds that require hepatic glucuronidation. This may cause certain drugs to accumulate if dosing regimens are not adjusted, causing toxic side effects. Alternatively, it may mean that the drug is less effective if the glucuronidation pathway is needed to produce an active metabolite.
    Examples: acetaminophen, carprofen, and morphine.
  - Drugs that require oxidation are commonly eliminated faster in cats than in dogs.
    - This may provide options for long-term administration of some analgesics or indicate that dosing regimens need to be adjusted. Examples include meloxicam, piroxicam, and buprenorphine.
  - Drugs or their metabolites that require renal excretion may accumulate in cats with chronic kidney disease.
  - Drugs may have an enhanced effect if the patient is azotemic due to increased permeability of the blood–brain barrier.
- Medicating patients [7]
  - Force-pilling is a common method of medicating cats, which can be distressing to both the owner and patient and may lead to a lack of compliance.
    - Solutions or suspensions have been shown to be tolerated more than tablets.
    - Offer positive reinforcement, like treats before and after medication.
    - Educate owners on how to administer medications using feline-friendly practices. The website of International Cat Care has some resources for veterinary staff to use at https://icatcare.org/veterinary/resources/ (accessed 13 March 2024).
- Misconception of opioids
  - Opioids cause respiratory depression – false: Opioids rarely cause adverse effects when appropriate doses are used. However, close observation and monitoring are especially important for high-risk patients, such as those who are obtunded or have other ventilatory issues [8, 9].
  - All opioids cause excitement in cats – false: Reports of this were mainly using excessive doses that did have sympathetic stimulating effects but were higher than what is required to provide analgesia [10–14].
  - Opioids are not effective in cats – false: The amount and distribution of opioid receptors in the central nervous system may differ from species to species and even individual to individual making the efficacy variable between patient to patient [6, 13].
- Managing side effects of opioids
  - *Monitor temperature more frequently postoperatively in feline patients and start cooling techniques if hyperthermia is observed.*
  - Monitor for dilated pupils (mydriasis) and dim the lights in the cat ward if observed.
  - Pretreat with an antiemetic to reduce nausea and vomiting.
- Adverse clinical effects of nonsteroidal anti-inflammatory drugs
  - Look out for anorexia, vomiting, diarrhea, and lethargy to indicate the patient needs to stop the medication and the client contacts the veterinarian.

Pain has often been underrecognized and undertreated in feline patients due to multiple factors, including assessment tools not being developed in cats or not being widely implemented, fears surrounding the unique characteristics of feline metabolism, and the effects of pharmacological agents on patients' comorbidities, as well as the availability of pharmacological agents that are labeled for use in feline patients. Veterinary technicians can play an integral part in continuing to advance pain management for their feline patients by performing more pain assessments using validated pain assessment systems and being part of the discussion for pain management in both the clinical and home settings.

Pain is a protective evolution that allows living organisms to avoid tissue-harming (noxious) stimuli and thus survive in their environment. It is a complex conscious phenomenon that has both a sensory and emotional experience associated with either actual or potential tissue damage, which can be augmented by fear, stress, and memories. Therefore, pain management is not only about identifying pain and administering an analgesic agent. Veterinary staff also need to consider the emotional factor of being in a hospitalized setting and should always try to provide feline-friendly practices. Although it is difficult to assess the effects of noxious stimuli on the emotional state in animals, research is advancing in these areas.

Nociception is the neural process of encoding a noxious stimulus. Specialized nerve endings called nociceptors are designed to detect noxious stimuli and send these signals to the spinal cord and then to the brain to initiate protective reflexes [15, 16]. This series of events are called the pain pathway, which consists of transduction, transmission, modulation, and perception. See Figure 7.1 for examples of pharmacological and nonpharmacological agents that act on parts of the pain pathway. Many of the analgesic therapies target nociception and the peripheral mechanisms that occur. Since the nociceptive mechanisms that lead to perception are still active even if a patient is unconscious as during general

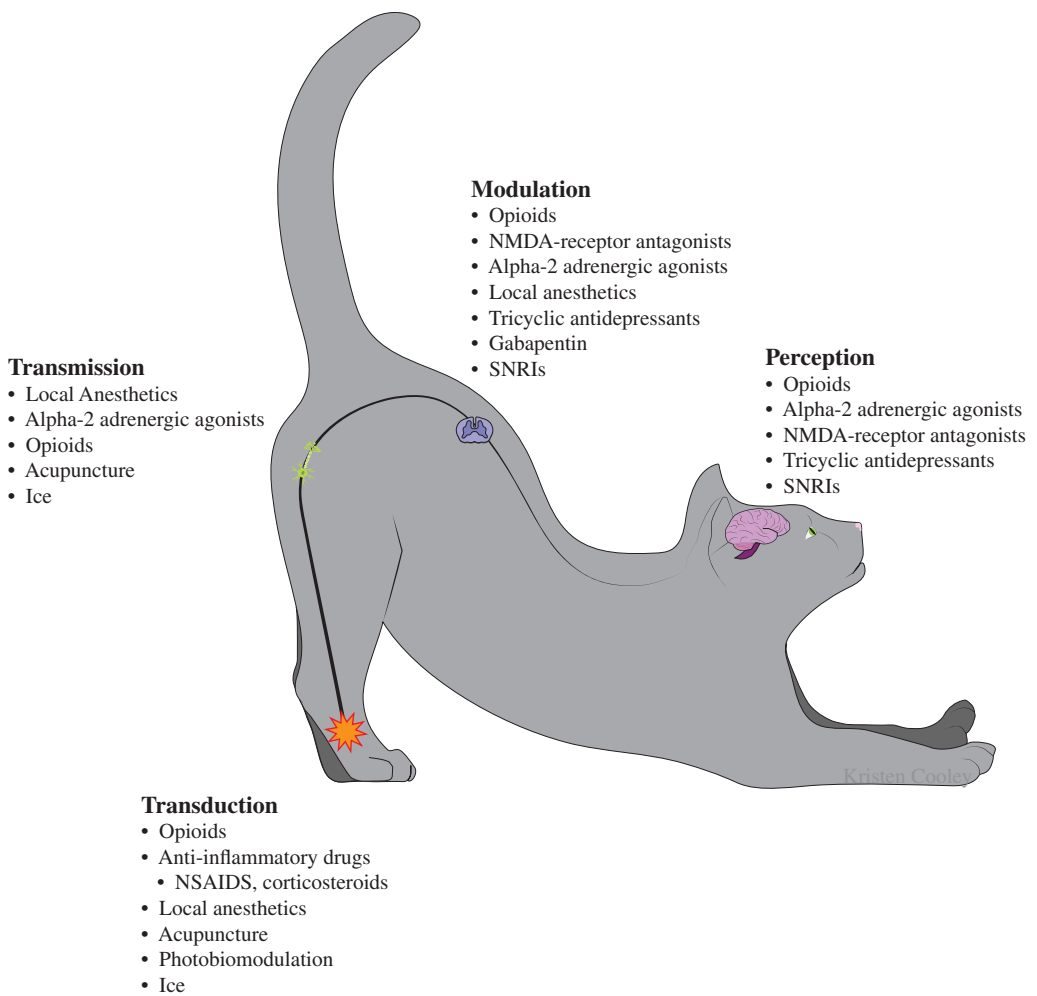


Figure 7.1 Illustration of the pain pathway, including transduction, transmission, modulation, and perception with examples of therapies that will target each mechanism. *Source*: Kristen Cooley.

anesthesia, interventions should be made to target those pathways to reduce the amount of pain perceived when the animal is in recovery and regains consciousness [17].

7.1 The Pain Pathway

7.1.1 Transduction

Transduction is the beginning of the pain pathway and is the activation of specific receptors called nociceptors, which cause the initiation of action potentials within the nerve fibers. Nociceptors within the tissues are primary afferents, meaning they are the first to detect and initiate the pain pathway. There are several types of nociceptors that respond to specific stimuli whether that be chemical, mechanical, or thermal. When the threshold for that stimulus is reached, the nociceptor will depolarize and create an electrical impulse [18]. Along with the initial stimulus, the body will also release compounds, commonly known as the "inflammatory soup," into the area, which will further stimulate and sensitize the nociceptors. (Table 7.1)

7.1.2 Transmission

Once the electrical impulse (action potential) is created during transduction, the next step in the pain pathway is started: transmission. Transmission occurs when the electrical signal is transmitted via nerve fibers in the peripheral nervous system to the spinal cord in the central nervous system. Peripheral nerves can be categorized into afferent nerve fibers, which move signals toward the central nervous system, and efferent nerve fibers, which will move signals from the central nervous system to the primary tissues. Afferent nerve fibers can be divided into three groups: A-delta, A-beta, or C-fibers, with A-delta and C-fibers normally being the nociceptors and conducting pain signals [8]. A-delta fibers usually transmit sharp pain, often referred to as "first pain," following an injury. C-fibers are slower in conduction and transmit "second pain," usually described as an unlocalized burning type of pain. Sometimes, following tissue damage and maladaptive pain, A-beta fibers may also transmit pain signals [8]. After continuous noxious stimulation, C-fibers can start to be associated with chronic or inflammatory pain [8, 18].

7.1.3 Modulation

The modulation phase of the pain pathway involves the inhibition or amplification of the transmission impulses within the ascending pathways up to the brain in the dorsal horn, as well as in the descending pathways from higher centers in the brain at the level of the cortex, thalamus, and brainstem. An assortment of neurotransmitters is responsible for modulating information traveling from the periphery to the spinal cord, such as substance p, glutamate, gamma-aminobutyric acid (GABA), endogenous opioids, serotonin, and norepinephrine, to act on receptors, either inhibiting or enhancing the incoming signals via ascending or descending pathways [18].

Table 7.1 Inflammatory soup – examples of mediators that can be released during an inflammatory process that promotes further sensitization of local nociceptors in the process of transduction.

Arachidonic acid
Bradykinin
Cytokines
Glutamate
Histamine
Interleukins
Leukotrienes
Prostaglandins
Serotonin
Substance P

Sources: Adapted from [19]; Lanette Jordan.

7.1.4 Perception

Perception is the conscious experience of recognizing and processing pain within the brain. There are two main tracts that send signals from the spinal cord to the brain: the spinothalamic and spinoreticular tracts. The spinothalamic tract is thought to be the primary conscious ascending pathway for pain in somatic tissues [20]. The spinoreticular tract sends signals originating from the visceral organs or deeper tissues and usually results in poorly localized perceived pain. Once the brain has processed the information, it will activate the efferent (descending) pathways to elicit a response to the noxious stimulus.

7.2 Types of Pain

7.2.1 Classification

Pain can be classified based on the type of pain (i.e., adaptive/physiologic or maladaptive/pathologic), site of origin or type of tissue (i.e., somatic, visceral, or neuropathic), and duration (i.e., acute or chronic) (Table 7.2). Adaptive pain cues the body to the presence of a potential tissue-damaging stimulus and thus has some protective functions. However, maladaptive pain usually represents a malfunction of the pain mechanisms and serves no protective function. Chronic pain is usually associated with maladaptive pain [8].

7.2.1.1 Peripheral and Central Sensitization

Peripheral sensitization occurs when chemical mediators, like those in the "inflammatory soup," increase the excitability of the nociceptors, lowering the pain threshold and allowing even more signals to be transmitted to the spinal cord [24]. Central sensitization occurs at the level of the spinal cord. When the spinal cord receives sustained stimulation from the peripheral nociceptors, neurotransmitters, like glutamate, are released and activate receptors such as 2-amino-3-(3-hydroxy-5-methyl-isoxazol-4-yl) propanoic acid and *N*-methyl-D-aspartic acid (NMDA). This leads to increased nerve transmission and excitability within the spinal cord, and decreased activity of descending inhibitory pathways [8, 25]. Both peripheral and central sensitization may lead to long-lasting changes in the nociceptors and nerve fibers, creating allodynia, where the nociceptors may react to a stimulus that does not normally cause pain, or hyperalgesia, where the noxious stimulus causes an increased pain response. These two effects are part of a maladaptive process that may also go beyond the point of healing and become chronic in nature.

7.3 Negative Effects of Pain

7.3.1 Physiological

The pain experience is different for each individual animal and is always potentially detrimental to the patient. Pain acts as a stressor on the body, which has the potential to lead to several physiological effects on several organ systems, including the endocrine, cardiovascular, gastrointestinal, and immune systems. Pain activates the endocrine system, leading to increased amounts of mediators, such as cortisol, epinephrine, norepinephrine, growth factors, and cytokines within the

Table 7.2 Types of pain [18, 21–23]. Classifications of pain based on the type of tissue, duration, and association of healing. Acute: pain that occurs after tissue injury with a duration that resolves with tissue healing.

Adaptive/physiological: pain that is from initial tissue damage or during the healing process and typically decreases as the damage and inflammatory response resolves
Chronic: pain that persists past the time of tissue healing and resolution of the inflammatory process
Maladaptive/pathologic: pain that is present without current tissue damage usually the result of abnormal processing
Neuropathic: arises from damage to or dysfunction of the peripheral or central nervous system
Somatic: arises from the skin, muscle, bone, or connective tissues
Visceral: arises from internal organs from the body cavities

Source: Lanette Jordan.

body. These mediators can create various effects within the body. One of these effects is sympathetic system activation, which will increase heart rate, blood pressure, cardiac workload, and oxygen demand, while also decreasing gastrointestinal (GI) emptying and motility. A decrease in GI motility can lead to nausea, loss of appetite, vomiting, and ileus [26, 27]. Sympathetic system activation can also increase the respiratory rate; however, pain can make the patient not want to take deep breaths and fully expand their chest, which can lead to atelectasis and increased susceptibility to respiratory infections [26]. Pain will also promote inflammation, which may increase the time it takes to heal and suppress the immune response, predisposing the patient to infection [26, 28, 29]. A catabolic state can also occur, where the body starts to break down stored reserves such as body fat and muscle. This can lead to muscle wasting [26, 28].

7.3.2 Emotional

Besides the physiological effects, the emotional effects of pain also need to be considered. Pain is known to cause negative emotions such as stress, fear, and anxiety in humans, which may all affect the pain perception. If extrapolated, our feline patients can start to see effects in their welfare, including the domains of nutrition, environment, health, behavior, learning patterns, and memory [26]. These effects can appear as changes in activity level, locomotion, posture, response to handling, appetite, or even aggression and vocalization [26]. To combat these emotional effects, studies have demonstrated that positive experiences during animal handling like providing treats, have been shown to improve animal welfare and therefore the possibility exists that providing positive experiences while the patient is hospitalized or experiencing pain may also help alleviate or reduce that pain [8, 30–32].

7.4 Assessment of Pain

It is not enough to simply administer an analgesic on the assumption that pain is present. Without a pain assessment tool and a baseline, it would be impossible to determine whether the drug or dose is effective. Veterinary technicians are an integral part of pain recognition and assessment. In general, veterinary technicians are the first staff members to intake the patient, performing the initial baseline assessment and the ones performing the assessments throughout the patient's hospitalization. To perform the assessments, the veterinary technician must be skilled and trained in recognizing both normal and abnormal behavior. This may also require the owner's input through verbal descriptions and videos or pictures of the patient at home and therefore should be a working relationship based on collaboration.

Pain has been considered the fourth vital sign and should be assessed in every patient, just like temperature, pulse, and respiration. Postoperative patients should be evaluated every 15–30 minutes during the immediate post-anesthetic recovery phase as the effects of anesthetic drugs (which may mask behavioral signs of pain) wear off [8, 33]. After the patient is fully conscious, pain should be assessed at least hourly for the first 4–6 hours, until discharge. Along with the assessments, the veterinary technician should discuss trigger points with the veterinarian for therapeutic intervention, depending on the pain scale that is implemented [8].

7.4.1 Behavioral Indicators

In veterinary medicine, most pain-measuring systems are based on behavioral observations made by the veterinary team and/or owner. To complicate assessment, each species has its own pain-related behaviors. This means that each pain measuring system needs to be developed for individual species and sometimes modified for individual patients. Behaviors used to assess pain in cats can include attitude, demeanor, posture, activity level, interaction with people and other pets, responses to palpation, attention to a specific area, vocalization, guarding, decreased appetite, and facial expressions [8, 34]. See Table 7.3 for detailed examples of behaviors indicating pain [6]. Any new behaviors that have presented or loss of previous behaviors may be indicative of pain. Anesthesia may complicate matters by augmenting behaviors during the recovery period. Dysphoria or emergence delirium during anesthetic recovery may elicit behaviors similar to pain but is usually only during the first 30 minutes of recovery. It is recommended that veterinary professionals treat for pain, and if the clinical signs worsen, that might suggest that the patient is experiencing dysphoria. If this occurs, sedation or reversal of the pharmacological agent can be considered, as long as the patient is closely monitored for signs of pain [8].

In cases of chronic pain, the owner may be able to observe and relay information to the veterinary team. However, the owner may not be aware that certain subtle behavior changes indicate pain; therefore, the owner needs to be educated

Table 7.3 Examples of behaviors indicating pain – feline behaviors and expressions that can be indicators that the animal is experiencing pain.

Attitude/demeanor	Dull mentation Restlessness Quiet Withdrawn
Posture	Hunched Flank contraction
Activity level	Decreased activity Reluctance to Move
Interaction with people and the environment	Decreased grooming Hiding Not playing or interacting
Evoked behavior during palpation	Aggression Biting Vocalization Guarding
Facial expressions	Ears pulled apart and rotated outwards Squinted eyes Tense muzzle Whiskers straight out

Sources: Adapted from [6]; Lanette Jordan.

[8, 35]. Some behaviors that may be linked to chronic pain include a decreased activity level and mobility leading to the animal spending less time roaming, playing, or interacting with other animals or the owner in the house. The decreased mobility may also lead to a decrease in activities like jumping up on counters, climbing up or down stairs, and using the litterbox, which may appear as urinating or defecating around the litter box or new locations. The cat might also show a reduction in grooming, leading to an unkempt hair coat or long nails, or an increase in grooming a particular area leading to alopecia [8, 36, 37]. With this wide variety of behaviors, open and thorough communication with the owner is key to identifying pain and creating a treatment plan.

7.4.2 Physiological Indicators

Unfortunately, many physiological indicators, like heart rate, respiratory rate, and cortisol levels in a clinical setting have been shown to be unreliable in clearly identifying pain due to the fact that they can be affected by other factors, including stress, anxiety, and fear [8, 34, 38–43].

7.5 Pain Scoring Instruments

In acute pain, the veterinary team is often responsible for the assessment, but in chronic pain, the owner often assumes that role. Therefore, the most effective pain scoring instruments, also called tools, scales, or systems, for the practice should be selected based on the specific needs of the team or client and the patient, as well as on the validity, reliability, and user-friendliness. All members involved in assessing the patient's pain should be trained in the implementation of the chosen tool. See Table 7.4 for a list of pain-scoring instrument attributes [34].

Validity means that the pain scoring instrument is measuring what it is intended to measure [44, 45]. Reliability means that the instrument allows the pain assessment to be repeated by the same observer, and results in the same score or two people measure the same patient at the same time and give the patient the same score. An instrument can show high reliability yet lack validity if it is not clearly measuring what it was intended to measure [46]. User-friendliness indicates that the instrument is easy to complete without lengthy training.

Table 7.4 Attributes of a pain scoring instrument [34], efficacious attributes of a pain scoring instrument with definitions.

Validity: the instrument measures what it was intended to measure
Reliability: repeatable and produces similar scores with the same observer or between different observers
Sensitivity: specific data is obtained that can prompt treatment and detect responses to treatment
Utility/user friendliness: easy to use and quick across multiple observers

Source: Lanette Jordan.

7.5.1 Complications to Pain Scoring Systems

7.5.1.1 Observer Bias

Observer bias can reduce the validity of the pain assessment tool. For example, if an observer has experienced a similar type of pain, they may score the pain more severely than someone who has not had that experience. Pain assessment tools must consider and account for a multitude of factors, some of those being the observer's primary language, educational background, and culture.

7.5.1.2 Time-consuming

Compliance with administering a pain scoring system is largely based on the amount of time it takes to complete. Some scoring systems may take 10 minutes or longer to complete effectively. This may not seem that significant, but if you consider that immediate postoperative patients may need to be assessed every 30 minutes to 1 hour. This can place a huge burden on a busy practice, which may have limited resources to delegate a team member to that endeavor. The same can be said for the owner completing pain assessments at home.

7.5.1.3 Type of Pain

Different types of pain may result in different behaviors. For example, oral pain may present as a reduction in eating and weight loss, may present as exaggerated licking and chewing movements, or may not present at all until oral examination. Therefore, pain scales need to be developed for the type of pain being assessed. Currently, there are scales focusing on musculoskeletal or arthritic pain and some focusing on maxillofacial pain which are common conditions in cats. However, many scales are generalized for assessment of acute or chronic pain.

7.5.2 Acute Pain Scales

There are many pain scoring systems available that range in complexity. The most important system to choose is one that shows reliability, validity, and matches the practice's needs.

7.5.2.1 Unidimensional

Veterinary technicians should be familiar with unidimensional instruments like simple descriptive scales, numerical rating scales, and visual analog scales as they are usually present in several doctors' offices. In pediatric offices, there is a series of faces with varied expressions all with a numerical value associated. The face or numerical value indicates the level of pain the patient is experiencing in a numerical order of 0–10 or 0–100 where zero indicates no pain and the highest number on the scale indicates the worst pain imaginable. Although these scales are easy to use, they can be very subjective based on the observer [38, 39]. They are also often not standardized and do not provide enough information to allow for the refinement of pain management. Therefore, multidimensional pain-scoring instruments should be used when possible.

7.5.2.2 Multidimensional

Currently, there are three multidimensional pain scoring instruments with research-reported validity for acute feline pain assessment. All three provide clinical guidance on a score for analgesic intervention. However, if the primary veterinarian feels that the cat could be in pain, analgesia can always be provided no matter the score.

7.5.2.2.1 Feline Grimace Scale©

The Feline Grimace Scale© (FGS) was developed from a variety of patients presented to the Veterinary Teaching Hospital at the University of Montreal. Cats were evaluated, videos were recorded, and facial images were analyzed.

The instrument five "action units" of measurement, including ear position, orbital tightening, muzzle tension, whiskers position, and head position [47]. Each unit is scored 0–2 with zero meaning the feature is absent, one meaning that there is moderate presence of the feature, and two meaning that there is obvious presence of the feature. The observer should observe the cat awake undisturbed but not grooming, eating, or vocalizing for 30 seconds and then score the patient. The sum of all the scores is obtained with a maximum score of 10. Scores of 4 or higher suggest that analgesic administration should be considered [48].

The FGS has been found to be valid, reliable, and user-friendly for multiple types of acute pain and for veterinary professionals as well as caregivers/owners [47, 49, 50]. It has also been found valid and reliable in kittens [51]. Technologically, smartphone applications are available for prediction of FGS scores, which may help veterinary personnel develop pain management techniques with the client while allowing the patient to remain in the stress-free environment of their home [52]. Unfortunately, like many pain-scoring instruments, sedation and general anesthesia can alter the FGS, making it unreliable. However, the effects are short-lived and if continuous pain assessment is implemented throughout the patient's stay in the hospital, the FGS will still be beneficial for the patient [53, 54]. Examples of using the FGS are provided in Figure 7.2a–d. For more information for the veterinary team on implementing this pain-scoring instrument please see the website https://www.felinegrimacescale.com/ (accessed 20 March 2024).

7.5.2.2.2 Refined Glasgow Composite Measure Pain Scale: Feline

The Glasgow Composite Measure Pain Scale for feline patients is another validated pain scoring instrument that is quick and easy to use. Within each category are rankings of pain based on physical descriptors, behavioral descriptors, or pictorial representations. The pain assessment tool takes into consideration the patient's posture and activity, attention to the wound or affected area, facial expressions, interaction with the observer, and response to palpation. The instrument was assessed for validity on a variety of surgical procedures, diseases, and conditions and is available in English, Spanish, and Greek. The score from each category is added together to provide an overall pain score for the patient with analgesic intervention being recommended at $\geq 5/20$ [34, 55, 56]. See Figure 7.3a–d for examples of using the pain scale.

7.5.2.2.3 Universidade Estadual Paulista-Botucatu Multidimensional Composite Pain Scale

The UNESP-Botucatu Multidimensional Composite Pain Scale and revised short form were first developed in Brazilian Portuguese, but have been validated in English, French, Spanish, German, Chinese, Japanese, Portuguese, and Italian [34, 57, 58]. The long form has ten items of elevation including posture, comfort, activity, attitude, reaction to palpation of wound or abdomen, blood pressure, appetite, and vocalization. Each item is ranked 0–3 with "0" indicating a normal nonpainful state. The total score ranging from 0 to 30 is calculated from the sum of the individual item scores. Mild pain is considered in the 0–8 range, moderate pain in the 9–21 range, and severe pain in the 22–30 range [59, 60]. It also has a numerical criterion indicating when analgesic intervention should be administered, which is when a score is eight or higher.

The short form is much more user-friendly and includes four items each scored from 0 to 3 with a summative maximum score of 12 with an analgesic intervention recommendation for a score of 4 or higher. The instrument is comprehensive, valid, and reliable, but was designed to observe cats receiving ovariohysterectomies. Therefore, it is currently unknown if the instrument provides the same accuracy and reliability for other types of pain or procedures [34]. For more information on using the instrument please see the website https://www.animalpain.com.br/en-us/avaliacao-da-dor-em-gatos.php (accessed 20 March 2024).

7.5.3 Chronic Pain Scales

In chronic pain the behavioral changes in a patient may be subtle and develop slowly over time, making it evident only in the patient's natural home environment. Therefore, oftentimes, owners need to be involved in the assessment of the patient's pain. Although many chronic pain scales rely on the owner, veterinary technicians still play a vital role in owner communication and education to assist in the implementation of these scales.

7.5.3.1 Client-specific Outcome Measures

Client Specific Outcome Measures is a pain scale originally developed for use in dogs and has been adapted for use in cats [61]. The benefit of this instrument is that it is individualized. This makes it highly relevant and allows for the owner to assess the cat's ability to perform its normal activities, which are specific to that individual animal [8, 36, 62]. The owner,



Figure 7.2 FGS. (a) The patient was admitted to the hospital for wounds from a dog fight. Prior to this photograph, the patient received dexmedetomidine and maropitant. Based on the Feline Grimace Scale, this patient received a total score of 8/10 and analgesic intervention was recommended. The ears were rotated outward (score 2). The eyes were partially closed (score 1). The muzzle was tense (score 2). The whiskers were forward and pulled away from the face (score 2). The head was lowered and aligned with the shoulder line (score 1). *Source*: Chelsea Connor, DVM, DACVAA. (b) The patient is in recovery following an enucleation. Based on the Feline Grimace Scale, this patient received a total score of 9/10, and analgesic intervention was recommended. The ears were rotated outward (score 2). The remaining eye was squinted (score 2). The muzzle was tense (score 2). The whiskers were straight and pulled forward away from the face (score 2). The head was lowered and aligned with the shoulder line (score 1). *Source:* Lanette Jordan, LVT, VTS (Anesthesia & Analgesia). (c, d) Both of these patients were nonpainful based on the FGS. The ears were forward, eyes open, muzzle relaxed, whiskers loose, and the head was above the shoulder line). *Source:* Lanette Jordan, LVT, VTS (Anesthesia and Analgesia).

with the help of the veterinary team, will select three to five activities for the owner to score as no problem performing, moderate difficulty performing, or severe or impossible performing [37]. Therefore, this instrument may take longer to initially develop and use when compared to other instruments.

7.5.3.2 Feline Musculoskeletal Pain Index (FMPI) and FMPI-Short Form

The FMPI and its short form is a pain scale developed for owner assessment of musculoskeletal pain. The long form contains 17 assessments of mobility including the performance of daily activities like jumping up and down, playing, grooming, using the litterbox, and interacting with other pets and people [37, 63].

The FMPI-short form (FMPI-sf) has been constructed to improve the responsiveness of the instrument but maintain the overall reliability. The items were reduced from 17 to 9 in the short form and studies have shown improvement in the ability



Figure 7.3 Refined Glasgow Composite Measure Pain Scale – feline. (a) Based on the Refined Glasgow Composite Measure Pain Scale – feline, the patient received a total pain score of 7/20. The patient was silent (score 0), tense/crouched (score 3), ignoring the wound (score 0), ears were slightly apart (score 1), and the muzzle was slightly tight (score 1). The patient was unresponsive to stroking (score 1), did not respond when pressure was applied around the painful area (score 0), and seemed disinterested/quiet (score 1). *Source:* Oscar Thamar-Torres, DVM. (b) After analgesia administration the same patient scored a 0/20. The patient was silent (score 0), relaxed (score 0), and ignoring the wound (score 0). The ears were forward (score 0). The muzzle was relaxed and round (score 0). The patient seemed to enjoy stroking (score 0), did not respond when the pressure was applied around the painful site, and seemed generally content (score 0). *Source:* Oscar Thamar-Torres, DVM. (c) This patient came to urinary blockage and scored a 10/20 on the Refined Glasgow Composite Measure Pain Scale – feline. The patient was silent (score 0), pacing and restless (score 2), and trying to lick the prepuce (score 1), the patient's ears were slightly apart (score 1), the muzzle was tense and elliptical (score 2), the patient was unresponsive to stroking (score 1), swished its tail when a technician tried to touch near the prepuce (score 1), and seemed generally anxious (score 2). *Source:* Beth Lozano, DVM, DACVECC. (d) After the patient received analgesia and was unblocked, the patient scored a 0/20. The patient was silent (score 0), relaxed (score 0), ignoring the prepuce (score 0), its ears were forward (score 0), muzzle was relaxed and round, and the patient no longer responded when a technician tried to touch near the prepuce (score 0), and seemed generally content (score 0). *Source:* Beth Lozano, DVM, DACVECC.

of the instrument to distinguish between patients that have received or not received analgesia. The nine items on the short form include jumping up and down, jumping up to the kitchen counter, playing, interacting with other pets, standing from a resting position, sitting down, stretching, and grooming [64]. Information for veterinary professionals and owners on the FMPI can be found at https://painfreecats.org/the-fmpi/ (accessed 14 March 2024).

7.5.3.3 Montreal Instrument for Cat Arthritis Testing-Veterinary

The Montreal Instrument for Cat Arthritis Testing-Veterinary was refined and has four assessment criteria on body posture, gait, obstacles, and global distance exam with a maximum summative score of 60. It has undergone preliminary validation and reliability testing but could benefit from further refinement to increase sensitivity and reliability to differentiate between cats with osteoarthritis and cats without the disease [37, 65]. Although one study has shown that the instrument can discriminate the functional severity of OA in cats and allows for assessment of treatment effect on patients receiving firocoxib [66].

7.5.3.4 Composite Oral and Maxillofacial Pain Scale – (Canine/Feline)

The Composite Oral and Maxillofacial Pain Scale – Canine/Feline (COPS-C/F ENG) was developed and refined as a two-part questionnaire with one part of the owner with six questions/items of assessment and one part for the veterinary professional with four questions/items of assessment [67]. The questions for the owner focus on eating habits, interactions with people and pets, physical activity, grooming, and other behaviors that involve the mouth. For the veterinary professional, the questions focus on current behavior, behaviors in response to the oral cavity, and other physical signs of oral disease. Although the scale would allow evaluation specifically for oral disease, the instrument currently has not been evaluated in its ability to differentiate between pain intensities or nonpainful or painful individuals and no score for interventional analgesia has been determined. Therefore, the English version will require further validation [67].

7.6 Treatment of Pain

Analgesia refers to the loss of sensitivity to a stimulus that would normally produce pain. Therefore, treatment of pain or nociception is often termed providing analgesia. Multimodal analgesia would be providing agents or processes that act at different points within the pain pathway to provide analgesia. There are many pharmacological and nonpharmacological options available for analgesia, and the selection of a particular therapy will depend on many factors including the type and severity of pain, the location of the pain, the expected duration of the pain, the location of the patient for the treatment of the pain [2]. The 2015 AHAA and AAFP Pain Management Guidelines have a nice acronym for approaching pain management called PLATTER, which stands for plan, anticipate, treat, evaluate, and return, meaning that the veterinary team should create a plan that is patient specific based on any anticipated pain or present pain with treatments that take in consideration the type, severity, and duration of the pain and then evaluate the effectiveness of the treatment with the option to modify the plan as needed [68]. The 2022 AAHA Pain Management Guidelines for Dogs and Cats use a decision tree using a tiered system for acute and chronic pain. For example, the first tier of acute pain may include a multimodal approach of opioids, local anesthetics, nonsteroidal anti-inflammatory drugs (NSAIDs), cold therapy, and nursing care. The second tier selection of analgesics would then depend on further diagnosis but could include adding NMDA antagonists, alpha-2 agonists, or other physical modalities [69]. For chronic pain, the first tier might include the use of NSAIDs or monoclonal antibodies (mAbs) as well as environmental modifications, with the second tier adding pharmacological agents like gabapentin or nonpharmacological modalities like therapeutic exercise [69].

From an acute pain standpoint, we often need to provide preemptive analgesia, which may mean that we need to attempt to predict the amount of pain a particular procedure may induce [21, 69, 70]. In general, the more tissue damage the procedure requires, the more painful the procedure is perceived to create [69, 71–73]. For example, a four-centimeter incision would be less painful than a twenty-centimeter incision. The type of tissue involved will also affect the amount of predicted pain. Pain is predicted to increase as the procedure moves from subcutaneous (SC) tissue to muscles, organs, bones, joints, and finally to nervous tissue [69, 71–73]. For example, a SC lipoma removal would be considered less painful than a liver lobectomy [8]. The next step in the process of pain management would be providing a multimodal approach where different parts of the pain pathway like transduction, transmission, and modulation are interrupted and therefore the overall control of the pain is more effective [69].

For chronic pain, the veterinary team needs to also consider the time and effort the owner will have to put forth to implement the treatment plan and balance the therapeutic modalities with the burden of care. For instance, administering an oral medication several times a day may put stress on the human–animal bond between the owner and pet.

7.6.1 Pharmacological

The following section contains some of the common pharmacological agents used in the management of acute and chronic pain; however, for further information on other pharmacological agents and their uses, please refer to Chapter 8: "Introduction to Feline Pharmacology."

7.6.1.1 Opioids

Opioids have the benefit of acting on various locations within the pain pathway by binding to opioid receptors in the peripheral and central nervous systems, reducing excitatory neurotransmitters, hyperpolarizing post-synaptic nervous cell membranes, preventing calcium from entering afferent neurons, and activating inhibitory pathways [2]. Opioids can

be administered via a variety of routes, including intravenous (IV), intramuscular (IM), SC, transdermal, oral transmucosal (OTM), or neuraxial. However, their use is focused on acute pain rather than chronic pain due to limitations in administration and the potential for human abuse.

7.6.1.1.1 Full mu Agonists

Some examples of full mu-agonist opioids include methadone, fentanyl, hydromorphone, and morphine. These drugs provide dose-dependent analgesia, usually for acute moderate to severe pain. Methadone is a synthetic full mu agonist with some activity as an NMDA receptor antagonist meaning that it may also be helpful in treating peripheral and central sensitization [74]. Another benefit of methadone is that it has been shown to cause minimal vomiting and nausea when compared to other full-mu agonists. Dosages have been recommended at 0.2–0.6 mg/kg IM or IV. The higher end of the dose has also been shown to be effective via transmucosal. The duration of methadone can last around 6 hours [2, 75].

Fentanyl is a potent short-acting full mu agonist commonly used as a continuous rate infusion at a dose range of 3–20 mcg/kg/h IV [2]. Fentanyl is a great choice in many situations due to its ability to reach therapeutic analgesia rapidly and be adjusted to meet the needs of the patient. However, since its duration is short (around 30 minutes after discontinuing), other agents may need to be considered in the postoperative period [2].

Hydromorphone has been shown to have analgesic effects at doses of 0.025–0.1 mg/kg. The IV route has been shown to provide the greatest intensity and duration of up to 6 hours with the least incidence of vomiting and salivation [2]. Another common adverse effect of hydromorphone and many other opioids is hyperthermia which has decreased its use in some practices [11, 76, 77]. However, increases in temperature are usually mild and short-lasting and can be treated with supportive care [2].

Morphine has been used clinically in cats, however, it seems to be less effective than compared to dogs potentially due to the limited production of the active metabolite [78]. Dosages have been recommended 0.1–0.3 mg/kg IM or IV for a duration of up to 6 hours, but if given IV it should be administered slowly due to the risk of histamine release [2, 75]. Vomiting and nausea commonly occur more frequently when administered IM [2]. Epidural administration can be used for multiple opioids, but morphine is the most used because it has a longer duration of action of up to 12–24 hours. Urinary retention may be observed with epidural administration. Therefore, the veterinary technician should monitor the bladder size during recovery [2, 79].

7.6.1.1.2 Partial mu Agonists

Since buprenorphine only has partial activity at the mu receptor, it should be used for mild or moderate pain relief. For example, it would not be suitable for acute pain management of major orthopedic procedures, especially as a sole analgesic, but it may be suitable for less invasive procedures like castration as part of a multimodal plan. Some negative aspects of buprenorphine are the "ceiling effect" and the long onset time. The "ceiling effect" means that increasing the dose may not produce an increase in analgesia [6]. Buprenorphine at doses of 0.02–0.04 mg/kg may take up to 30 minutes when given IV or OTM and up to 2 hours when given intramuscularly. A few benefits of buprenorphine are its duration and ability to be administered in a variety of routes. The duration of buprenorphine may be 4–12 hours [80, 81]. Most opioids have the highest efficacy IM or IV, but buprenorphine showed nearly complete bioavailability when the injectable formulation was placed in the oral mucus membranes due to the alkalinity of the mouth [81, 82]. This makes it possible to administer to aggressive patients or at home. Although the 0.3 mg/ml formulation has shown very low bioavailability via the SC route, the 1.8 mg/ml formulation is labeled for the SC route of administration at a higher dose of 0.24 mg/kg and may have a duration of up to 24 hours [2]. This formulation can also be used off-label via IV or OTM. Recently a transdermal buprenorphine solution with a solvent and permeation enhancer has been developed by Elanco, Zorbium™. This formulation needs to be applied by a trained veterinarian or veterinary technician in the clinic due to the risk of skin absorption and/or abuse, however, after a drying time of at least 30 minutes the buprenorphine is absorbed into the skin and released into the systemic circulation with peak plasma concentrations occurring after about two hours and the duration lasting approximately 4 days [83].

7.6.1.1.3 Agonist/Antagonists

Butorphanol is a commonly used mu antagonist/kappa agonist, which can be used for sedation but produces only mild analgesia when used as part of a multimodal plan at doses of 0.2–0.4 mg/kg IV or IM [2]. Butorphanol has a short duration of around 1.5 hours and a "ceiling effect" [84, 85]. Therefore, other analgesic options should usually be considered, especially for surgical procedures.

7.6.1.2 Side Effects

Although opioids can have some side effects in feline patients, analgesia should always be provided. If side effects are observed, nursing care should be provided, and a discussion started with the veterinarian to adjust the analgesic plan which may include just reducing the dose or altering the dosing schedule. The most common side effects of opioids are hyperthermia, mydriasis, vomiting, and salivation. Hyperthermia can be treated via supportive care and is usually self-limiting [76, 77, 86–88]. Patients with mydriasis may startle easier and may be sensitive to bright light, and may benefit from a dim room [11]. Vomiting and salivation have been seen more often with hydromorphone, especially via the SC or IM, but antiemetic medications can be given beforehand to reduce the occurrence [11, 89].

7.6.1.3 Chronic Pain Management

Although many times opioids are the cornerstone of acute pain management the benefits of using them during chronic pain conditions are not high. Routes of administration are a limiting factor considering that oral bioavailability is low for many opioids except for buprenorphine and methadone and the SC route is the least effective route when compared to IV or IM routes [7, 90]. Transdermal creams containing opioids have also not been scientifically supported, and transdermal patches of buprenorphine and fentanyl have shown variable effectiveness with suspected factors being skin permeability, body temperature, and patient size in comparison to patch size [87, 91–94].

7.6.1.4 Nonsteroidal Anti-inflammatory Drugs

NSAIDs have the benefit of being long-acting and able to be administered via an SC or oral route making them advantageous for both acute and chronic pain. NSAIDs are used to treat inflammatory pain by blocking the COX-1/COX-2 pathways to prostaglandin formation which means they reduce the transduction phase of the pain pathway and can be used for mild to moderate postsurgical pain and inflammation from chronic conditions. The timing of NSAID administration for acute conditions like during anesthesia can be a controversial subject. However, administering an NSAID preoperatively to a healthy patient that is normovolemic, receiving fluid therapy, and having blood pressure monitored can be beneficial for multimodal analgesia with little to no adverse effects [6]. The most common NSAIDs used are meloxicam and robenacoxib. Both meloxicam and robenacoxib are approved for the treatment of acute pain in cats in the United States. In the United States, meloxicam is labeled for the treatment of acute pain as a single-dose injection at 0.3 mg/kg SC, but the clinically recommended doses can range from 0.05–0.2 mg/kg SC [2]. In many other countries, meloxicam is approved to be used for multiple doses partially attributed to the fact that it uses oxidative pathways of elimination instead of glucuronidation [95]. Meloxicam has shown high bioavailability for both oral and SC routes and seems to be palatable, which can improve client compliance [96].

Robenacoxib has shown high SC bioavailability with only moderate oral bioavailability. In the United States, it is labeled for acute pain for a maximum treatment duration of 3 days, but other countries have labeled its use for up to 6 days [97–99].

The major drawback to NSAID use is the risk of toxicity due to reduced or variable glucuronidation pathways in cats leading to a prolonged duration or drug accumulation of some classes of NSAIDs. Side effects can include GI irritation, protein-losing enteropathy, and renal damage associated with their use. Patients who have comorbidities like anemia, coagulopathies, hypovolemia, hepatic disease, GI disease, or renal disease should use caution with these drugs. Patients who are currently on corticosteroids or another NSAID should also use caution and allow a wash-out period to decrease the risk of increased side effects.

However, not using NSAIDs because of the fear of potential adverse effects is not recommended. Unfortunately, it is very common for cats with chronic pain conditions like a degenerative joint disease to also have chronic kidney disease (CKD) as a comorbidity [9]. Therefore, despite risks to the renal system, several retrospective and prospective studies have investigated the use of NSAIDs in patients with CKD and have found that NSAIDs could be administered to those patients if they were overall clinically stable, had normal hydration and circulating blood volume, and blood pressures were maintained [9].

7.6.1.5 Local Anesthetics

Local anesthetics block pain transduction and transmission of the pain pathway [100]. Unlike other drugs, local anesthetics will provide complete analgesia and should be incorporated whenever possible [2, 69]. Other advantages include the fact that these drugs are easily accessible, low cost, and reduce the amount of general anesthetic or sedation required to perform a procedure. Contraindications are rare and adverse events are usually attributed to human errors like miscalculation leading to an overdosage or poor technique leading to nerve damage or accidental IV administration. If toxicity

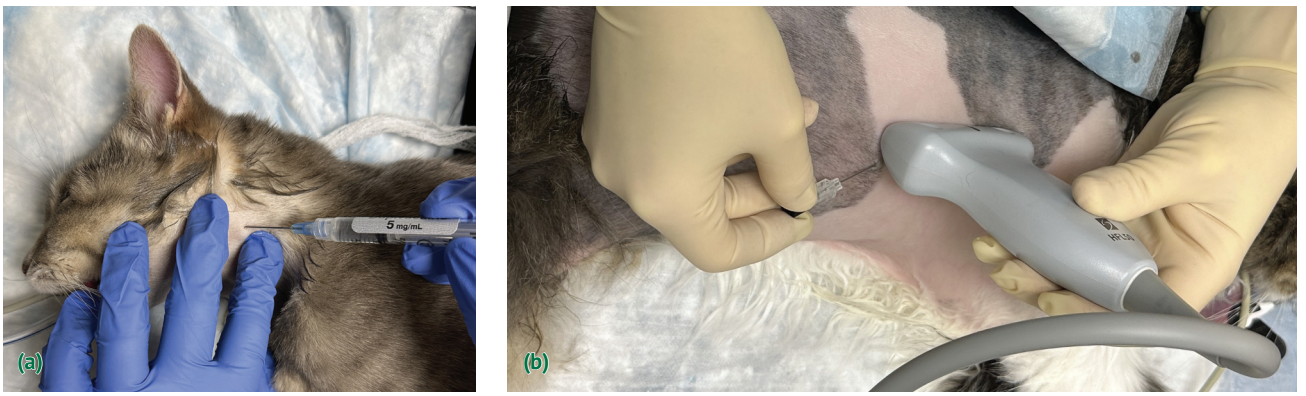


Figure 7.4 Examples of local blocks. (a) Patient receiving a great auricular block with bupivacaine by palpating and inserting the needle superficially along the wing of the atlas. (b) Patient receiving an ultrasound-guided intercostal block. *Source:* Lanette Jordan, LVT, VTS (Anesthesia and Analgesia).

is suspected the focus is on supportive care (e.g., fluid therapy and inotropic support), treatment of adverse events (e.g., seizures), and IV administration of lipid emulsion [8, 101].

Lidocaine, bupivacaine, mepivacaine, ropivacaine, and liposome-encapsulated bupivacaine have been approved for use in peripheral nerve blocks and have been used off-label for other blocks as well. Multiple types and techniques of local blocks have been reported in cats from simple anatomically guided to ultrasound-guided techniques (Figure 7.4a,b). Detailed descriptions of loco-regional techniques are beyond the scope of this chapter, but there are several resources available to provide education and guidance to the veterinary team including this website that has several videos https://www.zeropainphilosophy.com/vet-professionals (accessed 20 March 2024) [100, 102–106]. Veterinary technicians should be educated on the various techniques that are available for improving understanding of anatomical landmarks, safety, and efficacy to feline patients to either assist the veterinarian or perform the technique themselves. Besides loco-regional techniques, topical administration of local anesthetics should not be overlooked like transmucosal use before placement of a nasal oxygen cannula or transdermal use before placement of an IV catheter. Some available agents for transdermal application are a liposome-encapsulated formulation of lidocaine (L-M-X; Ferndale Laboratories, Ferndale, Minnesota), a mixture of lidocaine and prilocaine (EMLA cream; AstraZeneca LP, Wilmington, Delaware), and a lidocaine patch (Lidoderm 5%, Endo Pharmaceuticals, Chadds Ford, Pennsylvania) which have shown limited or no systemic uptake when applied to intact skin [2]. These products have been used to reduce discomfort from a variety of procedures like catheter placement or wound analgesia when used with other types of analgesia, but may take up to an hour to absorb and become effective [2, 11, 107, 108].

7.6.1.6 Alpha-2 Agonists

Alpha-2 agonists offer reliable sedation, anxiolysis, and chemical restraint. They have also been shown to decrease anesthetic requirements and provide analgesia. Dexmedetomidine is the most used drug from this class in small animals. Dexmedetomidine mainly provides analgesia at the modulation phase of the pain pathway by decreasing nociceptive input to the brain and inhibiting the release of excitatory neurotransmitters [109]. Using dexmedetomidine with opioids has also shown a synergistic activity in analgesia [110, 111]. It can be administered in a variety of routes including intramuscular, intravenous, neuraxial, and peripheral nerve blocks. When added to local blocks it has been shown to prolong blockade due to peripheral action of alpha-2 receptors that will provide a synergistic effect as well as local vasoconstriction that will reduce systemic absorption and elimination of the local anesthetic [103, 104, 106].

7.6.1.7 NMDA Antagonists

7.6.1.7.1 Ketamine

Ketamine's analgesic effect is mostly due to its NMDA receptor antagonism. The NMDA receptor is usually activated by excitatory neurotransmitters like glutamate during events of sustained nociception within the dorsal horn of the spinal cord. Therefore, ketamine can reduce the transmission and modulation phases of the pain pathway within the spinal cord and reduce the instances of central sensitization and maladaptive pain [112]. Ketamine is mainly used at subanesthetic doses via a constant rate infusion for adjuvant multimodal pain management during the perioperative and postoperative

period at 2–16 mcg/kg/min IV and has not been associated with increases in intracranial pressure or rough recoveries [113, 114]. However, ketamine should not be used as the sole analgesic.

7.6.1.7.2 Amantadine

Amantadine is an NMDA receptor antagonist with a high oral bioavailability in cats and may be useful for pain therapy and reduction of central sensitization in the modulation phase of the pain pathway, however, it should not be used as the only analgesia. Safety and efficacy have not been established yet and analgesic effect may take 3–6 weeks to be apparent [9].

7.6.1.8 Amitriptyline

Amitriptyline is a tricyclic antidepressant that provides analgesia by reducing the serotonin and norepinephrine reuptake, antagonizing the NMDA receptor, and blocking calcium channels, thereby reducing nervous system excitation and reducing central sensitization in the modulation phase of the pain pathway. It may take 3–6 weeks to notice analgesic effects [7].

7.6.1.9 Gabapentin

Gabapentin is a structural analog of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA) but has little activity at the GABA receptor. Gabapentin produces analgesia by decreasing the release of excitatory neurotransmitters, increasing the concentrations of GABA, and blocking calcium channels, all of which reduce nervous system stimulation and affect the modulation phase of the pain pathway, making it beneficial in neuropathic, maladaptive, and chronic pain [9, 113]. Gabapentin has a high oral bioavailability, making it ideal for oral administration with peak plasma concentrations occurring in 2 hours or less, but it needs to be readministered every 6–8 hours to maintain the plasma levels [115]. Besides being used for sedation and improving feline-friendly handling, gabapentin is used extensively in chronic or maladaptive pain conditions, where it has shown improvement in activity and mobility in those patients. There is a wide range of doses, and recommendations have been made to start a low dose until the sedative effect subsides and increase as needed until the analgesic response is observed, which may take 3–6 weeks [9].

7.6.1.10 Monoclonal Antibodies

Solensia™, the brand name for frunevetmab, is part of a class called anti-nerve growth factor monoclonal antibodies (mAbs). mAbs, in general, can be administered via various routes including IV, IM, or SC; however, oral administration is limited due to their molecular size and the fact that they are broken down in the stomach [116]. Solensia is labeled for the SC route of administration. Frunevetmab works to reduce pain signals by binding to the NGF that may contribute to peripheral and central sensitization, therefore mAbs may help in both the transduction and modulation phases of the pain pathway. NGF has been found to be elevated in osteoarthritic joints and is released during noxious stimulation as part of the transduction process as an inflammatory mediator [117]. Long-term exposure to NGF can also result in allodynia [17]. Frunevetmab prevents NGF from binding and decreases transduction in as fast as 14 days according to a study by Gruen et al. [116, 118].

7.6.2 Nonpharmacological

7.6.2.1 Nursing Care

Nursing care should always be applied as an adjunct to other pain management techniques. Nursing care that can reduce pain can be as simple as positioning a patient to reduce pressure or friction on painful areas, providing a soft-cushioned surface, and repositioning the patient regularly to prevent muscle stiffness, ulcers, and promote circulation [8]. Patients who are used to human contact may also benefit from gentle grooming and soft tissue massage, which may release a variety of proteins and neurotransmitters that can augment pain processing, improve blood flow, and reduce inflammation [8].

7.6.2.2 Weight Optimization

Increased weight can increase the workload on joints. Adipose tissue can secrete proinflammatory substances, like cytokines. Providing a nutritional calorie-restricted diet and increasing the cat's physical activity through enrichment is important [7].

7.6.2.3 Acupuncture

Acupuncture is the placement and manipulation of needles at acupoints, which are defined locations that have a high amount of neurovascular or myofascial structures [8]. Analgesia from acupuncture may be due to the effects of

neuromodulation from neuronal gating and the release or endogenous opioids [8, 119]. It has been shown to inhibit transduction via inflammation and transmission. Acupuncture is generally well tolerated but should be used with caution in patients who may be experiencing allodynia or central sensitization because the needles may trigger these responses [7].

7.6.2.4 Physical Rehabilitation

Physical rehabilitation may involve, but not be limited to therapeutic exercise like low-impact aerobic exercise and weight-bearing to improve blood and lymph flow, stretching to enhance range of motion and improve muscle strength, thermotherapy to increase blood flow and facilitate healing, cryotherapy to reduce activation of tissue nociceptors, and photobiomodulation to reduce inflammation and provide analgesia [7, 8, 119].

7.6.2.5 Environmental Modification

Environmental modifications that can be made to reduce stress and promote analgesia can begin with the location by reducing auditory, visual, and olfactory stimulation. For example, providing a quiet area away from busy treatment rooms, keeping feline patients separate from canine patients, or providing some sort of background noise, like white noise can reduce stressful auditory stimulation [8]. Visual modifications can include dimming the lights or providing a place for the patient to hide or a vertical space to use. Olfactory modifications can include keeping the feline patient away from the treatment rooms or canine-housed rooms as well as providing feline pheromones [8]. Other environmental modifications include providing easy access to food, water, and the litter box. It is also important to provide environmental enrichment to stimulate interest and physical activity. Scratch posts must provide good stability with a wide base. Toys to stimulate hunting like chasing and pouncing, elevated areas to encourage jumping [7].

Feline patients present unique challenges in both the assessment and treatment of pain. Veterinary technicians can play an integral part in advancing pain management in feline patients. Performing pain assessments, using validated assessment tools, discussing and implementing various pain management techniques in the clinical setting, and providing communication and client education to engage pet owners in discussions about pain recognition, treatment goals, and ensuring compliance for successful long-term pain management strategies and improving the quality of life for our feline companions.

See the companion website for further clinical references.

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8

Introduction to Feline Pharmacology

Ann Wortinger BIS, LVT, VTS (ECC) (SAIM) (Nutrition), Elite FFCP

TECHNICIAN TIDBITS

- Delayed gastric emptying can affect drug absorption.
- Thinner skin can increase the rate of topical absorption.
- Oxidation utilizes cytochrome p450 enzymes.
- Glucuronidation utilizes uridine diphosphate glucuronosyltransferase (UGT) enzymes.
- Conjugation makes some drugs more soluble.
- Acetaminophen should not be administered to cats.
- Buprenorphine is 25–50 times more potent than morphine.
- Gentamicin can cause nephrotoxicity.
- Pentobarbital is the most common euthanasia agent in veterinary medicine.
- Antimicrobial stewardship can preserve the effectiveness of antimicrobial drugs.

As with most things cats there is little research on exactly how cats metabolize drugs, though we have found out, mostly through trial and error, which they do indeed metabolize drugs differently than either humans or dogs. This chapter will look at these differences in pharmacokinetics, and metabolism as they relate to cats, specifically.

8.1 Unique Pharmacokinetics for the Feline Patient

For any drug to be utilized by the body, there must first be absorption, and then frequently metabolism allowing the drug to be converted into its active form or combined with other biological molecules for activation.

Cats tend to consume foods with higher protein and fat and lower carbohydrate contents, so there may be delayed gastric emptying affecting drug absorption, especially for medications administered with a meal [1]. Conversely, for orally absorbed medications, such as buprenorphine, the higher pH found in a cat's mouth can increase bioavailability (Figure 8.1).

For topical medications, such as fentanyl and selamectin, the fact that a cat has thinner skin compared to a dog can increase the rate at which medications are absorbed, allowing therapeutic levels to be reached quickly [1].

8.2 Metabolism

We have long understood that cats metabolize some drugs differently than humans and dogs. Cats have lower levels of drug conjugation pathways that can lead to relatively slow elimination of certain drugs, and the need for dose adjustments or alternative therapies to avoid serious adverse effects [2]. Research has shown that cats have lower levels of glucuronidation when compared to dogs and humans. No evidence has been found for a slower clearance of drugs that are eliminated by oxidation or are eliminated unchanged in the urine or bile [2].

Their status as obligate carnivores has been rationalized as the reason behind this difference. Naturally, their intake of plants and other natural sources of plant toxins is lower due to their lower overall plant material intake. They did not need to metabolize chemicals found in plant products [3].



Figure 8.1 Oral medication. The higher pH found in a cat's mouth can increase the bioavailability of certain drugs. *Source*: Ann Wortinger.

8.2.1 Phase I Enzyme Metabolism

Phase 1 metabolism involves the formation of a new or modified compound by oxidation, reduction, or hydrolysis that becomes more conducive to phase II metabolism [4]. In phase I metabolism, one of four things can happen. Inactivation, as seen with most nonsteroidal anti-inflammatory drug (NSAIDs), activation from a pro-drug to an active form of the drug, modification of the activity of the compound that can cause the formation of active metabolites, that may have a greater than, less than, or equal action to that of the parent compound, and the formation of toxic metabolites. The formation of toxic metabolites is generally due to direct cell damage, as seen with acetaminophen, and in some instances, the toxic metabolites can act as an antigen, causing immune-mediated toxicity, as with the sulfonamides [4]. Oxidation of drugs by cytochrome p450 monooxygenase (cyp 450) is the most important enzyme involved in the biotransformation of a broad range of chemicals found both inside (endogenous) and outside (exogenous) the body [5]. This enzyme is found in the largest amounts in the liver and is also found in substantial amounts in the gastrointestinal mucosa [5]. A cat's production of cyp 450 is approximately 20% lower than rats, and 33% lower than dogs.

8.2.2 Phase II Enzyme Metabolism

Phase II drug metabolism almost exclusively inactivates drugs. Because of this, it often protects the organ of metabolism from drug-induced toxicosis [4]. Phase II reactions involve the conjugation of the compound with an endogenous substance, such as glucuronic acid, sulfate, or glycine [4]. Cats are relatively inefficient in glucuronidation of simple phenols and other aromatic chemicals. This is thought to be because cats mostly lack functional uridine diphosphate glucuronosyltransferase 1A6 (UGT1A6) and 1A9 (UGT1A9), enzymes in the glucuronidation pathway that transform small lipophilic molecules, such as steroids, bilirubin, and drugs into water-soluble, excretable metabolites. Remember that a drug must be water soluble to be excreted through the kidneys. In drug toxicities, N-acetylcysteine increases the intracellular concentration of glutathione, enabling more effective metabolism through conjugation [4] (Table 8.1).

8.2.3 Oxidation

Oxidative metabolism of drugs is done primarily using the cytochrome p450 enzymes (Phase I). In cats, 2 cytochrome genes are present, of which one is a pseudogene and is not expressed, and the other is produced at low levels in the liver [6]. Liver-produced cyp 450 reduces compounds, including drugs, which in turn react with oxygen to form an "active oxygen"

Table 8.1 Method of drug metabolism and enzymes or processes involved [2–4, 6–9].

Method of metabolism	Organ of metabolism	Enzyme or addition
Oxidation	Liver	Cytochrome p450
Glucuronidation	Liver	UGT1A1 and UGT1A2
Conjugation	Liver	Addition of amino acids glutamine, glycine, and acetyl or sulfa groups
Acetylation	Liver	NAT1
Methylation	Cellular cytoplasm	TPMT
Renal excretion	Kidney	The drug is minimally metabolized, or unchanged

molecule. These "active oxygen" molecules seem to be involved in the oxidation of a variety of substrates by a group of nonspecific enzymes. This means that the enzymes can oxidize various types of compounds, rather than working with only specific compounds as seen with amylase or lipase [7].

Highly lipid-soluble compounds are oxidized by liver enzymes to make the compounds more water soluble. The rate of drug oxidation in the liver is influenced by the amount of cyp 450 present with low specificity for what type of drugs they are [8].

8.2.4 Glucuronidation

In this route of drug metabolism, UGT enzymes transfer glucuronic acid in various compounds promoting the efficient elimination into the urine or bile [4, 8]. The UGT1A6 and UGT1A9 enzymes are found primarily in the liver, kidney, and intestinal mucosa of other species but are lacking in cats [2]. Research has shown that the inability of cats to glucuronidate drugs is dependent on drug structure, and not on the pathway specifically. Cats only produce two different UGT1As in the liver, UGT1A1, and UGT1A2, whereas humans produce five different versions. This deficiency appears to mainly affect simple phenolic structures, such as propofol, carprofen, and chloramphenicol [2, 3].

Due to the lack of the UGT1A6 and UGT1A9 enzymes in cats, they have shown sensitivity to the adverse effects of many drugs and toxins that are normally glucuronidated after oxidation, which can cause a deficiency of glucuronidation. An example of this deficiency is the slower clearance of acetaminophen, resulting in increased levels of acetaminophen metabolites in the blood. The feline liver only expresses two different forms of the UGT enzymes, UGT1A1 and UGT1A2. UGT1A1 is likely conserved since it is essential for the glucuronidation and clearing of bilirubin and is not available for drug metabolism, leaving only UGT1A2 available to help with metabolism [2].

There is evidence to also suggest that the commonly used preservatives benzyl alcohol and benzoic acid are poorly metabolized, with delayed conjugation potentially contributing to benzoic acid poisoning in cats (Table 8.2).

Table 8.2 Drugs with direct evidence of slower glucuronidation and those with efficient glucuronidation in cats [2].

Slower glucuronidation in cats	Efficient glucuronidation in cats
Acetaminophen	Flurbiprofen
Chloramphenicol	Ibuprofen
Clofibrate	Lorazepam
Morphine	Phenolphthalein
Orbifloxacin	Pirprofen
Valproate	Salicylate
	Telmisartan

8.2.5 Conjugation

Conjugation occurs during glucuronidation in Phase II metabolism. Conjugation makes most drugs more soluble and therefore more easily excreted by the kidneys. When the compound is conjugated with the amino acids glutamine or glycine, these compounds are more easily excreted in the urine and bile. Conjugation can also occur through the sulfoconjugation of compounds, where an acetyl or sulfa group is added to the compound [4]. Glycine conjugation is one of the major pathways in the elimination of salicylates in other species. In cats, this pathway is defective, which results in a slower clearance of salicylates, such as aspirin [3].

8.3 Acetylation

Acetylation utilizes the N-acetyltransferase enzymes NAT1 and NAT2. Cats lack the NAT2 enzyme but do have the NAT1 enzyme at a lower activity level than other species [2]. A deficiency in NAT2 has been associated with very low acetylation of sulfamethazine, sulfanilamide, sulfadimethoxine, and isoniazid by the cat liver. This deficiency is proposed to be the mechanism of toxicity of acetaminophen in multiple species [6].

8.4 Methylation

Cats have low activity of the cytoplasmic enzyme thiopurine methyltransferase (TPMT) compared to other species. This is an important detoxification mechanism for several drugs used especially in the treatment of cancers and for immunosuppression. This may be responsible for the adverse effects seen in cats related to the use of azathioprine [3]. Feline erythrocytes have less activity of TPMT, which can affect the enzyme level and the affinity for the drug and its activity [9].

8.5 Renal Excretion

Some drugs undergo little if any metabolism before being excreted unchanged in the urine. This includes such drugs as ampicillin, cefazolin, ciprofloxacin, doxycycline, and fluconazole [3].

For ampicillin and cefazolin, the drug is excreted unchanged in the urine, having undergone no metabolism, instead being removed through glomerular filtration and active tubular secretion. Ciprofloxacin has a clearance in the urine that exceeds the glomerular filtration rate, suggesting that tubular secretion or extra-renal excretion mechanisms are involved. Doxycycline is highly bound to plasma proteins, which impairs its tissue distribution. Due to the absence of metabolites in the urine, it is assumed that doxycycline is poorly metabolized and is primarily excreted unchanged via the kidneys. Clearance of fluconazole is lower than expected from glomerular filtration alone, and tubular reabsorption likely occurs in cats [3].

8.6 Medications with Unique Pharmacokinetics in the Feline Patient

8.6.1 Acetaminophen

Drug description and brand names: Tylenol. A derivative of P-aminophenol that has analgesic and antipyretic activity.

Formulations: Acetaminophen is available in more than 200 prescription and nonprescription formulations, including extended-release and strengths up to 650 mg. It can also be found in combination with other drugs [10].

Metabolism and mechanism of action: Acetaminophen inhibits the effects of pyrogens by blocking prostaglandin synthesis and inhibiting cyclooxygenase (COX), which results in an increased pain threshold [11]. It is rapidly absorbed and metabolized in the liver by glucuronidation and sulfation. Feline patients have low UDP-glucuronosyltransferase activity decreasing their ability to *conjugate* acetaminophen [12]. Acetylation utilizes the N-acetyltransferase enzymes NAT1 and NAT2. Cats lack the NAT2 enzyme but do have the NAT1 enzyme at a lower activity level than other species (Court NIH). A deficiency in NAT2 has been associated with very low acetylation of sulfamethazine, and other sulfa-containing compounds by the cat liver. This deficiency is proposed to be the mechanism of toxicity of acetaminophen in multiple species [3].

Contraindication and precautions: Do not administer to cats [13]. A single dose of 10 mg/kg has produced signs of poisoning in feline patients therefore, there is no safe dose for cats [12]. The limited glucuronyl transferase activity causes glucuronidation and sulfation pathways to become saturated and cellular glutathione stores to deplete. This results in N-acetyl-parabenzequinoneimine production leading to hepatocyte damage and oxidative stress to red blood cells leading to hemolysis and methemoglobinemia [11].

8.6.2 Aspirin

Drug description and brand names: Bufferin, Ascription. Aspirin is a salicylate that is used as an analgesic, NSAID, and antiplatelet drug in many species [13].

Formulations: Aspirin is available in 81 and 325 mg tablets.

Metabolism and mechanism of action: Anti-inflammatory action is caused by the inhibition of prostaglandins. Aspirin binds irreversibly to the cyclo-oxygenase (COX) enzyme in tissues to inhibit the synthesis of prostaglandins. Anti-inflammatory effects are attributed to this inhibition of COX, but other anti-inflammatory mechanisms may also contribute to other anti-inflammatory actions, such as inhibition of NF kappa-b [13]. Aspirin is broken down through *glycine conjugation* [3].

Indications and clinical uses: Many sources indicated aspirin for mild analgesia and anti-inflammatory use. In low doses, aspirin is more specific for the COX-1 than the COX-2 selective inhibitor and antiplatelet drug than other NSAIDs. Platelets collected from feline patients after administration of 5 mg/kg of aspirin had a decrease in thromboxane production (TXA2), a potent platelet activator, but platelet aggregation did not seem to be affected. Although aspirin has been available for many years, it is not registered by the Food and Drug Administration (FDA) for use in any species. No controlled studies have been done on cats to document the efficacy of this medication [13].

Contraindication and precautions: High doses can cause vomiting and other gastrointestinal complications, such as ulceration and bleeding. Do not administer other ulcerogenic drugs, such as corticosteroids. Hepatic injury has also been reported [10]. Cats are deficient in glucuronyl transferase and experience a prolonged excretion rate for salicylates. Longer elimination half-life in cats has been reported in cats of 22+ hours compared with dogs at 5–6 hours [14]. Due to this, cats are more susceptible to salicylate intoxication. NSAID toxicity in cats usually results from the failure to follow accepted guidelines [14].

Dosage: The recommended dosages for a cat range from 10 mg/kg every 48 hours for mild analgesia to 20 mg/kg every 48 hours for anti-inflammatory properties [13]. For antiplatelet effects, a dose of 0.5–1 mg or 5 mg/cat every 72 hours has been recommended. However, this would require the use of a compounded form that results in many veterinarians using a dose of 20 mg/cat every 72 hours or ¼ of an 81 mg tablet [10]. Some sources recommend a dose of 80 mg/cat every 48 hours for ease of dosing and administration [13].

8.6.3 Azathioprine

Drug description and generic name: Imuran. A thiopurine drug or purine antimetabolite is widely used as an immunosuppressive drug.

Formulations: Azathioprine is available in 50, 75, and 100 mg tablets. The dosage for cats may require the use of a compounded option.

Metabolism and mechanism of action: Azathioprine is active against T- and B-cell lymphocyte strains and acts to inhibit T-cell proliferation causing immunosuppressive activity. The exact mechanism of action is not known. It is initially spontaneously metabolized to 6-mercaptopurine (6-MP). The metabolite 6-MP is further *metabolized via* **TPMT** to 6-methylmercaptopurine (6-MMP), which may be associated with adverse effects. It is also metabolized via TPMT to other metabolites, including 6-thioguanine (6-TG), which may be responsible for the immunosuppressive effects because it can accumulate in cells and acts as a purine antagonist that disrupts DNA in leukocytes. TPMT in cats is universally low, making them more susceptible to the myelosuppressive effects of azathioprine than dogs and humans.

Indications and clinical uses: Used for immunosuppression for the treatment of autoimmune diseases, such as inflammatory bowel disease and immune hemolytic anemia.

Contraindication and precautions: Should be used with caution in cats due to the lack of metabolizing enzyme TPMT in this species resulting in a high incidence of severe myelosuppression [10]. Gastrointestinal side effects and liver toxicity have also been reported. Close monitoring should be considered with the administration of azathioprine to cats.

Dosage: Due to the bone marrow-suppressing effects, many veterinarians will not use this drug on cats. If treatment is still considered, 0.3 mg/kg q 24 hours PO and adjust the dose to q 48 hours after careful monitoring. Due to the small dose needed compounding will be necessary [13].

8.6.4 Buprenorphine

Drug description and brand names: Buprenex, Simbadol, Zorbium. Opioid analgesic. Buprenorphine is a Schedule II opioid.

Formulations: Buprenex is available in 0.3 mg/ml injection solution. Simbadol is available in 1.8 mg/ml for use in cats only. Zorbium is a topical that provides up to 4 days of pain control.

Metabolism and mechanism of action: Buprenorphine is a partial mu-receptor agonist and kappa-receptor antagonist. It is 25–50 times more potent than morphine. It has a higher binding affinity for the opiate receptor, which may prolong the effect. Buprenorphine has fewer adverse effects compared to other opioids. Transmucosal absorption in cats may be as low as 23–32%.

Indications and clinical uses: Buprenorphine is an opiate analgesic used primarily for pain control. At lower doses, the IM or IV route of administration is more effective than the SQ or topical routes. Simbadol is a concentrated solution available for the administration of SQ to cats once daily. Buprenorphine-SR is designed to produce effective concentrations for 72 hours.

Contraindication and precautions: Side effects of buprenorphine are similar to other opiate agonists, except there is less respiratory depression. Sedation is common.

Dosage: For analgesia- 0.01–0.02 mg/kg IV or 0.02 mg/kg IM. Buccal (transmucosal)- 0.02–0.04 mg/kg q 8 hours. Subcutaneous (Simbadol) 0.24 mg/kg q 24 hours × 3 days. Topical (Zorbium) is available in two sizes 8 mg dose for cats 2.6–6.6 lbs. and a 20 mg dose for cats > 6.6 lbs. and up to 16.5 lbs [13] (Table 8.3).

8.6.5 Carprofen

Drug description and brand names: Rimadyl, Vetprofen. NSAID.

Formulations: Carprofen is available in 25, 75, and 100 mg caplets, and a 50 mg ml injectable solution.

Metabolism and mechanism of action: Similar to other drugs in this class, carprofen has analgesic and anti-inflammatory effects by inhibiting the synthesis of prostaglandins. The enzyme inhibited by an NSAID is the COX. COX-2 is induced and responsible for synthesizing prostaglandins that are important mediators of pain, inflammation, and fever. Carprofen is relatively COX-1 sparing compared to older NSAIDs, but it is not known if the specificity for COX-1 or COX-2 determines efficacy or safety. Carprofen is broken down using the *glucuronidation* cycle in the liver [3, 13].

Indications and clinical uses: Carprofen is used primarily for the treatment of musculoskeletal pain and acute pain related to surgery or trauma. Long-term safe use has not been established in cats.

Table 8.3 Opioid drugs and their schedule [13].

Drug name	Schedule
Buprenorphine	II
Diazepam	IV
Gabapentin	III–IV (varies by state)
Ketamine	III
Lorazepam	IV
Meperidine	II
Midazolam	IV
Morphine	II
Pentobarbital	III
Propofol	IV (in some states)

Contraindications and precautions: Carprofen has produced toxicity in cats if administered at the same dose as dogs. Do not administer to cats prone to gastrointestinal ulcers. Do not administer with corticosteroids.
Dosage: The only approved dose is 4 mg/kg as a one-time injection for surgical pain [13].

8.6.6 Cephalexin

Drug description and brand names: Cefa-tabs, Cefa-drops, Duricef. A beta-lactam antibiotic.
Formulations: Available in 250 and 500 mg capsules, 75, 150, 30, and 600 chewable tablets for dogs, 100 mg/ml oral suspension, and 125 and 250 mg/5 ml oral suspension.
Metabolism and mechanism of action: Cephalexin is an antibiotic that inhibits the synthesis of the bacterial cell wall, resulting in cell death. Cephalosporins are divided into first-, second-, third-, and fourth-generation drugs depending on the spectrum of activity. Cephalexin is a first-generation cephalosporin and is active against gram-positive bacteria, including S*taphylococcus* and *Streptococcus* and some gram-negative bacteria. Antibiotic resistance is common among gram-negative bacteria. Cephalexin is *excreted unchanged* in the urine [3].
Indications and clinical uses: Cephalexin is indicated for the treatment of common infections in cats, including UTIs, soft-tissue infections, pyoderma, other dermal infections, and pneumonia.
Contraindication and precautions: Do not use in animals with allergic sensitivity to other beta-lactam antibiotics, or other cephalosporins.
Dosage: 15–20 mg/kg q 12 hours PO [13].

8.6.7 Chloramphenicol

Drug description and brand names: Chloromycetin. A bacteriostatic drug.
Formulations: Chloramphenicol palmitate 30-mg/ml oral suspension, 250 mg capsules, and 100, 250, and 500 mg tablets.
Metabolism and mechanism of action: Chloramphenicol is an antibiotic that works by inhibiting protein synthesis via binding to the 50-A ribosome subunit. It has a broad spectrum of activity that includes gram-positive cocci, gram-negative bacilli, and Rickettsia.
Indications and clinical uses: Chloramphenicol is used to treat infections caused by bacteria that are resistant to other common drugs, such as methicillin-resistant *Staphylococcus* spp.
Contraindication and precautions: Chloramphenicol can produce toxicity in cats and has a narrow margin of safety, with gastrointestinal disturbances being commonly seen. A decrease in bone marrow synthesis of protein can be seen with prolonged treatment. This suppression is reversible. Avoid use for >14 days. Use should be avoided in pregnant or neonatal cats.
Drug Interactions: Chloramphenicol is notorious for producing drug–drug interactions. It is a **cytochrome p450: CYP2B11 inhibitor**, and possibly other CYP enzymes. This causes decreased clearance of other drugs that utilize this pathway. This includes inhibition of opiates, barbiturates, propofol, phenytoin, salicylate, and possibly other drugs.
Dosage: 12.5–20 mg/cat q 12 hours IV or IM [13].

8.6.8 Ciprofloxacin

Drug description and brand names: Cipro. A fluoroquinolone antibiotic.
Formulations: Ciprofloxacin is available in 100, 250, 500, and 750 mg tablets and 5, 10, and 20 mg/ml injection.
Metabolism and mechanism of action: Ciprofloxacin is an antibiotic that acts to inhibit DNA gyrase and cell DNA and RNA synthesis. It is a broad-spectrum antibiotic, which is effective against gram-negative bacilli, and some gram-positive cocci. In cats, oral absorption is low (22–33%) and would not be effective for gram-positive bacteria, even at 10 mg/kg. Ciprofloxacin is **excreted unchanged in the urine** [3].
Indications and clinical uses: Ciprofloxacin is a human drug and is not approved for use in animals. Veterinary use is considered extra-label, and subject to other extra-label restrictions. Ciprofloxacin has potentially low availability when administered orally, which would suggest that oral doses should be higher than for similar drugs, such as enrofloxacin or orbifloxacin.
Contraindications and precautions: High concentrations of ciprofloxacin may cause CNS toxicity, especially in animals with renal failure. It can also cause occasional vomiting. Intravenous solution should be given slowly (over 30 minutes). Ciprofloxacin may cause arthropathy in kittens.
Dosage: 20 mg/kg q 24 hours PO, 10 mg/kg q 24 hours IV [13].

8.6.9 Clomipramine

Drug description and brand names: Clomicalm (veterinary), Anafranil (human). Useful in behavior modification. Used in people to treat anxiety and depression.

Formulations: Clomipramine is available in 20, 40, and 80 mg tablets (veterinary preparation), and 25, 50, and 75 mg capsules (human preparations).

Metabolism and mechanism of action: Clomipramine is a tricyclic antidepressant (TCA) drug. Action is via inhibition of the uptake of serotonin at the presynaptic nerve terminals. Beneficial effects may be due to primarily blocking the reuptake of serotonin and modulation of serotonin in areas of the brain that affect anxiety and behavior. It is broken down through **oxidation** using the cytochrome p450 cycle [3].

Indications and clinical uses: Clomipramine is used to treat various behavioral disorders, including obsessive-compulsive disorders, and separation anxiety. In cats, long-term treatment has been effective in decreasing urine spraying. However, treated cats return to urine marking abruptly after the drug has been discontinued. It is not effective for psychogenic alopecia in cats. When initiating therapy, start with a lower dose and increase gradually until the desired effect is seen. There may be a 2–4-week delay after initiating therapy before beneficial effects are observed.

Contraindications and precautions: In cats, sedation and weight gain have been observed. Reported adverse effects include sedation and a reduced appetite. It has a bitter taste and can cause challenges with oral administration. Do not use with other behavior-modifying drugs, such as serotonin reuptake inhibitors (SSRI), or with monoamine oxidase inhibitors (MAOIs).

Dosage: 1–5 mg per cat q 12–24 hours PO (0.5 mg/kg per day) [13].

8.6.10 Diazepam

Drug description and brand names: Valium. Diazepam is a benzodiazepine. Diazepam is a Schedule IV controlled substance.

Formulations: Diazepam is available in 2, 5, and 10 mg tablets, and 5 mg/ml solution for injection.

Metabolism and mechanism of action: Diazepam is a central-acting CNS depressant, with a mechanism of action that appears to be via potentiation of gamma-aminobutyric acid (GABA) – receptor-mediated effects because it binds to the GABA binding sites. It is metabolized to desmethyldiazepam and oxazepam. Cats have a decreased capacity for *glucuronidation* of diazepam and metabolites for clearance and excretion. The IV half-life is approximately 3.5–5 hours.

Indications and clinical uses: Diazepam is used for sedation, anesthetic adjunct, anticonvulsant, and behavioral disorders. It can be administered IV for short-term appetite stimulation. Oral administration has been effective in decreasing urine spraying, but relapses are common when the drug is discontinued.

Contraindication and precautions: Reports of idiopathic fatal hepatic necrosis have been received. Chronic administration may lead to dependence and withdrawal syndrome if discontinued. Administration of IM or SQ can be painful and irritating. Intravenous injection can cause phlebitis. As metabolism is highly dependent on liver blood flow, do not administer it to patients with impaired liver function. Long-term use should be avoided because of the risk of liver toxicity. As diazepam is highly lipophilic and will bind to and be absorbed into soft plastic containers, such as infusion bags, containers, infusion, and sets, storage in these containers is not recommended.

Dosage: Preanesthetic – 0.5 mg/kg IV, appetite stimulant – 0.2 mg/kg IV, behavior treatment – 1–4 mg/cat q 12–24 hours PO [13].

8.6.11 Digoxin

Drug description and brand names: Lanoxin and Cardoxin. Cardiac inotropic agent.

Formulations: Digoxin is available in 0.0625, 0.125, and 0.25 mg tablets, and 0.05 and 0.15 mg/ml elixir.

Metabolism and mechanism of action: Digoxin increases cardiac contractility and decreases the heart rate. This is through the inactivation of cardiac muscle sodium-potassium ATPase and increased intracellular availability of calcium, triggering calcium release from the sarcoplasmic reticulum (a network of specialized smooth endoplasmic reticulum that is important in transmitting the electrical impulse, and storage of calcium). The heart rate decreases due to increased vagal tone.

Indications and clinical uses: Digoxin is used in heart failure and to decrease the heart rate in cats. It is used for supraventricular arrhythmias to decrease ventricular response to atrial stimulation through suppression of the AV node. It may be used in combination with other drugs for heart failure.

Contraindications and precautions: Cats are more sensitive to the adverse effects of digoxin. Digoxin concentrations need to be monitored to determine the optimal therapeutic dose.

Dosage: 0.008–0.01 mg/kg q 48 hours PO (approximately ¼ of a 0.125 mg tablet/cat) [13].

8.6.12 Doxycycline

Drug description and brand names: Vibramycin, Monodox, Doxy Caps. Tetracycline antibiotic.

Formulations: Doxycycline is available in a 10-mg/ml suspension, 50, 75, and 150 mg tablets, and 50 and 100 mg capsules. Doxycycline hyclate injection is available in 100 and 200 mg vials.

Metabolism and mechanism of action: Doxycycline binds to the 30S ribosomal subunit and inhibits protein synthesis. The action of tetracyclines is usually bacteriostatic. It has a broad spectrum of activity, including bacteria, some protozoa, *Rickettsia*, and *Ehrlichia.* Doxycycline is **excreted unchanged in the urine** [3].

Indications and clinical uses: Doxycycline is administered to cats with infections caused by *Mycoplasma* or *Chlamydophila felis* and has been effective in eliminating the organism and improving clinical signs.

Contraindications and precautions: If solid-dose forms (tablets or capsules) are administered to cats, lubricate the tablet/capsule, or follow immediately with food or water to ensure passage into the stomach. If left in the esophagus, strictures are common. Do not administer rapidly IV. Do not administer the injectable form IM or SQ.

Dosage: 5-mg/kg q 12 hours PO or IV. *Mycoplasma haemofelis*: 10 mg/kg PO q 24 hours x 7 days [13].

8.6.13 Fluconazole

Drug description and brand names: Diflucan. Azole antifungal.

Formulations: Fluconazole is available in 50, 100, 150, and 200 mg tablets, 10 and 40 mg/ml oral suspension, and 2 mg/ml IV injection.

Metabolism and mechanism of action: Fluconazole is an azole antifungal. Its actions are fungistatic, by inhibiting ergosterol synthesis in fungal cell membranes. It has activity against dermatophytes, systemic fungi, and yeasts. This includes *Candida, Coccidioides*, and *Cryptococcus* spp. It has weak activity against molds, such as *Aspergillus* or *Zygomycetes.* Compared to other oral azole antifungals, fluconazole is absorbed more predictably and completely, even on an empty stomach. It is excreted unchanged in the urine.

Indications and clinical uses: Fluconazole is effective against dermatophytes, yeasts, and a variety of systemic fungi.

Contraindication and precautions: Fluconazole can be an inhibitor of cytochrome p450 enzymes, which can increase the concentration of other drugs. Use cautiously in pregnant animals. At high doses in laboratory animals, it has caused fetal abnormalities.

Dosage: 50 mg/cat q 24 hours PO. In refractory cases, increase to 50 mg/cat q 12 hours PO [13].

8.6.14 Gabapentin

Drug description and brand names: Neurontin. Anticonvulsant, analgesic, calming/sedation. Gabapentin is a Schedule III–IV controlled substance.

Formulations: Gabapentin is available in 100, 300, and 400 mg capsules, 100, 300, 400, 600, and 800 mg scored tablets, and 50 mg/ml oral solution.

Metabolism and mechanism of action: Gabapentin is an analog of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA); however, it is not an antagonist or agonist for the GABA receptor. It inhibits the alpha-2-delta subunit of the N-type voltage-dependent calcium channel in neurons. This reduces the calcium influx that is needed for the release of neurotransmitters. This action may suppress stimulated neurons involved in seizure activity and pain.

Indications and clinical uses: Gabapentin is used as an anticonvulsant, sedative, anxiolytic, and to treat chronic pain syndrome, including neuropathic pain. Studies are not currently available demonstrating efficacy in the treatment of pain in cats. It helps alleviate anxiety in cats, especially associated with travel or veterinary visits as a previsit pharmaceutical [14].

Contraindication and precautions: Sedation and ataxia are reported as adverse effects. Concurrent use of antacids can decrease oral absorption.

Dosage: Anticonvulsant, 5–10 mg/kg q 12 hours PO, can be increased to 20 mg/kg q 8–12 hours if needed. Neuropathic pain, 5–10 mg/kg q 12 hours PO. Calming/sedation, 10–20 mg/kg/dose or 50–100 mg/CAT administered 1–2 hours before need [13, 14].

8.6.15 Gentamicin

Drug description and brand names: Gentocin, Garasol, Garacin. Aminoglycoside antibiotic.

Formulations: Gentamicin is available in 10 and 100 mg/ml injectable solution.

Metabolism and mechanism of action: Gentamicin inhibits bacterial protein synthesis via binding to 30S ribosome. It is bactericidal with a broad spectrum of action, including activity against staphylococci and gram-negative bacilli of *Enterobacteriaceae*. However, it has impaired activity against streptococci and anaerobic bacteria.

Indications and clinical uses: Gentamicin has rapid bactericidal action and is indicated for acute, serious infections, especially those caused by gram-negative bacilli. It can be administered IM, SQ, and IV; however, it is not absorbed after oral administration. Gentamicin can be used with beta-lactam antibiotics as it broadens the spectrum when used with drugs, such as penicillin, ampicillin, or cephalosporins.

Contraindication and precautions: Nephrotoxicity is the most dose-limiting toxicity. Ensure that there is adequate fluid volume during therapy. Do not administer to cats with compromised renal function, renal insufficiency, kidney disease, or renal failure.

Dosage: 5–8 mg/kg q 24 hours SQ, IM, or IV [13].

8.6.16 Ivermectin

Drug description and brand names: Heartgard, Ivomec, Acarexx, Otimectin. Antiparasitic.

Formulations: Ivermectin is available in 1% (10 mg/ml), 2% (20 mg/ml), and 0.27% (2.7 mg/ml) injectable solutions, 10 mg/ml oral solution and 55 and 165 mg feline tablets.

Metabolism and mechanism of action: Ivermectin is a macrocyclic lactone that is neurotoxic to parasites by potentiating glutamate-gated chloride ion channels in the parasites. Paralysis and death are caused by increased permeability to chloride ions and hyperpolarization of nerve cells. Ivermectin is active against intestinal parasites, mites, bots, heartworm microfilaria, and developing larvae. Ivermectin has no effect on trematode or cestode parasites.

Indications and clinical uses: Ivermectin is used as a heartworm preventative in cats at the lower dose and treats mites and intestinal parasites at the higher dose. Dose ranges are listed below.

Contraindication and precautions: Do not use ivermectin on kittens younger than 6 weeks of age. If used on nursing queens, it is important to be aware that ivermectin is excreted in the milk.

Dosage: Lower dose for heartworm preventative, 24 mcg/kg q 30 days PO. Higher dose for endo- and ecto-parasite therapy, 200–400 mcg/kg (0.2–0.4 mg/kg) q 7 days SQ or PO. Topical dose for ear mites, 0.5 ml per ear (0.1 mg/ml) [13].

8.6.17 Ketamine

Drug description and brand names: Ketalar, Ketavet, Vetalar. Anesthetic agent. Ketamine is a Schedule III controlled substance.

Formulations: Ketamine is available in 100-mg/ml injectable solution.

Metabolism and mechanism of action: Ketamine is believed to be a centrally acting dissociative agent, but the exact mechanism of action is unknown. Ketamine produces mild analgesia and modulates pain via its ability to act as a noncompetitive antagonist for n-methyl D-aspartate (NMDA) receptors.

Indications and clinical uses: Ketamine's duration of action is generally 30 minutes or less, making it useful for short-term anesthetic procedures. It provides some analgesic properties via its effects on the NMDA receptors and has been administered as an adjunct to other analgesic medications, usually opiates, sometimes as a CRI infusion. Ketamine is often combined in use with other anesthetics and sedatives, such as benzodiazepines, propofol, opiates, or alpha$_2$ agonists. Such combinations are synergistic and allow lower doses of each component.

Contraindication and precautions: Do not use in cats with head injuries because it may increase CSF pressure. Use cautiously in cats with glaucoma, as it can increase intraocular pressure (IOP). Do not use in cats prone to seizures, as seizures

have been reported with use [13]. When used alone, ketamine can cause hyperexcitability and involuntary muscle movements. In cats, a sedative, such as acepromazine or a benzodiazepine is recommended before use, or in combination.

Dosage: 2–25 mg/kg IV or IM [13].

8.6.18 Ketoprofen

Drug description and brand names: Ketofen. NSAID

Formulations: 12.5 mg tablets (OTC), 100 mg/ml injection (only approved for use in horses).

Metabolism and mechanism of action: Ketoprofen, similar to other NSAIDs, produces analgesic and anti-inflammatory effects by inhibiting the synthesis of prostaglandins. It is a nonselective inhibitor of COX-1 and COX-2 enzymes.

Indications and clinical uses: Ketoprofen is used for the treatment of moderate pain and inflammation. It is not approved in the United States for use in small animals.

Contraindications and precautions: Do not use in cats prone to GI ulcers. Do not use with other ulcerogenic drugs, such as corticosteroids. Do not use extended-release formulations.

Dosage: 1 mg/kg q 24 hours PO for up to 5 days. The initial dose can be given at 2 mg/kg SQ, IM, or IV [13].

8.6.19 Lorazepam

Drug description and brand names: Ativan. Benzodiazepine. Lorazepam is a Schedule IV controlled substance.

Formulations: Lorazepam is available in 0.5, 1, and 2 mg tablets, and 2 and 4 mg/ml injection.

Metabolism and mechanism of action: Lorazepam is a central-acting CNS depressant, with action similar to diazepam. Mechanism of action appears to be through potentiation of GABA receptor-mediated effects in the CNS. It does not undergo extensive hepatic metabolism but is **glucuronidated** before excretion [13].

Indications and clinical uses: As a benzodiazepine, it is useful for anxiety disorders. It is also effective for treating seizures.

Contraindications and precautions: Sedation is common, as is polyphagia. Paradoxical excitement can be seen. Long-term administration may lead to dependence on the drug and a withdrawal syndrome can be seen if abruptly discontinued.

Dosage: 0.05 mg/kg q 12–24 hours PO [13].

8.6.20 Meloxicam

Drug description and brand names: Metacam, Loxicam. NSAID

Formulations: Meloxicam is available in 0.5 and 1.5 mg/ml oral suspension, and 5% (50 mg/ml) injection.

Metabolism and mechanism of action: Meloxicam is a NSAID, with analgesic and anti-inflammatory effects by inhibiting the synthesis of prostaglandins. Meloxicam has a COX-1-sparing effect compared to older NSAIDs. The half-life in cats ranges from 15 to 26 hours. Metabolism is through hepatic glucuronidation.

Indications and clinical uses: Meloxicam has been used for the acute and chronic treatment of pain and inflammation in cats. Its efficacy is comparable to butorphanol for treating pain associated with surgery. Meloxicam can be administered to cats with renal disease at low doses if hydration is maintained.

Contraindications and precautions: Major adverse effects are gastrointestinal, including vomiting, diarrhea, and ulceration. Because of the COX-1 sparing effects, these are expected to be less than other NSAIDs. Kidney injury has been reported, particularly when high doses are administered repeatedly or when administered at lower doses to dehydrated cats. The manufacturer does not recommend a second dose via injection in cats.

Dosage: 0.05 mg/kg q 24 hours PO. Long-term treatment may be reduced to 0.03 mg/kg q 24 hours, 0.05 mg/kg q 48 hours, or 0.05 mg/kg q 72 hours PO [13].

8.6.21 Meperidine

Drug description and brand names: Demerol. Opioid. It is a Schedule II controlled substance.

Formulations: Meperidine is available in 50 and 100 mg tablets, 10 mg/ml syrup, and 25, 50, 75, and 100 mg/ml injection.

Metabolism and mechanism of action: Meperidine is a synthetic opioid agonist with activity primarily at the mu-opiate receptor. It is similar in action to morphine, except with approximately one-seventh of the potency. Clearance is rapid in cats after administration, and the duration of effect is short.

Indications and clinical uses: Meperidine is useful for short-term sedation and is often used with other sedatives and anesthetics. Due to its short duration of action, it is not useful for treating pain. Meperidine may produce fewer gastrointestinal motility problems compared to other opioids.

Contraindications and precautions: As with all opiates, some side effects are predictable and unavoidable. These include sedation, urine retention, constipation, and bradycardia. Respiratory depression can be seen in high doses. Tolerance and dependence can occur with chronic administration, and some excitement in cats can be seen.

Dosage: 3–5 mg/kg IV q 2–4 hours (or as needed) [13].

8.6.22 Midazolam

Drug description and brand names: Versed. Benzodiazepine. Midazolam is a Schedule IV controlled substance.

Formulations: Midazolam is available in 5 mg/ml injection.

Metabolism and Mechanism of Action: Similar to other benzodiazepines, midazolam is a central-acting CNS depressant, with a mechanism of action that appears to be via potentiation of gamma-aminobutyric acid (GABA) – receptor-mediated effects because it binds to the GABA binding sites. Benzodiazepines may act as muscle relaxants by inhibiting certain spinal pathways or directly depressing motor nerve and muscle function.

Indications and clinical uses: Midazolam is used for sedation, anesthetic adjunct, anticonvulsant, and behavioral disorders. Because it is water soluble, unlike diazepam, it can be administered IM. It can be mixed with other water-soluble anesthetic agents in the same syringe (e.g., ketamine and dexmedetomidine).

Contraindications and precautions: When given IV, midazolam serious cardiorespiratory depression can be seen. Some cats may experience paradoxical excitement. Long-term administration may lead to dependence on the drug and a withdrawal syndrome can be seen if abruptly discontinued.

Dosage: Sedation- 0.05 mg/kg IV. Anesthetic induction- 0.3–0.6 mg/kg IV combined with 3 mg/kg ketamine.

8.6.23 Morphine

Drug description and brand names: MC Contin, Oramorph SR. Opioid analgesic. Morphine is a Schedule II controlled substance.

Formulations: Morphine is available in 1, 2, 4, 5, 8, 10, 15, 25, and 50 mg/ml injection (15 mg/ml is the most common), 15, and 30 mg tablets.

Metabolism and mechanism of action: Morphine is the prototype for other opioids. The mechanism of action is to bind to mu-opiate and kappa-opiate receptors on nerves and inhibit the release of neurotransmitters involved with the transmission of pain stimuli.

Indications and clinical uses: Morphine is indicated for short-term analgesia, sedation, and as an adjunct to anesthesia. It is compatible with most anesthetics and can be used as a part of a multimodal approach to anesthesia/analgesia. Injectable forms can be used in cats, but doses are generally lower than in dogs to prevent excitement.

Contraindications and precautions: Side effects from morphine administration include sedation, vomiting, constipation, urinary retention, and bradycardia. Excitement is more common in cats and horses. Respiratory depression occurs with high doses. As with other opiates, a slight decrease in heart rate is expected. In most cases, this decrease does not have to be treated with anticholinergic drugs (e.g., atropine), but it should be monitored. Tolerance and dependence occur with chronic administration.

Dosage: Analgesic, 0.1–0.2 mg/kg IM, IV, or SQ q 3–6 hours. CRI loading dose of 0.2 mg/kg IV, followed by 0.05–0.1 mg/kg/hour IV. Epidural, 0.1 mg/kg diluted in saline to 0.3 ml/kg [13].

8.6.24 Orbifloxacin

Drug description and brand names: Orbax. Fluoroquinolone antibiotic

Formulations: Orbifloxacin is available in 5.7, 22.7, and 68 mg tablets. Oral suspension is 30 mg/ml.

Metabolism and mechanism of action: Orbifloxacin acts through the inhibition of DNA gyrase in bacteria to inhibit DNA and RNA synthesis. It is bactericidal with a broad spectrum of activity. In cats, the oral absorption of tablets is nearly 100%. However, oral suspension absorption is not as high as tablets.

Indications and clinical uses: Similar to other fluoroquinolones, it is used to treat susceptible bacteria. Infections have included skin, soft tissue, and urinary tract infections.

Contraindications and precautions: Use should be avoided in kittens because of the risk of cartilage damage, and it should be used cautiously in cats prone to seizures.

Dosage: Tablets, 2.5–7.5 mg/kg q 24 hours PO. Suspension, 7.5 mg/kg (1 ml/kg) q 24 hours PO.

8.6.25 Pentobarbital

Drug description and brand names: Nembutal. Barbiturate anesthetic, euthanasia. Pentobarbital is a Schedule III controlled substance.

Formulations: Pentobarbital is available in 50 and 65 mg/ml solution for injection. Euthanasia solutions contain 390 mg/ml often combined with 50 mg phenytoin.

Metabolism and mechanism of action: Pentobarbital is a short-acting barbiturate anesthetic. The action is through non-selective depression in the CNS. Pentobarbital is usually used to induce euthanasia but can be used as an IV anesthetic.

Indications and clinical uses: This is the number one drug that is used for companion animal euthanasia. To decrease the potential for abuse by humans, the cardiotoxic substance, phenytoin sodium, can be added. This combination speeds up the stoppage of electrical activity in the heart.

Contraindications and precautions: As an anesthetic, rapid IV doses can be lethal, and respiratory depression may occur.

Dosage: Anesthesia- 25–30 mg/kg IV to effect. Euthanasia 1 ml/10 pounds [13, 15].

8.6.26 Piroxicam

Drug description and brand names: Feldene. NSAID.

Formulations: Piroxicam is available in 10 mg capsules.

Metabolism and mechanism of action: Piroxicam is an NSAID of the oxicam class. The clinical effects are similar to other NSAIDs. Piroxicam is somewhat more selective for COX-2 enzymes. COX-2 is responsible for synthesizing prostaglandins that are important mediators of pain, inflammation, and fever. It may also have some antitumor or tumor-preventative effects and is used in some anticancer protocols. Piroxicam is broken down through **oxidation** in the cytochrome p450 cycle [3].

Indications and clinical uses: Piroxicam is used to treat pain and inflammation associated with arthritis and other musculoskeletal conditions. It is not used as often for these conditions as other approved NSAIDs are. It can be used as an adjunct for treating cancer. Reports of its tumor-suppressing activity include transitional cell carcinoma of the bladder, squamous cell carcinoma, and mammary adenocarcinoma.

Contraindications and precautions: Elimination of piroxicam is slow compared to other NSAIDs. Adverse effects are primarily gastrointestinal toxicity in the form of gastric ulcers. Renal toxicity is also a risk, especially in cats prone to dehydration or having compromised renal function.

Dosage: 0.3 mg/kg q 24 hours PO. A common dose is 1 mg per cat q 24 hours PO.

8.6.27 Prednisone/Prednisolone

Drug description and brand names: Deltasone, Meticorten, PrednisTab, generic brands.

Formulations: Prednisolone is available in 5 and 20 mg tablets, 3 mg/ml syrup, and 25 mg/ml acetate suspension for injection.

Metabolism and mechanism of action: Prednisone and prednisolone are glucocorticoid anti-inflammatories. After administration, in most species, prednisone is converted to the active form, prednisolone in the liver [16]. When compared to cortisol, prednisolone is approximately four times more potent. When compared to dexamethasone, it is about one-seventh as potent. In cats, administration of prednisone results in low systemic levels of the active drug prednisolone. This may be due to poor absorption of prednisone or because of a deficiency in the ability to convert prednisone into the active form, prednisolone. After oral administration, only about 21% of the drug occurs in the bloodstream in the active form of prednisolone [16]. Due to this variability in drug absorption, it is recommended only to administer prednisolone to cats.

Indications and clinical uses: Prednisolone is used to treat various inflammatory and immune-mediated diseases.

Contraindications and precautions: Common side effects of prednisolone use include polyphagia, pu/pd, and behavior changes. Adverse effects include gastrointestinal ulceration, diarrhea, hepatopathy, diabetes, hyperlipidemia, decreased thyroid hormone, decreased protein synthesis, delayed wound healing, and immunosuppression. Secondary infections can also occur as a result of immunosuppression.

Dosage: Prednisone is not recommended for use. Prednisolone anti-inflammatory dose: 0.5–1 mg/kg q 12–24 hours IV, IM, or PO, with tapering to q 48 hours at a dose of 0.3–0.5 mg/kg. Immunosuppressive dose: 2.2–6.6 mg/kg/day IV, IM, or PO, with tapering to 2–4 mg/kg q 48 hours. Keep in mind that cats may require twice the dose of dogs [13].

8.6.28 Propofol

Drug description and brand names: Rapinovet, PropoFlo, PropoFlo 28, PropoFlo Plus. Anesthetic. Propofol is a schedule IV drug in some states.

Formulations: Propofol is available in 10 mg/ml injection.

Metabolism and mechanism of action: Propofol produces effects through a similar mechanism as barbiturates, but the mechanism of action is not well defined. It produces depression in the CNS through its effect on the GABA receptor. Propofol produces short-acting (i.e., 10 minutes) anesthesia, followed by a rapid and smooth recovery. Propofol is eliminated by direct **glucuronidation and by oxidation** using cytochrome p450 [3].

Indications and clinical uses: Propofol is used for short-term anesthesia and anesthetic induction. If long anesthesia is required, induction needs to be followed by an inhalation anesthesia, such as isoflurane, or sevoflurane. It can also be used for the treatment of status epilepticus when other drugs have proven to be ineffective.

Contraindications and precautions: Apnea and respiratory depression are the most common adverse effects, which are more likely when the dose is increased. Phenolic drugs, such as propofol may cause oxidative damage to hemoglobin in cats because of the higher concentration of oxidizable sulfhydryl groups in feline red blood cells (RBCs), leading to Heinze body formation and methemoglobinemia. Propofol is a Schedule IV controlled substance (Figure 8.2).

Dosage: Anesthetic induction- 4–8 mg/kg IV slowly. If other preanesthetics and sedatives are used, reduce the dose by 16–24%. Short-term surgical anesthesia- 10 mg/kg IV over 1 minute. Duration of anesthesia approximately 10–20 minutes (Tables 8.4 and 8.5).

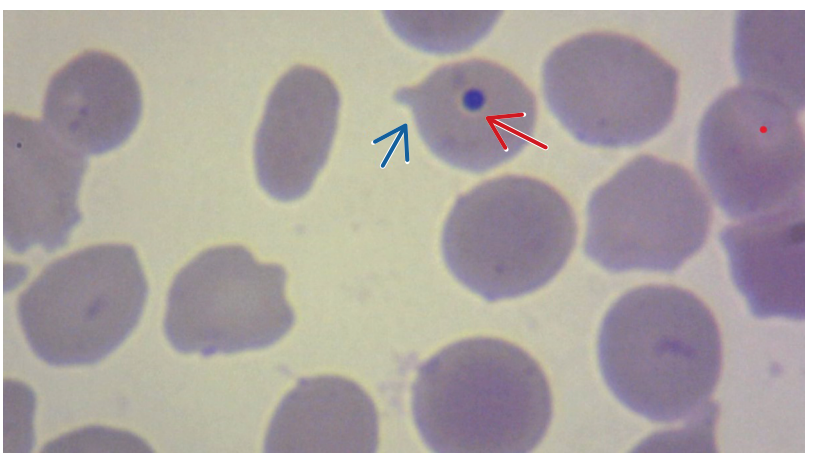


Figure 8.2 Heinz body and Howell–Jolly body. This image of a blood smear shows a Heinz body on the edge of an RBC indicated with a blue arrow, and a Howell–Jolly body indicated by the red arrow. Heinz bodies occur when there has been oxidative damage to the RBC. Howell–Jolly bodies are an indicator of an immature RBC that has retained a bit of its nuclear material. *Source:* Ann Wortinger.

Table 8.4 Definition of drug dispensing terms [17].

Term	Definition
Prescription	An order, usually from a doctor, for the preparation and administration of a medicine or other treatment.
Over the counter (OTC)	Medications sold over the counter, which do not require a prescription.
Schedule/controlled substance	Drugs that are regulated by the US Drug Enforcement Agency (DEA) and require a special license for the prescriber.
Off-label/extra-label	Use of a prescription drug for a condition or species other than what it has been officially approved for.
Brand name	A name given to a medication by the manufacturer that often becomes synonymous with its identity.
Generic	A medication not protected by patent, distributed, and marketed under its pharmaceutical or chemical name, usually by multiple manufacturers at a lower cost.
Compound	The creation of a drug mixture to fit the unique needs of a patient. For example, creating liquid versions of medications is normally available only in tablet, capsule, or capsule form.
Opioid	Synthetic drugs that have the narcotic effects of opium are typically used for pain management.

Table 8.5 Drugs that are contraindicated in cats due to impaired metabolic pathways [9].

Class of drug	Drug name	Mechanism of action (how does the drug work)	Reason for toxicity
NSAID	Aspirin	Cyclooxygenase enzyme inactivation leads to suppression of the thromboxanes and prostaglandins	Less glucuronyl transferase and glycine **conjugation**
NSAID	Salicylates	Nonselective inhibition of the peripherally and centrally mediated cyclooxygenase. Potent inhibitor of thromboxane production	Deficiency in glucuronosyl transferase, which **conjugates** salicylate with glucuronic acid
NSAID	Acetaminophen	Prostaglandin synthesis is weakly inhibited with decreased concentration of prostaglandins	Deficient **glucuronidation** and sulfation abilities
NSAID	Ibuprofen, carprofen, etodolac	Inhibition of cyclooxygenase activity, blocking the production of prostaglandins	Low capacity for hepatic **glucuronidation** needed for elimination
Antibiotics	Chloramphenicol	Inhibition of microbial protein synthesis through the binding to the bacterial ribosomal subunits	Metabolized in the liver to chloramphenicol glucuronide (**toxic metabolite**)
Antiparasitics	Pyrethrins and pyrethroids	Prevents the closure of the voltage-gated sodium channels on the nerve membranes in muscle and nervous channels	Lack of glucuronosyl transferase for *conjugation*
Anesthetics	Benzocaine	Decreases the permeability to sodium ions with inhibition of depolarization of the neuronal membrane, blocking initiation and conduction of nerve impulses	Due to the unique hemoglobin structure in cats, *oxidative* damage can easily occur.
Anesthetics	Propofol	Decreases the rate of dissociation of GABA from the receptor	Lack of glucuronosyl transferase for *conjugation*

Table 8.6 Antimicrobial stewardship.

Antimicrobial stewardship
• Preserves effectiveness and availability of current drugs. • Use preventative measures to prevent disease. • Use evidence-based approaches to determine which drug to use. • Avoid prophylactic use. • Provide clear and concise instructions for client use.

8.7 Introduction and Current Guidelines of Antimicrobial Stewardship

To preserve the effectiveness and availability of antimicrobial drugs, veterinary professionals should practice good antimicrobial stewardship through conscientious oversight. Responsible medical decision-making, by only using antibiotics when medically necessary, while safeguarding animal, public, and environmental health [18]. To aid practicing veterinarians in choosing antimicrobial therapy an expert task force from the American Veterinary Medical Association (AAHA) and the Feline Veterinary Medical Association, formerly known as the American Association of Feline Practitioners (AAFP) published antimicrobial stewardship guidelines in 2022. These guidelines have identified the following key points for veterinarians to follow [19].

Prevent common diseases through preventative health measures, such as good nutrition, appropriate husbandry, and hygiene. Follow management strategies identified with guidelines for vaccinations and parasite control. Use evidence-based approaches to make medical decisions about the use of antimicrobial drugs. Including obtaining an accurate clinical diagnosis whenever possible to determine the presence of a bacterial infection that would warrant antimicrobial use. Utilizing diagnostic testing, including culture and susceptibility testing, to aid in the appropriate selection of antimicrobials. The duration of therapy should be based on scientific and clinical evidence to obtain the desired outcome while minimizing antimicrobial resistance. Prophylactic use of antimicrobials should be avoided except in cases where the incidence of bacterial infection is increased or would be detrimental to the patient's outcome. A veterinary–client–patient relationship should be established, and client education should be a part of any antimicrobial treatment. Administration instructions should be clear and labeled correctly. Instructions on administration techniques and follow-up communication should be prioritized to minimize a lack of compliance by the owner. Veterinary professionals should be part of the effort to responsibly diagnose and treat infections with antibiotics to protect the health of pets and their owners by decreasing the incidence of resistance [19] (Table 8.6).

Medications have widely expanded the care we can provide to our feline patients; however, we need to be mindful that cats do metabolize drugs differently, and may require different doses, or even alternate medications when contraindications are present. Challenge yourself to look into how some of our most common medications are metabolized, and how this can affect our level of care.

See the companion website for further clinical references.

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9

Feline Immunology and Current Vaccination Guidelines

Ellen M. Carozza, LVT, VTS (CP-Feline)

TECHNICIAN TIDBITS

- Know the core vs. noncore vaccinations for cats, as they are now lifestyle-dependent, and the needs of the cat can change over time. Understanding the five feline populations can help determine their specific lifestyle and their unique vaccination protocol.
- Be familiar with your local vaccination laws. Your state will have laws with specific vaccination requirements, and your local county laws may have their own specific requirements as well (especially for hybrid cats). In areas with rabies, many counties will have their own rabies quarantine recommendations when cats have been potentially exposed, or if a nonvaccinated cat has bitten another animal or human.
- No vaccine is 100% effective! This is where boosting a vaccination is recommended to maintain immunity.
- In kittens, it can be common to see adverse vaccination responses, especially in orphaned kittens that did not receive passive immunity from the queen. Antibody testing will show a positive for a disease (i.e., panleukopenia) if symptoms appear within 14 days of vaccination. Mild to moderate side effects can include sore limbs or upper respiratory infection symptoms from the feline viral rhinotracheitis, calicivirus, and panleukopenia vaccination in that time period as well. When in doubt, have the kitten treated symptomatically and monitored with good nursing care.
- While feline injection site sarcomas (FISS) are typically seen with vaccination, there is a possibility for *any* injection to cause a FISS. It is important to document *where* on the limb or tail (distal and proximal to the elbow or stifle) an injection is given. Not just "right forelimb or left hindlimb" as one can give multiple injections in the same area. Never use the scruff for vaccination injections, as it is highly recommended to refrain from interscapular injections due to possible FISS. It is important to document and monitor any injection-site swelling for further growth or abnormalities.

In 2020, the American Animal Hospital Association (AAHA) and the American Association of Feline Practitioners (AAFP) updated the vaccination guidelines for cats, which included a focus lifestyle, and better defined what type of cats are seen in practice [1]. It now includes all feline patient populations, updated guidance on FISS, and staff education on proper handling, practices, and compliance. The feline vaccine calculator, available for public use on the AAHA website helps clinicians and cat owners make the decision together about which vaccinations their cat should be protected with. It is highly recommended that the feline-centric technician stay informed about the updated guidelines to help keep their patients healthy. The author highly recommends that the reader become familiar with the vaccination guidelines, as they not only provide recommendations for the feline patient but also provides easily understandable charts for reference.

As veterinary technicians, we know that vaccines provide immunity from communicable diseases within the same species and zoonotic diseases between species. However, knowing which vaccines are necessary for each patient is important, as the recommendations have evolved over time. The feline-centric technician in practice should know and understand the core and noncore vaccines recommended based on the cat's lifestyle and living situation, regardless of their origin. In this chapter, we will review how vaccinations work to provide immunity against disease, which vaccines are necessary to keep cat populations healthy, the unfortunate side effects vaccines can cause to an individual while attempting to maintain herd health among the population, and how we can work with our clients to help them understand the importance of vaccination of their beloved feline companion.

9.1 Vaccine History

History taught us that the start of vaccines began in the late 1800s by Louis Pasteur for chicken cholera and anthrax for sheep and cattle [2]. With the economic importance of livestock to the country, this led to government support of further research to control and understand what diseases affected the animals we cohabitate with, work with, and how to control them. During the early era of vaccination production, infected tissues were utilized to source microbial antigens by macerating down the tissue samples, putting the infected sample through a process of inactivation and filtration to clarify the sample for use as a vaccination. Over the years, we have recognized vaccines do play a critical role in preventing zoonotic disease. For domestic pets, we witnessed the first rabies vaccination for use in the canine patient in clinical practice in the 1950s. This led to future development of other vaccinations for use in the canine and feline species as it led to a decrease in communicable disease between animals and zoonotic disease to the human population, in particular with the development of the rabies vaccination [3].

9.2 How Vaccines Work

Vaccines play a crucial role in preventing illness by training the body to recognize a foreign invader and take care of the issue before the illness can occur and cause a significant problem for the host. We know that by introducing antigens, the body becomes trained to recognize illnesses and set a course to defend the body against those diseases. Training does take time, and depending on the antigen introduced (vaccine series vs. single dose), we need to educate our clientele to understand that it can take several days for an active immune response to occur, especially when the first injection introduced to the cat is given. Vaccines that require a series of "booster" shots may not produce immunity until 7–10 days *after the final vaccination* is given. Reminding the client that not exposing the pet to other unknown vaccine-status cats during the vaccine course is important to ensure they have the opportunity to build the antibodies against the disease and not be exposed to the disease itself, as the animal may not have enough antibodies to fight off the actual disease as it's building its antibody army against the antigen it was told to seek and destroy.

9.3 Natural Immunity: Maternal Derived Antibodies

Maternal-derived antibodies (MDA) play a crucial role in protecting the neonate. While cats are quite prolific in reproducing with large litters (as the goal is to ensure there are survivors), the MDA passed to the neonate is dependent on the health status of the queen. Cats have an endotheliochorial placenta that acts as a barrier for antibodies, preventing transfer from maternal serum to the fetus's circulatory system. Unfortunately, it is believed that only 5–10% of MDA is actually transferred to the feline fetus during pregnancy, and the body is more dependent on building immunity through the introduction of colostrum during the first 24 hours of nursing, preferably. The dominant immunoglobulin class in colostrum is IgG and is concentrated 2–5 times more in the milk gland than in the serum of the queen [4]. These immunoglobulins are protected by a trypsin inhibitor that prevents the immunoglobulins from breaking down in the gastrointestinal tract of the newborn [4]. Again, the health status of the queen plays a crucial role in the quality of the immunoglobulins passed to the neonate. A sick queen can pass her diseases to her kittens, eliminating the entire litter rather quickly even without clear clinical signs from the kitten. Many times, once the kitten is symptomatic, it will still succumb to the illness.

In the past, cats were recommended to receive three basic vaccines and were typically seen only once per year for boosters or when the cat presented with an illness, and unfortunately, this trend still continues today in practice. The feline viral rhinotracheitis, calicivirus, and panleukopenia (FVRCP), feline leukemia virus (FeLV), and rabies typically were injected in the area (sometimes the same spot) of the scruff with little concern for issues. Over time, the recognition of localized inflammation was noticed, with the potential for an aggressive sarcoma (FISS) to form.

9.4 Feline Injection Site Sarcoma

An unfortunate side effect is seen from a localized inflammatory response from injectable products. While the specific cause of these tumors has not been established, the role of adjuvants (including aluminum) causing local inflammation in the pathogenesis of FISS is not transparent. *Any injectable has the potential to cause FISS and is not limited to vaccinations.*

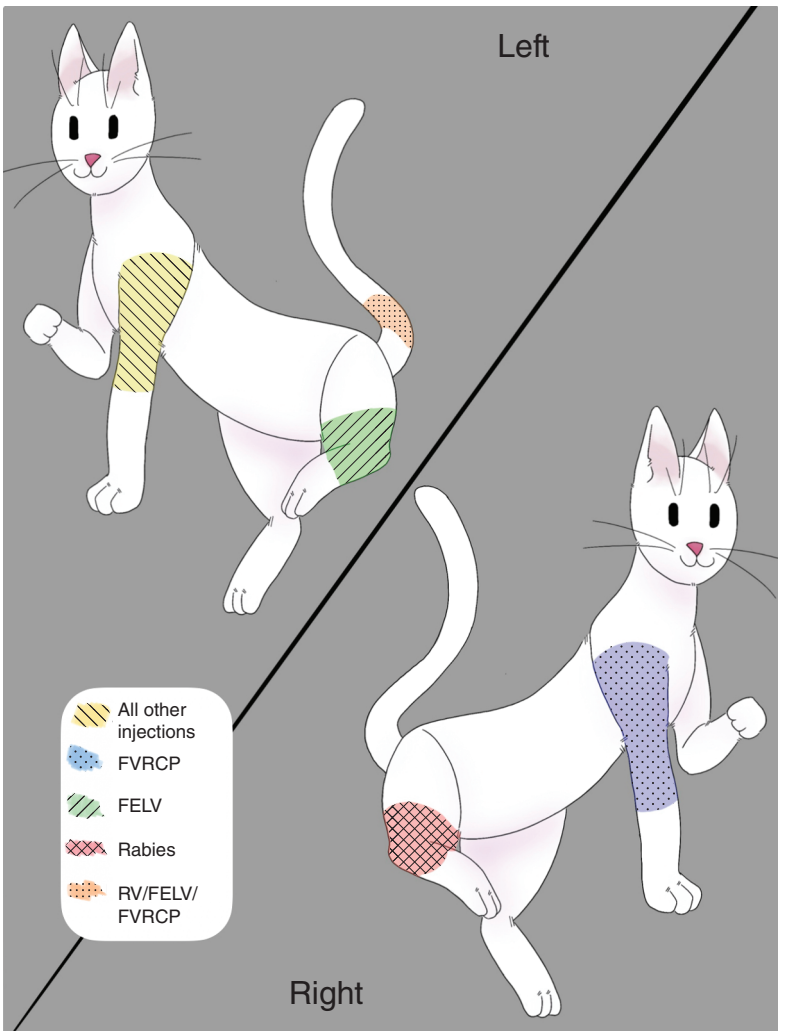


Figure 9.1 Injection-site diagram of the cat, utilizing a specific area for injections allows for better monitoring of any adverse, localized inflammatory responses. Based on the 2020 AAFP/AAHA Feline Vaccination Guidelines. *Source:* Oliva Johnson.

While an unfavorable occurrence for the cat and client, reports indicate only one case in 10,000–30,000 vaccinations [5]. From that localized inflammatory spot, these aggressive tumors grow rather large and spread out in a tentacle-like formation from the injection site, creating a significant challenge for full, clean margins with surgical intervention. Successful surgery requires very large tissue margins (5 cm and two fascial layers) along with recommended radiation therapy (RT) depending on the case. Regardless of intervention, it may only provide the cat with a limited window of time depending on the severity and early diagnosis. With margins of >5 cm, approximately 95% of the tumor is excised, and with smaller margins of 2–3 cm, <50% of tumors are completely excised. Localized biopsies or fine needle aspirates (FNA) may stimulate the offending tumor to progress more quickly at times, and the current medical literature shows that even with surgery and RT, 30–45% of these tumors will recur locally. Palliative RT for cats that are not candidates for surgical intervention of FISS can be utilized. However, progression-free intervals are shortened (approximately 4 months) [6]. In cases with successful aggressive surgery and other treatment options, the median life expectancy is 800 days, compared to 400 days or shorter with less aggressive surgical margins. See Chapter 24: "Oncology," for further information on FISS.

This led to the development and agreement of vaccine injection sites (Figure 9.1) to allow for monitoring of localized inflammation and potentially a FISS (Box 9.1).

Box 9.1 Based on the interpretation of the 2020 AAFP/AAHA Feline Vaccination Guidelines.

All injections have the potential to cause a localized inflammatory response that can cause an injection-site sarcoma, hence the importance of documenting where and how all injections are performed on the cat.

9.5 Vaccination Administration Sites

Vaccines should be administered as low as possible on the limb/tail; however, the conscious cat may not allow for that particular area to be utilized.

- Right distal forelimb: preferably *below* the olecranon of the elbow (FVRCP).
- Right distal hindlimb: *preferably below* the stifle (rabies).
- Left distal hindlimb: preferably *below* the stifle (FeLV).
- Left distal forelimb: preferably *below* the olecranon of the elbow (*all other* subcutaneous [*SC*] *injectables*).
- Tail: distal third—while this can be uncomfortable for conscious cats, this is a valid area of use for cats receiving vaccination in recovery post sedation/surgery and with community cats that cannot be monitored postinoculation.

It is no longer recommended to use the scruff, hips/haunches, or even lower abdomen of the cat, as aggressive surgical margins or amputation cannot be completed. Due to the possibility of localized inflammation from injectables, the author encourages the limited use of epaxial intramuscular injections and any SC injections in the scruff of the neck in the cat. It is advisable to get into the habit early of *documenting where and how injections are administered* to the feline patient in their chart, as it allows for a stronger case and likelihood of identifying the offending factor if a FISS is to occur. *Any* suspicious lump or growth on a cat should be taken seriously, as many are not benign. Clients who call with concern for a lump seen on their cat post-vaccination inoculation or any injectable that was administered should be offered an appointment immediately to rule out the potentials for concern and to start monitoring the area for growth.

9.6 Vaccine Site Monitoring

Monitoring of injection-site inflammation requires the "3-2-1 rule." Biopsies are recommended for any mass effect if:

- Present after 3 months post-vaccination.
- Larger than 2 cm in diameter.
- Increased in size 1 month post-vaccination.

Any lump in the area where an injection is given should be monitored closely with hands-on appointments to measure the area and check for tentacled growth.

9.7 Vaccine Hypersensitivity

Vaccine hypersensitivity in the cat is possible and is a frequent complaint with many of the hand-reared pediatric patients seen in practice, most likely due to the lack of MDA exposure post-parturition. A vaccine hypersensitivity can occur at any point in time during the lifespan of the cat, regardless of previous exposure, and cannot be predicted but should be noted in the chart for any future vaccines to prevent an adverse response. Types of hypersensitivity seen may include:

- Hives, facial swelling, vomiting, diarrhea, and generalized pruritus, which can be treated quickly with the use of antihistamines and steroids.
- Anaphylaxis can lead to respiratory distress and collapse and may require resuscitation.
- Sneezing/watery eyes (particularly with an intranasal vaccination).
- Limb tenderness/lameness.

Any vaccine hypersensitivity that includes swelling, hives, vomiting, diarrhea, or pruritus, should be treated immediately for an anaphylaxis reaction due to the potential for the need of resuscitation. Staff, regardless of their role in the practice, should be trained and informed what to ask the client and to whom to relay any complaint immediately for the cat to be seen and treated as this is considered an emergency situation.

With millions of cats vaccinated per year, reports of adverse responses are low. However, the most commonly reported post-vaccination adverse responses are lethargy, anorexia, and elevated temperature/fever for a few days post-vaccination. *Where revaccination needs to be considered, using a different vaccine formulation and pretreating the cat with a glucocorticoid and antihistamine 20–30 minutes prior to vaccination are recommended, followed by close monitoring of the patient for several hours post-vaccination.*

Other less severe vaccine complaints that are seen but important to recognize are latent vaccine responses that are reported (again, a particular complaint in pediatrics with no or unknown history of receiving colostrum or the health status of the queen) with a window of typically 3–10 days post-vaccination (usually seen with an attenuated vaccine), causing the same symptoms of the disease we are attempting to protect the cat against. Regardless of the response, many cats may require treatment for their symptoms while the body builds immunity. One concern for the latent vaccine response with attenuated vaccines is when to test for the disease itself. An example is panleukopenia and the use of a point-of-care (POC) canine parvovirus test. We know that panleukopenia is a parvovirus, and the POC test is used as a reliable indicator for infection. If the kitten displays the same symptoms of the disease within that 3–10-day window of time and the POC test is used, it can be hard to determine if the kitten is actually infected with the disease or if we are seeing the vaccination displayed on the test. Whether it be panleukopenia, calicivirus, or upper respiratory infection (URI) symptoms, the consideration should be to treat the animal should be addressed and the proper nursing care protocol initiated to provide comfort to the animal.

9.8 Vaccination Types

There are three types of vaccines available for use in the feline patient, each stimulating the body and causing a reaction to stimulate immunity. Each provides protection against disease and has its own risks vs. benefits. It is important to know which vaccines your clinic hosts and how they stimulate the body for an immune response.

9.8.1 Modified Live (Attenuated)

They contain microorganisms that are artificially manipulated so as to reduce their virulence. Because these organisms replicate in the host, they stimulate an immune response that closely mimics the natural infection. They also provide a more rapid onset than inactivated vaccines. A feature of attenuated vaccines is that with the absence of MDA's the host can be provided a sufficient immune response with a single vaccination dose.

9.8.2 Inactivated "Killed" Vaccines

The targeted pathogen is "killed" and unable to replicate in the host. While these vaccines are unable to become virulent, added adjuvants and excipient proteins are usually enough to stimulate an immune response but can also play a role in acute and delayed adverse reactions in the cat. This type of vaccine produces a weaker immune response with a shorter duration and tends to require more frequent "boosters," with *the exception of rabies.* While they *are considered safer to give to a pregnant animal* than the attenuated vaccines, *systemic allergic reactions can occur and still cause a risk to the pregnancy.*

9.8.3 Recombinant Vaccines

Created through manipulation of the deoxyribonucleic acid (DNA) of a pathogen in the laboratory, with reduction in pathogen virulence. Currently, the only available recombinant vaccines in the United States are vectored vaccinations which use a recombinant canarypox as the vector. Canarypox vectors provide a faster onset of immunity and do not require adjuvants which have a reduced risk of FISS. The canary-pox vectored vaccine has limited replication in the body and is then aborted shortly after administration.

9.9 Routes of Administration

- **Parenteral (SC):** under the skin.
- **Intranasal (IN):** dripped into each nare for maximum coverage of the nasal cavity this type of vaccination provides faster protection in high-risk populations and with kittens, particularly against respiratory disease. It is important *not* to aggressively administer IN vaccines due to the possibility of aspiration.
- **Intramuscular:** intramuscular (*due to FISS possibility in cats, never use the epaxial region for vaccination injections*).

Follow the recommendations of the route of administration of the vaccination by the individual manufacturer. It is important to ensure the vaccine is given correctly to not only prevent an adverse response, but for a proper immune response.

9.10 Feline Core Vaccines

Depending on core vs. noncore vaccinations, revaccination is recommended every 1–3 years based on the risk of infection. Vaccination intervals are based on the minimal duration of immunity (DOI), as determined by research studies in the vaccine industry. The Feline Veterinary Medical Association (FeVMA) has "Disease Fact Sheets" available on their website that discuss each in great detail. The listing below are the core and noncore diseases that can presently prevented with vaccination in cats.

9.10.1 Panleukopenia

Panleukopenia (FPLV), also known as feline distemper and feline parvovirus is a highly contagious viral infection in the parvovirus family and many times a fatal (>90% in some cases) [7] disease; especially to neonatal/pediatric patients, the sick, unvaccinated, and high-risk feline populations. This disease is present everywhere in the environment, and almost all cats at some point in their lives are exposed to it, even in the hospital setting. The more crowded the cat population, such as shelters, high-volume foster homes, pet stores that host cats, and unvaccinated community cat populations, the greater the likelihood of infection. This virus works by attacking cells that grow and divide quickly, making bone marrow, the intestines, growing fetuses, and lymph nodes easy targets, thus causing a significant decrease in white blood cells in the body that help fight infection.

- Sources of infection come from poor environmental cleanliness (cages, bedding, contaminated food/water, and toys).
- Human contact from hands, face (sympathetic kiss on the head, along with not handling a sick cat with disposable gloves and other personal protective equipment), and clothing, including shoes.
- The virus is present in all secretions of the cat, particularly the feces, and the route of infection is fecal to oral.

Most cases have the telltale signs of vomiting, severe hemorrhagic diarrhea, fever, and significant lethargy due to the attack on the rapidly growing cells of the intestinal tract. The incubation period from infection until the cat develops symptoms is typically 3–5 days.

Currently, there is no specific treatment for cats other than aggressive supportive care at the start of the clinical signs, which can have a high recovery rate. The use of in-house SNAP® ELISA canine (Figure 9.2) parvovirus testing has been shown to be reliable in making a quick diagnosis while waiting for confirmation from a fecal polymerase



Figure 9.2 FPV1-positive test, a canine POC antigen test can be utilized to determine a positive panleukopenia test as panleukopenia is in the parvovirus family. It is important to remember that using a modified live virus vaccine may provide a positive test result on a POC test if the kitten develops panleukopenia symptoms within 5–12 days after being vaccinated. It is important to know the difference between a true infection and a vaccine response. Regardless, symptomatic cats should be advocated for and treated. *Source:* Ellen Carozza, LVT, VTS.

chain reaction (PCR) test, as the PCR is the current reference standard. However, the test has a longer wait time of 1–5 days, depending on the laboratory. The high cost can be prohibitive [8], and many patients will succumb to the disease while waiting if aggressive care is not initiated on with clinical symptoms. Negative results seen with the SNAP® test in clinically infected cats are viewed as unreliable and should be followed up with a PCR test. *It should be noted that recently vaccinated cats given a modified live vaccine (5–12-day window post-vaccination) that become symptomatic for the disease will show up positive on the SNAP® ELISA test, as the test is not reliable to determine the difference between a true infection or the vaccination.*

While there has been discussion about the use of Tamiflu (oseltamivir) and Neupogen (filgrastim) in cats, there are currently no studies to support their assistance in decreasing the mortality rate, other than anecdotal use. Preventive vaccination is highly effective and can provide a long DOI.

9.10.2 Calicivirus

A highly virulent upper respiratory disease in cats that mutates readily, leading to new strains that may not be covered by the current vaccinations on the market. This can lead to cats that are vaccinated having an outbreak of the disease, especially in the high-risk groups. It is secreted through nasal mucus, eye discharge, and aerosolized droplets from sneezing. This virus is shed 2–3 weeks after infection, and many cats can be considered long-term carriers of the disease and continue to shed this virus for months. As this is a hardy virus in the environment, thorough cleaning is necessary as any object that has come into contact with secretions from the eyes or nose can be a source of infection. The incubation period is 2–14 days before symptoms appear. Not only causing URI symptoms (Figure 9.3), but painful oral ulcerations (Figure 9.4) as the virus initially infects the back of the oral cavity and in severe cases infects the lungs causing pneumonia. FCV can not only cause abortions in pregnant cats at times, but it can also cause chronic inflammatory gum disease, making it painful for the cat to eat [9], even after recovery. In many severe cases of the virulent systemic disease (VSD) of FCV, edema of the head and limbs can be noted. It is not unusual to see crusting sores on the pads of the feet, nose, and ears as well subcutaneous and gastric hemorrhaging (Figures 9.5–9.8).

Laboratory testing through reverse transcriptase PCR (RT-PCR) or growth of cellular material in a petri dish are both reliable methods and available lab dependent. Recent vaccination with FCV can also cause false positives with the use of a modified live vaccine. *One should note that at this time commercial testing currently cannot distinguish the difference between a mild or the more virulent strains of calicivirus.*

Supportive care, antibiotics when necessary, and the use of antivirals (e.g., famciclovir) are successful as treatment options [10]. Cats with oral lesions should be monitored and treated for pain, regardless of age, as inappetence is common with FCV, and tube feeding may be necessary to meet the cat's caloric and hydration needs.

Unfortunately, vaccination does not protect against FCV entirely but can only reduce the severity if the cat is exposed. The vaccination is still recommended as a core vaccination by the AAFP/AAHA 2020 Feline Vaccination Task Force.



Figure 9.3 Painful, oral plaques may develop with kittens that have the more classic symptoms of FCV. Other symptoms that may not be as noticeable are painful, swelling of the joints. Fever is common with both. *Source:* Ellen Carozza, LVT, VTS.

9.10.3 Feline Rhinotracheitis/Feline Herpes Virus

A commonly seen upper respiratory tract disease (URD) that tends to cause watery eyes, conjunctivitis, nasal discharge, and sneezing, yet at times can be severe enough to cause ocular and skin lesions, and in many cases, it can lead



Figure 9.4 With FCV, it is common to have ocular erythema and nasal discharge. *Source:* Ellen Carozza, LVT, VTS.



Figure 9.5 FCV-VSD facial/head swelling lateral view. In systemic calicivirus cases, facial and head edema can occur. See frontal and neck view for other referencing. *Source:* Ellen Carozza, LV, VTS.

to pneumonia. After the initial infection, viral latency occurs in the trigeminal ganglia of the head and face. Generalized and chronic symptoms of this virus are seen in immunocompromised and chronically stressed cats, leading to lifelong symptoms of flare-ups and necessary treatment. Feline herpes virus 1 (FHV-1) is primarily transmitted via direct contact with ocular, oral, and nasal secretions but has a short life span in the environment of less than 24 hours and aerosols do not play a major role in the importance of spreading the disease. It is considered that environmental contamination can contribute to the spread of the disease. In practice, it is common to see kittens infected with FHV-1 due to the decrease of MDA's and the lifestyle of the kitten in high-risk groups, such as cat colonies, catteries, and shelters. Currently, only one serotype of FHV-1 vaccine is available, and if all isolates are genetically similar, the vaccine strains available on the market are usually equally effective and tend to be present in the combination vaccine with FCV. In cats, it is common to see mild clinical signs of sneezing and watery eyes several days post-vaccination and is typically the most common complaint reported to the clinic. In cats that already have FHV-1, vaccination does not prevent infection or viral latency, but post-viral shedding may be reduced [11].

9.10.4 Rabies

Rabies is 100% fatal, with no current treatment options, yet is a 100% preventable deadly disease in cats. This is the single vaccination most clients remember to give their pets each year, as rabies is zoonotic to humans. Rabies is also the vaccination that can, in practice, cause a lot of ethical conflict for our feline patients who are not vaccinated, or their vaccination is considered "expired" if a bite from an animal with an unknown or expired, rabies status occurs to them, or if they are to bite another animal or human. Whether this occurs at the practice, at home, or in the environment, it is usually required to report the bite to animal control and the county may request euthanasia regardless of whether a titer against the disease is present. It is of utmost importance to know your local laws regarding rabies and your rabies algorithm of how to proceed with reinoculation and quarantine or euthanasia depending on the scenario.

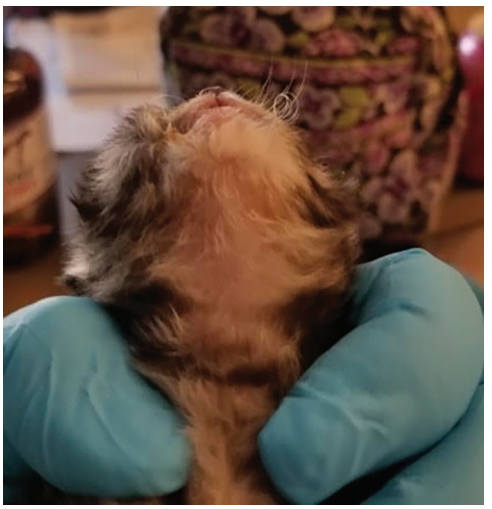


Figure 9.6 FCV-VSD frontal view. *Source:* Ellen Carozza, LVT, VTS.

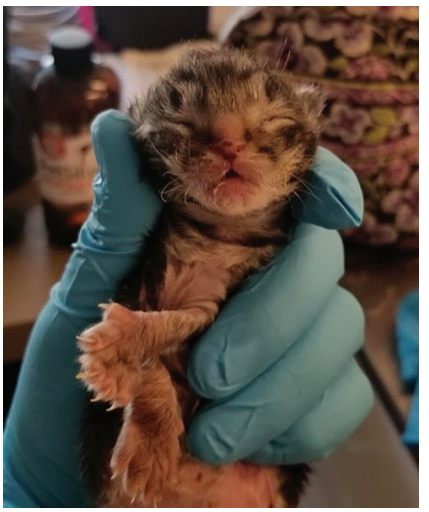


Figure 9.7 FCV-VSD neck. *Source:* Ellen Carozza, LVT, VTS.

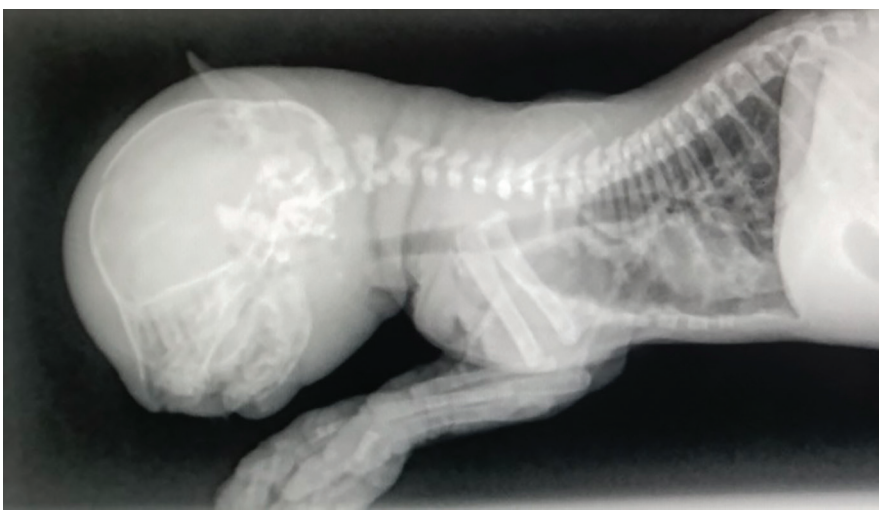


Figure 9.8 FCV-VSD lateral radiograph. Notice the soft tissue edema present on the radiograph. *Source:* Ellen Carozza, LVT, VTS.

This disease stems from the order of Mononegavirales, viruses with nonsegmented, negative-stranded RNA genomes [12]. This bullet-shaped virus (and packs a large punch just as a bullet would) infects the animal's central nervous system via infected saliva from a bite that ultimately leads to death. Rabies is most commonly associated with wildlife, particularly raccoons, bats, skunks, and foxes. However, reports of infected livestock, such as cattle and horses are not uncommon to be seen in the required state rabies reports. In many countries, exposure to rabid dogs is the number one cause of human exposure, but in the United States that number is less <1% due to the vaccination protocol. Yet, exposure to rabid dogs outside the United States is the second leading cause of rabies death to Americans according to the CDC. Most animals that have been infected have been shown to have the following symptoms, and while tempting to want to help, it is recommended never to pet or handle an animal with an unknown vaccination status without being vaccinated against the disease yourself. (Box 9.2) The three stages of rabies typically seen in cats are:

- **Prodromal stage:** Changes in temperament. Usually, the exact opposite of the cat's current personality is noticed at first.
- **Furious stage:** Most commonly seen in cats as they tend to act erratic, overly nervous, uncommonly, and suddenly aggressive. This is the most dangerous stage as this is when bites tend to occur to humans. Excessive drooling, inability to swallow due to muscle spasms may be seen. The furious stage is also when hydrophobia is seen, and that is simply due to the intense esophageal spasms when attempting to swallow.
- **Paralytic stage:** Occurs usually within 7 days of infection; comatose and death occurs.

Box 9.2 A summary of caretakers consideration of zoonotic concern for unvaccinated, intact cats.

Our community cats that have not been TNR'd and vaccinated against rabies is of concern as a zoonotic risk as the caregivers must be cautious around the colony when feeding and caring for the cats with an unknown vaccination status, including kittens. Many colony caretakers are private citizens with NO rabies vaccination status themselves.

It is incredibly important that anyone working in the veterinary industry, shelter/rescue medicine is vaccinated against the disease, including anyone who travels into other countries to provide veterinary care. Contact your local health department for options regarding human vaccination against the disease. The author recommends that anyone who is working in animal rescue that is not associated with a hospital or shelter and feeds/cares for community cats should highly consider vaccination for themselves. Responsibility for caring for these cats starts with protecting yourself.

Note: *It is important to understand that rabies can infect cats at any age, including kittens.*

Any person(s) working with local shelters/rescues that rehabilitate "feral" kittens for adoption is at risk of bites and can be exposed to the virus when working with these kittens. Non-vaccinated kittens that have dentition and cause a bite wound to a human or animal or have a bite wound present on them are not exempt from the rabies algorithm of quarantine regardless of their age.

In all animals, testing is performed via the direct fluorescent antibody (DFA) test, which looks for the presence of rabies virus antigens in brain tissue [13]. Depending on whether the cat is showing symptoms of rabies, euthanasia may be warranted immediately, and the entire animal or the head is sent to the diagnostic lab for rapid testing due to the high zoonotic risk of the disease. If the animal is not showing symptoms, a 10-day quarantine (local jurisdictions may be different) is usually recommended to monitor for symptoms. At any time, if the animal exhibits signs of the disease, euthanasia and testing are required.

Rabies is considered a core vaccination for ALL cat populations regardless of lifestyle.

9.10.4.1 Vaccination with Exposure to Rabies

The current recommendations, local law dependent, usually recommend that if there has been potential exposure in an unvaccinated cat but no human exposure, vaccination and strict quarantine are recommended for several months with no direct contact with humans or other animals. However, euthanasia and testing may be elected. *If* the cat has been vaccinated previously with the ability to prove vaccination and is hopefully current on the vaccination, revaccination is normally recommended, and the cat placed into quarantine at home depending on the state's algorithm for rabies. For more information regarding your state, visit https://rabiesaware.org/.

Where local law permits, the AAFP/AAHA feline vaccination task force recommends a 3-year vaccination interval using a 3-year vaccination in pet cats [14]. In all other cats, the authority to vaccinate is stipulated by local law and is necessary where legally allowed/mandated by the state. In states where vaccination is not mandated, it is recommended for shelters to consider the benefits of rabies vaccination [15].

9.10.5 Feline Leukemia

FeLV is one of the most common and important retroviruses (an enveloped RNA virus) tested for in feline populations as it can affect a large number of cats in specific feline populations, and not all infections are the same for each cat, which makes it frustrating to determine the outcome of the cat's longevity and actual infection due to a rather complicated algorithm. While FeLV is contagious, the main point of infection tends to be exposure to prolonged contact with the saliva of a positive cat: grooming, shared water and food bowls, cats that have physical altercations with bites, as well as the virus can be found in feces, urine, and milk [16]. Yet, not all cats exposed to FeLV will become positive. The virus is unstable outside the body and does not last long in the environment, making it more difficult to be infected from environmental contamination alone without prolonged contact of any infected cat.

In the intact female cat, FeLV has been implicated to cause a host of issues from embryonic absorption, fetal resorption, abortion, and infertility [17]. Cats that are positive for FeLV and found pregnant have a higher likelihood of kittens born with the disease and succumbing to secondary infections due to immunosuppression or other FeLV related weeks after birth. In kittens, it can be passed vertically from an infected pregnant queen. Age is not a disease, yet kittens are more

prone to infection and developing progressive FeLV infections than their adult counterparts, yet adult cats can also develop progressive FeLV. However acquired, the disease itself may not manifest for months after exposure in the adult cat, making it difficult to determine a positive result with known recent exposure. Due to this issue, it is important that FeLV tests, which can discriminate exogenous FeLV from endogenous FeLV-like sequences, are used [18]. and to follow the diagnostic algorithm created to help determine the type of infection and potential outcome of the disease.

- **Progressive:** Persistent viremia, FeLV-associated diseases are common and the prognosis is poor.
- **Regressive:** Undetectable or transient viremia. FeLV-associated disease is uncommon (bone marrow suppression/lymphoma), yet common if reactivation occurs.
- **Abortive (formerly labeled as regressive):** No viremia, no associated FeLV-associated disease is seen, and prognosis is good.
- **Focal (rare infection):** No viremia, FeLV-associated disease is uncommon and prognosis is variable.
- **No Infection:** No association with FeLV [18].

Regressive infections can be frustrating not only for the cat, but also for the caregivers as the cat requires repeated testing over the course of several months becomes costly and this may also be a situation of an animal in foster or in the shelter setting where time may be a factor to determine their outcome. It is becoming increasingly popular for shelters to *not* routinely test for FeLV in kittens. This not only saves the shelter funding to use elsewhere, but it also makes their mortality rate numbers better as their euthanasia rate goes down. They have space for other animals that need their assistance and are not stuck in a waiting period for the FeLV algorithm. Yet this leaves the clinician and the new family to deal with a potentially poor outcome post-adoption. One concern with not testing is the kittens that are positive that are kept in multi-cat rooms, high-risk foster homes with the potential to spread the disease unknowingly. See Chapter 23: "Infectious Diseases," for further information on diagnostics and therapies for FeLV.

The FeLV vaccination is considered a core vaccination for all kittens and for cats at risk.

9.11 Feline Noncore Vaccinations

Pet cats, shelter/high-risk cats should be considered for vaccination.

9.11.1 Bordetella Bronchiseptica

A highly contagious respiratory tract disease commonly seen in high-risk group/high-risk housing, such as shelters or homes with infected animals. This is easily spread through direct and indirect contact and is zoonotic between dogs and cats (sneezing, coughing, grooming, face touching). The disease can be severe in kittens due to their lack of immunity and their proneness to infection and pneumonia. While not always thought about, treated, and tested for, it should be a consideration for possibly infected cats that are adopted from shelters/high-risk foster groups. In most cats, signs are clinically mild that taper off in about 10–14 days. PCR, trans-tracheal lavage, or nasopharyngeal swabs for testing are available. The vaccination, however, does not provide complete protection and may not be beneficial. For the frequency and interval of vaccination, it is advised to follow the recommendations of the manufacturer.

Vaccination should be considered for cats that are kept in high-risk shelters, catteries, feline events/shows, and high-volume rescues where cats are under chronic stress.

9.11.2 Chlamydia

Occurs through direct contact with other infected cats, as it has poor environmental survivability, or passed to kittens from the infected queen at birth as infected cats also shed *Chlamydophila* from their rectum and vagina. At this time, venereal transmission may occur but has not been confirmed. Cats and kittens typically present with conjunctivitis with thick, yellow discharge. Many neonatal infected kittens that still have their eyes closed may develop neonatal ophthalmia when the purulent material builds up behind the eyelid and then the eye then has an appearance of it bulging from the socket. Treatment is to apply warm compresses open the eye early and begin topical treatment regardless of age to salvage the eye and vision. The vaccine is seen as not providing complete protection and it is advised to follow the manufacturer's instructions for frequency and intervals.

9.12 Vaccines No Longer Recommended

9.12.1 Feline Immunodeficiency Virus

While this disease is still of concern among pet populations, it is no longer perceived as detrimental as it was in the past with many cats simply being euthanized due to a positive test result. With direct transmission through bites, cats that live in harmonious homes have little risk of transmission between cats. The higher-risk cats, such as community cat colonies where fighting can regularly occur, can be managed with TNR with better outcomes as fighting goes down when there is no desire to seek intact female cats or tom cats simply having to fight due to ending up in the wrong turf.

While there was a feline immunodeficiency virus (FIV) vaccination used in the past, it is no longer available. Testing could not tell the difference between cats that were inoculated with the vaccination or positive from the disease itself as well as most cats are indoors not being in a high-risk group. This led to a lot of confusion in the clinics and required stricter record keeping preventing cats from being misdiagnosed at future visits. Regardless, FIV-positive cats can live long, happy lives in the home and should not be ostracized for being positive. See Chapter 23: "Infectious Diseases," for further information.

9.12.2 Feline Infectious Peritonitis

While there are intranasal attenuated live vaccinations available on the market, the AAFP/AAHA Feline Vaccination Task Force does not generally recommend the vaccination at this time due to the uncertain ability to uniformly protect against the disease in North America. Only seronegative cats have the ability to be protected. Usually, by the time the vaccination is given by the recommended age, the kitten/juvenile cat has most likely already become seropositive. Another concern with the vaccination is predominantly serotype (II) which is different from serotype (I), which predominantly causes the clinical disease presented in cats. Currently, the benefits remain unclear to justify giving the vaccination routinely in practice. At this time, a cure is available for feline infectious peritonitis (FIP; GS-441524), but not currently FDA-approved as of 2024. As of the summer of 2024, Stokes Pharmacy had formed an exclusive partnership with the Bova group to offer a US-made oral treatment for FIP. This treatment is supported by Bova's unique drug formula, which has been utilized in clinical research studies and now is available for veterinary use allowing for patients to have a treatment option by their veterinarian and not utilizing online formulations with little knowledge on the manner, manufacturing, or efficacy.

9.13 Feline Patient Populations That Need Protection: What and When to Provide Vaccination

There are five feline patient populations seen in practice, and each population requires core vaccines, however, depending on lifestyle, this is where the roles of noncore vaccinations become recommended due to where they are and how they live. They are classified as the following:

- **Pet Cats:** Owned as a pet and serve as companions in the home.
- **Shelter Cats:** Institutionalized cats awaiting adoption for permanent placement in homes. Time is not determined for length of stay.
- **Foster Cats:** Cats that are kept in a home setting with the outcome for adoption in their own home. There is no determined period of time for fostering and can be short or long term.
- **Community (TNR) Cats:** Feral cat communities or stray cats that are outdoors and dependent on different levels of care (i.e., food and medical care).
- **Cattery Cats:** Boarding cats, rescues with their own buildings that are not shelter, big box pet departments that have small adoption cubicles, and breeding catteries.

Core vaccines are recommended for all cats with an unknown vaccine history! Non-core vaccines are optional vaccines that should be considered with the level of exposure.

9.13.1 Pet Cats

9.13.1.1 Core vaccinations

Vaccines that are necessary to prevent communicable diseases between cats (FVRCP for example) and other species (rabies for example.) The current core vaccination recommendations for cats are:

- Rabies
- FVRCP
- FeLV in kittens and cats <1 year and in households with cats that may come in contact with unknown vaccination status cats outside if they are indoor/outdoor free roaming.

9.13.1.2 Noncore Vaccinations

Vaccines that are recommended due to the cat's lifestyle to prevent them from obtaining a disease from other cats and then passing in the household or outside to other cats (FeLV for example in the adult cat.)

- Bordetella
- Chlamydia
- FeLV is considered noncore for low-risk cats with no potential exposure to other FeLV+ cats or unknown status cats

9.13.1.3 Vaccinations NOT Recommended

- FIV
- FIP

9.13.2 Core Vaccine Considerations for Other Populations

9.13.2.1 Shelter Cats

- Rabies
- FVRCP
- FeLV – strongly advised for group housing, optional for individually housed.

Non-core/optional vaccinations for bordetella and chlamydia vaccinations are dependent on the exposure level and geographic distributions and lifestyle of the cats in the facility.

9.13.2.2 Foster Cats

Considered a high-risk category due to the heavy rotation of cats in the home. All permanent residents of the home should be kept up to date on vaccines at all times.

- Rabies
- FVRCP
- FeLV

9.13.2.3 Community Cats

Regardless of the community cats not being able to come back for boosters, each cat should be vaccinated with rabies and FVRCP to lower the risk of disease transmission.

- Rabies (the decision for a 3-year vaccination vs. a 1-year vaccination is the choice of the clinician as we know the 3-year vaccination has a high reputation for efficacy with the single dose. However, by law in many states, we know the vaccination for the first time for rabies is considered 1-year. The challenge is this may be the only time the cat is ever vaccinated due to their lifestyle.
- FVRCP (both intranasal and parenteral can be given simultaneously due to the high-risk population category).

9.14 Vaccination and Age

One thing to remember is that there is limited information and no current studies on modern vaccinations available given to the pediatric patient less than 6 weeks of age; however, the AAFP/AAHA Feline Vaccination task force currently does not recommend the vaccination of the feline patient less than 4 weeks of age due to the potential increased risk of cerebellar hypoplasia.

9.14.1 FVRCP Vaccine

- **Pet Cats:** Can start vaccines at 6 weeks of age with regular boosters every 3–4 weeks until 16 weeks, then depending on lifestyle a single booster is given at 24 weeks of age and that vaccine can be elected to be boosted in 1–3 year intervals from that date depending on exposure.
- **Shelter Cats:** Can start vaccine series no earlier than 4 weeks of age with regular boosters every 2 weeks until 14–16 weeks of age.
- **Foster Cats:** Depending on the number of kittens being cared for in the home, they should be considered high risk if multiple litters are present and follow the shelter cat protocol.
- **Community Cats:** Core vaccines are given at the time of trapping/surgery before returning to their location. Kittens that are of appropriate age can either be kept for adoption and follow shelter/foster protocols or vaccinated and returned to the population if they have already been programmed as feral and rescues/shelters are unable to put the effort into taming and adoption.

9.14.2 Rabies (All Cat Populations)

Follow the manufacturers guidelines and local law. Typically given no earlier than 12 weeks of age. State dependent, it is up to the veterinarian's discretion to administer a 1- or 3 year rabies vaccination as the *initial* dose. *All animal rabies vaccines currently licensed in the United States require a booster 1 year after the initial vaccine.* However, with feral cat colonies, this may be the only rabies vaccination ever given to the cat.

9.14.3 Feline Leukemia Virus

It is recommended to know the FeLV status of the cat before starting the vaccine series. There is no proven benefit to vaccinating an infected cat.

- **Pet Cats:** Can start as early as 8 weeks of age. Two doses given 3–4 weeks apart.
- **Shelter Cats:** Can start as early as 8 weeks of age in the kitten. Two doses given 3–4 weeks apart. With the increasing number of shelters electing not to test, it is up to the shelter protocol and veterinarian in charge to elect to give the vaccine to a cat with unknown status.
- **Foster Cats:** Can start as early as 8 weeks of age in the kitten. Two doses given 3–4 weeks apart.
- **Community Cats:** While most cats are not tested during TNR programs, and cats are not re-trapped for booster vaccinations, it is ultimately up to the clinician to provide a vaccination that may or may not contribute to preventing disease but contribute to an already stressed immune system.

9.15 Lifestyle Vaccinations: When Vaccination Plans Have the Possibility of Changing

The decision to vaccinate vs. not to vaccinate is a conversation each clinician has with their clients, and each case is as unique as the cat it involves. Discussing the *risks vs. benefits* with the client and determining what pet population their cat falls under can assist with determining what vaccines are necessary (Figure 9.9). Age/life stage, health status, immunodeficiency, history of previous vaccination, and agent exposure as well as their environment are factors that determine when and when not to vaccinate. This is where the discussion of lifestyle-based vaccination plans has been

created to help keep the cat populations healthy by choosing what vaccines are necessary based on risks and exposure to disease. This helps the clinician choose an individualized plan for each patient, and not a set plan for every cat. The denser the feline population, the likelihood of increased opportunity for disease. Cats that are in a shelter setting, high volume foster homes, multi-cat households and community cat populations are considered higher risk for disease transmission.

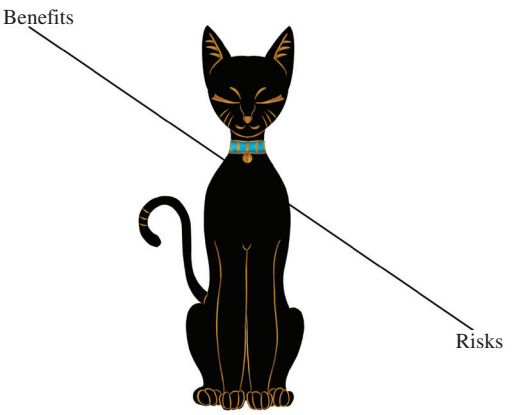


Figure 9.9 Risks vs. benefits diagram. *Source:* Olivia Johnson.

It is equally important for technicians to know their state laws regarding specific vaccines required. Available online, Michigan State University has a table of State Rabies Laws Concerning Cats that is authored by Rebecca F. Wisch with the Michigan State University College of Law [19]. A valuable resource, as it allows for at-a-glance links to the states that require the rabies vaccine, the age it is supposed to be performed on the animal, and penalties for failure to vaccinate. Not only do we need to understand state law regarding a deadly but preventable zoonotic disease, but each state and county tends to provide online resources and algorithms for animals in their jurisdiction that have potential exposure and provide recommended guidelines on euthanasia, quarantine, and vaccination (Table 9.1).

Table 9.1 While in practice, we typically provide three routine vaccinations for cats, yet, with the latest guidelines, lifestyle has been added in regard to susceptibility to disease. This at-a-glance guide allows you to understand core vs. noncore and other optional vaccines available as well as administration time, revaccination, and concerns with the vaccinations. See the AAFP/AAHA 2020 Feline Vaccination Guidelines for full details pertaining to each vaccination and a more robust reference chart.

Vaccine	Core	Noncore	Not recommended	Administration period	Revaccination	Concerns
FVRCP	X (all cats)			As early as 4 weeks in high-risk environments only; 6–8 weeks in low-risk environments Pet cats start at 6 weeks at 3–4 week intervals until 16–20 weeks of age Adult cats can get two vaccines 3–4 weeks apart Shelter cats as early as 4 weeks then every 2 weeks until 16–20 weeks	Consider a booster at 6 mo. of age, then can be given every 3 years.	Avoid attenuated live-in pregnant cats. Intranasal can cause URI symptoms. Possible for kittens to show symptoms of panleukopenia or calicivirus within a short window post-vaccination and be positive on tests.
Rabies	X (all cats)			Starting as early as 12 weeks of age (1 dose)	The first vaccine is a 1-year vaccination. Vaccines after can be yearly or every 3 years	The titer may not be high enough for some countries when traveling

(Continued)

Table 9.1 (*Continued*)

Vaccine	Core	Noncore	Not recommended	Administration period	Revaccination	Concerns
FeLV	It is recommended that kittens receive a series and dependent on lifestyle continue during their lifetime	Optional noncore, lifestyle-dependent in adult cats		Recommended for kittens as early as 8 weeks of age Two doses 3–4 weeks apart Adults two doses total 3–4 weeks apart	Yearly-lifestyle dependent	FISS has been one of the higher concerns related to this vaccination if a nonadjuvanted vaccine used
FIP			X			
FIV			X			Can cause a positive POC ELISA test result
Bordetella		High-risk facilities/ demographics		Follow label instructions		Never administer parentally!
Chlamydia		High-risk facilities/ demographics		Follow label instructions		Higher potential for adverse effects

Note: At a glance Vaccine Chart Based on the 2020 AAFP/AAHA Vaccination Guidelines; *this chart does not substitute the Feline Vaccination Guidelines*.

9.16 Postvaccination Serological Screening: The Debate on Over-vaccination

In the past several years, the debate not only from the public but from the veterinary community, has been that we are over-vaccinating our pets and instead of protecting them, we are harming them with unnecessary immunity distress, which has gained more attention. The European Advisory Board Against Cat Diseases (ABCD) in 2002 [20] presented the current knowledge and opinions on antibody testing to determine re-vaccination in cats. In kitten, antibody testing has been proposed to aid in determining the best vaccination schedules for them, but it can be costly to the client and impractical to monitor the decline of MDAs and how they vary with each kitten. Other conflicts noted have been cats that have undergone subclinical infection and might have life-long protection without receiving any vaccinations (i.e., healthy, feral cat populations). It is also understood that different factors, such as breed, nutritional status, age, and any concurrent sub-clinical infections, could affect the DOI.

Antibody testing in clinical practice is utilized for the interpretation of:

- Diagnosis of infection
- Identification of previous exposure to pathogens
- Assessment of immunity prior to or following vaccination (mostly seen for international travel to prove a rabies titer status vs. the choice of not to vaccinate due to over-vaccination)

9.16.1 Serology Testing is Useful for Assessment of Immunity: Antibody Testing

- **FPLV:** The presence of antibodies strongly correlates with protection, and results can be interpreted to determine whether or not to vaccinate depending on results.
- **FeLV:** Results from the FeLV antigen testing (not antibody) should be used to determine whether or not to vaccinate.
- **FCV:** It is not reliable to determine whether to vaccinate, or not as effective immunity relies on antibody and cell-mediated immune response and therefore not a reliable assessment for immunity.
- **FHV-1:** Same as FCV

- **Rabies:** Serum neutralization results cannot be used to decide whether or not to vaccinate against the disease, as vaccination is essential in states/regions by law and endemic countries. Most countries require 0.5 IU/ml or greater for adequate immunization against rabies when performing titer sampling for international travel.
- **FIV:** While no longer available, cats that were vaccinated in the United States with the inactivated whole virus vaccination between 2002 and 2015 had the possibility of interfering with the test results on antibody test kits. The vaccines also had the probability of these cats testing seropositive for FIV up to 7 years post-final vaccination. POC rapid in-house test kits for hospital use cannot distinguish the difference between vaccination and true infection [21].

9.17 Staff Compliance: Who Is Responsible for What?

Each staff member plays a role in making sure the patients we see at the hospital are provided with the optimal care they deserve, which includes vaccines. Knowing who to assign specific tasks not only utilizes the staff to their maximum ability but also allows everyone understands what is going on with the patient's medical history.

The veterinarian is ultimately in charge of the cat's care in practice. Their role is not only to prescribe the appropriate treatment and vaccination plan but to ensure the rest of the staff understand and follow the plan provided. They are responsible for keeping the clinic's practices up to date with the latest veterinary guidelines to keep these cats healthy and happy as well as staff training when changes are made. Their requirements include, but are not limited to:

- Preventing zoonotic disease with the pets seen at the practice.
- Knowing and training the rest of the team on the proper injection sites and routes to administer vaccinations.
- Discuss adverse and potential life-threatening events that can follow vaccination with the client and staff training on how to assist in an adverse reaction emergency.
- Vaccine reconstitution and handling training (the current guidelines recommend any reconstituted vaccination be given within 30 minutes to maintain efficacy.)
- Safety protocols using sharps to prevent accidental needle sticks (Table 9.2).

Table 9.2 Chapter definitions.

Chapter definitions
Adjuvant: A substance used to increase the effectiveness of the component antigens. An unfortunate side effect of localized inflammation can cause a FISS.
Antibody (immunoglobulin): Are blood proteins that circulate the body looking for unwanted substances that cause illness. These proteins are created by the immune system when stimulated by an antigen. Their role is to recognize, attack, and destroy.
Antigen: A substance either from viruses, bacteria, pollen, or other environmental stimulus that causes the body to produce antibodies to protect the body against illnesses. The immune system does not recognize the foreign material and thus causes an immune response to fight against the material. They also train the body to recognize and destroy future same-type antigens.
Core vaccinations: Vaccines that are necessary to prevent communicable diseases between cats (i.e., FVRCP) and other species (i.e., rabies).
DOI: Point in time where the vaccination begins to wane ineffective immunity. Vaccine-dependent, some immunity can be lifelong with a single vaccination, and others need more frequent boosting to remain protected.
FISS: A malignant tumor caused by an inflammatory reaction from vaccinations. However, this tumor is not just limited to vaccinations, but other injectables that cause localized inflammation.
Indoor cat: A cat that spends 100% of their time indoors with very limited access to the outside.
Indoor/outdoor cat: A cat that has access to the outside, even if this is a closed-in porch/catio, leash walked, or provided enrichment via a pet stroller. These cats may also be let outside without supervision for them to come and go as they please in the home.
Maternally derived antibodies: Antibodies passed from the queen to the neonate and protect the kitten from disease as their immune system has the opportunity to mature. While they may have been given antibodies, their immune system is still fragile and if exposed to disease without the proper level of immunity, illness and death can occur.
Noncore vaccinations: Vaccines that are recommended due to the cat's lifestyle to prevent them from obtaining a disease from other cats and then passing in the household or outside to other cats (FeLV, for example).
Outdoor cat: A cat that spends 100% of its time outside. This includes community cats that are friendly.

The credentialed technicians in practice and veterinary assistants play an important role in maintaining vaccinations. Often assuming the role of maintaining inventory and order when stock is low, they can also make sure proper storage, and handling occur when shipments arrive. With the ability to reconstitute vaccinations, it is important to know the cat is to be receiving the vaccinations after the clinician has examined the animal as issues can occur that can postpone a regular wellness appointment and vaccines can be elected not to be given during that specific appointment time. Proper handling of the patient during vaccine administration may be necessary depending on the cat's level of stress utilizing feline-friendly methods leading to a more compliant patient. See Chapter 2: "Feline-friendly Interactions," for further information. Depending on their role during the appointment, the technician/assistant may be responsible for verbally or providing written literature on vaccine adverse events and the diseases the pet is being protected against.

The client service coordinator and receptionist are to maintain records. From adding previous medical history, including vaccinations, to obtaining records from other clinics, they can help provide an at-a-glance overview of what vaccines are needed. Not only dates are important but ensuring clients receive their copy of legal documents/tags necessary for their local laws in regard to vaccines as well as forward-booking any necessary booster vaccinations ahead of time to stay on schedule. All nonclinical staff is to be trained to speak to a client whose pet may be experiencing an adverse vaccine event and to help them obtain the veterinary assistance needed.

See the companion website for further clinical references.

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10

Critical Thinking and Kirby's Rule of 20

Courtney Waxman, MS, CVT, RVT, VTS (ECC)

TECHNICIAN TIDBITS

- Kirby's Rule of 20 is an established, evidence-based patient care checklist that can be used by veterinary technicians for critically ill patients in any veterinary setting.
- The benefits of using checklists include helping with memory recall, creating a culture of accountability, standardizing patient care, improving consistency of patient care, reducing patient harm, and avoiding medical errors.
- When caring for a critical feline patient, Kirby's Rule of 20 empowers veterinary technicians to assess the overall clinical picture and elevate the quality of patient care.
- Using Kirby's Rule checklist allows veterinary technicians to implement critical thinking skills.

As veterinary technicians, we have a central and fundamental role in providing patient care. When it comes to caring for hospitalized patients, it is our responsibility to provide the veterinarian with valuable information about a patient's physiological status. Within a hospitalized patient population, critically ill animals inherently require a higher patient care priority. Critically ill patients are those who are considered unstable because they have more than one abnormal vital parameter and one or more systemic disease processes [1]. There are a variety of systemic disease processes that contribute to feline critical illness, and as such, these patients require daily assessment and critical care monitoring. When we have critically ill patients, the reality is that we are just as able to cause harm as we are to heal due to the intensity of their care [2]. To minimize the potential for patient harm, veterinary technicians need to be considerate of the potential for medical errors as they care for patients.

10.1 Veterinary Medical Error Background

In human healthcare, patient safety research has found that up to 98 000 patients die annually in the United States as a result of medical errors [3]. The most common contributor to these medical errors is human error, which can be from either cognitive limitations, deficiencies in nontechnical skills, or system or environmental limitations that influence decisions [3].

Although there is limited veterinary research investigating the overall morbidity and mortality statistics, we know that medical errors occur in our field as well. A survey published in 2015 sought to determine the causes and types of errors in veterinary practices and found that, broadly, errors were categorized as either active failure (representing errors of the individual) or system failures (representing organizational influences) [3]. Individual (active) failures occur due to cognitive limitations, individual factors, lack of technical ability, and inadequate care [3]. System failures occur due to communication, leadership, product or equipment design, productivity, organizational structure and/or workflow, or pet owners [3].

To reduce the probability of the veterinary team making medical errors, an emerging concept is the use of patient care checklists.

10.2 Patient Care Checklist Background

Checklists have been implemented as safety systems in several fields, including aviation, engineering, construction, and healthcare [2, 4]. The use of checklists allows for greater efficiency, consistency, and safety, and can be interrelated across areas of daily and professional life [2]. Within human healthcare, patient care checklists have been widely researched for their effectiveness at preventing medical errors and ultimately reducing morbidity and mortality in the critical care setting.

In the context of medicine, a checklist is defined as a step-by-step process of evidence-based interventions and procedures that help prevent medical oversights [5, 6]. A checklist is typically specific to a given procedure or treatment and does not encompass all aspects of patient care [6]. The benefits of checklists include helping with memory recall, creating a culture of accountability, standardizing patient care, improving consistency of patient care, reducing patient harm, and avoiding medical errors [4, 5] (Figure 10.1).

Within veterinary healthcare, checklists can be used by the team as tools to minimize medical errors and optimize patient care standards and quality. Checklists are one of many tools veterinary technicians can use as part of their patient care plan for critically ill feline patients. Patient care checklists empower veterinary technicians to elevate their standard of patient care, follow a standardized approach, and ultimately improve patient outcomes. The most prominent patient care checklist used for critically ill veterinary patients is Kirby's Rule of 20.

10.3 Kirby's Rule of 20

Kirby's Rule of 20 is a patient care checklist created by Rebecca Kirby, DACVIN, DACVECC. It consists of 20 patient parameters that should be evaluated daily in critically ill patients to ensure quality patient care and minimize or prevent medical oversights due to the nature of their critical illness [1]. Kirby's Rule of 20 is a tool that veterinary technicians can use to approach caring for a critical feline patient as it enables them to assess the overall clinical picture of a patient and implement critical thinking skills. The patient parameters included in Kirby's Rule of 20 are summarized in Table 10.1

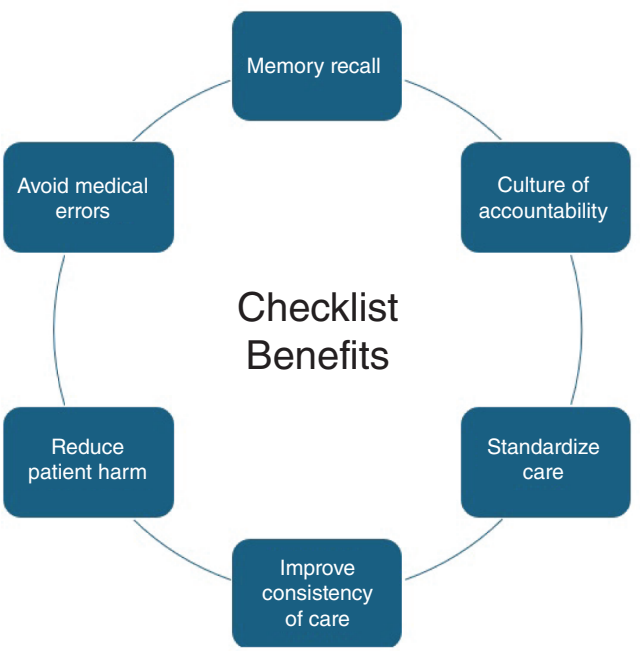


Figure 10.1 Benefits of using patient care checklists in veterinary medicine. *Source:* Courtney Waxman.

Table 10.1 List of the 20 patient parameters included in Kirby's Rule of 20.

Kirby's Rule of 20	
Fluid balance	Renal function
Albumin and oncotic pull	GI motility and integrity
Electrolytes and acid–base	Nutrition
Mentation	Glucose
Heart rate, contractility, and rhythm	Immune status and antibiotics
Blood pressure	Wound care and bandages
Body temperature	Drug dosage and metabolism
Oxygenation and ventilation	Pain control
RBCs and hemoglobin	Nursing care
Coagulation cascade	Tender loving care

Source: Courtney Waxman.

10.3.1 Fluid Balance

Physiologically speaking, the body is comprised of roughly 60% water, which is referred to as total body water (TBW). Fluid pathophysiology is based on the understanding of TBW distribution, which is comprised of two fluid compartments, the intracellular fluid (ICF) and extracellular fluid (ECF). The ICF compartment accounts for approximately 66% of TBW, whereas the ECF compartment accounts for approximately 33% of TBW [7]. The ECF compartment is further broken down into the interstitial space (accounting for 75% of ECF) and intravascular space (accounting for 25% of ECF) (see Figure 10.2). While the fluid volume within the intracellular compartment remains static, fluid within the extracellular compartment moves between the intravascular and interstitial spaces based on a concept known as Starling's forces (discussed further in the next parameter). Under normal conditions, TBW is maintained in a constant balance between each fluid compartment. When patients have a critical illness, it can alter their ability to adequately compensate and restore their own fluid requirement, resulting in fluid imbalances that require intervention.

Fluid therapy is considered a mainstay component of critical patient care, with the intravascular space within the ECF being the fluid compartment with which we are most concerned. Intravenous (IV) fluids are used in the critically ill to maintain intravascular volume and adequate perfusion [8]. The primary fluid type used in IV fluid therapy is isotonic crystalloids, as they have the most similar composition to a patient's ECF compartment. Crystalloids are water-based solutions

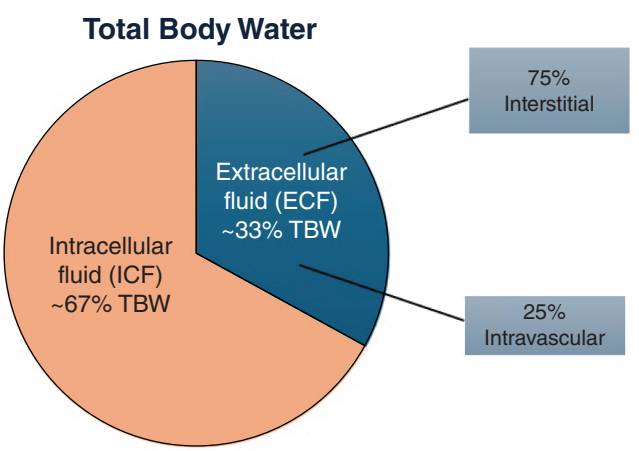


Figure 10.2 Distribution of total body water in feline patients. *Source:* Courtney Waxman.

composed of small, osmotically active molecules that are permeable to capillaries [7]. Examples of crystalloid solutions include 0.9% normal saline (NaCl), Lactated Ringer's solution, Normosol-R, and Plasmalyte-A.

When developing a fluid therapy plan, factors, such as the patient's level of disease, life stage, hydration status, and any ongoing losses must be taken into consideration. Fluid therapy requirements include maintenance and replacement. The maintenance fluid requirement refers to the volume of fluid needed to maintain normal homeostasis and fluid balance [9]. Since maintenance is a patient's base for what is needed physiologically, it often must be augmented by a factor to account for critical illness (e.g., 1.5× maintenance, 2× maintenance). Even though there has been widespread research to determine the maintenance fluid needs in cats (and dogs), there are too many variables, such as species, breeds, weight, life stage, and activity level. In the author's experience, the most used formulas for feline maintenance fluid rates used in critical care medicine are either $80 \times (\text{kg})^{0.75}$ per day or 40 ml/kg/day [7, 9]. The replacement fluid requirement refers to the volume of fluid needed to replace body water lost, which takes into account dehydration and any ongoing loss. Dehydration is a fluid loss within the interstitial space of the ECF compartment and is an estimated value when calculating fluid requirements. The formula used to replace a dehydration deficit is kg × % dehydration × 1000 ml = volume (in ml) to correct [8]. Replacing the dehydration deficit occurs over a four to 24-hour period and is calculated as an hourly fluid rate in addition to the maintenance fluid rate [7, 9]. Ongoing loss is fluid loss that is considered abnormal and typically secondary to a disease state (e.g., vomiting, diarrhea, hemorrhage). Ongoing losses are estimated or measured on a continuous basis (in the author's experience, every 4–6 hours) and replaced on an as-needed basis.

When monitoring a patient's response to fluid therapy, the veterinary technician can assess a variety of parameters. These include perfusion parameters (e.g., heart rate, pulse quality, mucous membrane color, capillary refill time, blood pressure), hydration status (e.g., skin turgor, mucous membrane moisture), ongoing losses, body weight, and lab values (e.g., packed cell volume, total protein, blood urea nitrogen, creatinine) [10]. Feline patients receiving fluid therapy should also be closely monitored for signs of hypervolemia, as they are more susceptible and therefore at greater risk due to their smaller blood volume [8, 9]. Hypervolemia, which is more commonly referred to as fluid intolerance, refers to a state of volume overload in which there is excess fluid content within the interstitial and intracellular spaces [10]. Clinical signs of fluid intolerance range across the spectrum from mild or moderate to severe. The milder signs of fluid intolerance include serous nasal discharge, chemosis (conjunctiva swelling), jugular vein distension, subcutaneous edema, and weight gain. The most severe sign of fluid intolerance is pulmonary edema, which has the clinical signs of tachypnea or dyspnea, harsh lung sounds on auscultation (e.g., crackles or wheezes), coughing, and restlessness [7, 9].

10.3.2 Albumin/Oncotic Pull

Albumin and oncotic pull are closely related to fluid balance, specifically when looking at their relationship to Starling's forces. Starling's forces refer to the forces that dictate water movement within the ECF compartment [11]. Starling's Forces are a major factor of fluid balance in that fluid exchange occurs based on the hydrostatic and oncotic pressures between the capillaries of the intravascular space and the lymphatic system of the interstitial space [7]. Hydrostatic pressure is generated because of forces involved in normal blood flow and works to pull water out of the intravascular space into the interstitial space [8]. Oncotic pressure (pull) is generated by plasma proteins in the vascular space and works to hold water within the intravascular space rather than in the interstitial space [7, 8].

Albumin is the predominant plasma protein within the intravascular space and is a key determinant of fluid balance [9]. Albumin is responsible for maintaining vascular integrity and oncotic pressure, essentially dictating whether fluid remains in the intravascular space or moves to the interstitial space [11]. As such, albumin is considered a nonspecific biomarker related to critical illness; while albumin levels alone cannot be used in overall patient assessment, they have been found to be a prognostic indicator [12].

In relation to patient monitoring, understanding the concepts of hydrostatic pressure, oncotic pressure, and albumin for the veterinary technician can be clinically significant. Increases in capillary hydrostatic pressure will result in fluid movement out of the intravascular space into the interstitial space, causing tissue edema (e.g., peripheral, pulmonary) [7]. Patient examples of this physiologic process include a cat with congestive heart failure, anuric renal failure, or fluid intolerance. Decreases in capillary oncotic pressure will also result in fluid movement out of the intravascular space into the interstitial space, again causing tissue edema [7]. A patient example of this physiologic process is a cat that has hypoalbuminemia due to its critical illness (e.g., loss from hemorrhage, liver disease, renal disease, malnutrition) and no longer has adequate albumin levels to maintain vascular integrity and oncotic pull [12]. Therefore, when monitoring a patient's

albumin level, the veterinary technician can assess patient parameters (e.g., heart rate, respiratory rate, blood pressure), lab values (e.g., albumin, total protein), and tissue edema [12].

10.3.3 Electrolytes and Acid–Base

Electrolytes are essential, electrically charged particles within the intracellular and extracellular fluid compartments. The six electrolytes that are most clinically relevant are sodium, potassium, chloride, calcium, phosphorus, and magnesium. The balance of each of these electrolytes is important as they play a vital role in many bodily functions.

Sodium is the major extracellular cation, and its primary function is to help maintain the ECF volume by balancing water intake and water loss [13]. The sodium disturbances that are concerning in critically ill patients are hypernatremia and hyponatremia. Hypernatremia primarily results from either a free water deficit (e.g., lack of water intake, pure water loss) or excessive sodium gain (e.g., ingestion of salt, sand, or litter) [8]. Hyponatremia primarily results from changes in osmolarity [8].

Potassium is the major intracellular cation, and its primary function is to maintain the proper resting potential of cardiac and skeletal muscle cells. The potassium disturbances that are most concerning in critically ill patients are hyperkalemia and hypokalemia. Hyperkalemia primarily results from either renal disease or hypoadrenocorticism [8]. Hypokalemia primarily results from decreased dietary intake, increased losses through the gastrointestinal (GI) or renal systems, metabolic acidosis, or iatrogenic sources.

Chloride is the major extracellular anion, and its primary function is to influence acid–base balance, which is maintained through secretion and reabsorption in the kidneys [13]. The chloride disturbances that are most concerning in critically ill patients relate to acid-base derangements.

Calcium is an extracellular cation, and its primary functions are muscle contraction and maintaining coagulation. The calcium disturbances that are concerning in critically ill patients are hypercalcemia and hypocalcemia. Hypercalcemia primarily results from an underlying chronic disease (e.g., renal failure, skeletal disorders, neoplasia) [8]. Hypocalcemia primarily results from renal failure, ethylene glycol toxicity, acute pancreatitis, sepsis, and eclampsia [8].

Phosphorus is the major intracellular anion, and its primary functions are to provide the structure of cells (e.g., the phospholipid bilayer of cell walls), synthesize adenosine triphosphate (ATP), and carry out metabolic processes [13]. Gradual changes in phosphate levels can occur unnoticed because the body will often compensate.

Magnesium is an intracellular cation, and its primary functions are carrying out cellular functions (e.g., catalyst for more than 300 enzymes, formation and use of ATP, cell membrane integrity) and maintaining muscle contraction and vascular smooth muscle tone [13]. Magnesium levels are maintained within narrow limits; however, very little is known about regulatory mechanisms.

Electrolyte disturbances manifest clinically based on disease processes and can involve the neurological, cardiovascular, renal, musculoskeletal, and GI systems. Clinical signs of these disturbances can range from being subtle, with minimal impact to the patient, to acutely life-threatening. Sodium disorders can cause life-threatening movement of water into or out of brain cells in response to osmotic shifts, resulting in neurologic effects (e.g., changes in mentation, disorientation, ataxia, changes in behavior, seizures, coma) [8]. Potassium disorders can cause life-threatening complications associated with heart contractility and rhythm, musculoskeletal weakness, and respiratory depression [8]. Chloride disorders are closely linked to sodium transport and are related to changes in acid–base status. Calcium disorders can cause cardiac arrhythmias, hypertension, renal dysfunction, and neuromuscular dysfunction (e.g., muscle tremors, weakness, seizures) [8]. Phosphorus disorders can disrupt receptor-ion channels and membrane-associated ion pumps, ATP production, and regulation of cardiac output (CO) and vascular resistance [8]. Magnesium disorders can affect normal neurotransmission, cardiac conduction and contractility, vascular tone, and skeletal muscle activity [8].

When monitoring a patient's electrolytes, the veterinary technician can assess physical parameters relevant to the disturbance (e.g., the body system most affected) as well as point-of-care lab testing. Refer to Chapter 11: "Interpretation of Common Diagnostic Test Results," for further information.

Acid–base refers to the regulation of the body's internal environment through the potential of hydrogen (pH). Dysregulation of the body's acid-base status can affect the ability to synthesize and utilize proteins, maintain cellular integrity, transport intracellular and intercellular molecules, and maintain essential body functions to sustain life [14]. The body's level of acid or base is determined by measuring the amount of hydrogen ions (H^+) within the blood. The pH scale goes from zero (most acidic) to 14 (most alkalotic/basic), with normal pH being in the very narrow range of 7.35–7.45 [8].

Table 10.2 Quick reference chart for general reference ranges of venous blood gas analysis and the primary acid–base disturbances.

Value	Feline reference range	Disturbance	pH	PCO_2	HCO_3
pH	7.35–7.45	Metabolic acidosis	↓	↓	↓
PCO_2	26–35 mmHg	Metabolic alkalosis	↑	↑	↑
HCO_3	18–24 mmHg	Respiratory acidosis	↓	↑	↑
–	–	Respiratory alkalosis	↑	↓	↓

Source: Courtney Waxman.

Acidosis refers to a disease process in the body that decreases the pH, while alkalosis refers to a disease process in the body that increases pH. To help regulate pH, the body utilizes a buffering system and physiologic responses [13].

The four acid–base disturbances are metabolic acidosis (most common), metabolic alkalosis, respiratory acidosis, and respiratory alkalosis. Metabolic acidosis is characterized by a low pH, low HCO_3, and compensatory low PCO_2. Metabolic acidosis occurs due to an increase in the amount of acid in the body, in which the body responds by increasing renal excretion of ammonia and hyperventilating to increase alveolar ventilation in an effort to raise the pH [14]. Primary causes that contribute to metabolic acidosis include a loss of bicarbonate-rich fluids (e.g., small intestinal diarrhea), addition or production of an acid (e.g., toxin ingestion, lactic acidosis, diabetic ketoacidosis), or failure of renal excretion of an acid (e.g., hypoadrenocorticism, renal failure) [13]. Metabolic alkalosis is characterized by a high pH, high HCO_3, and compensatory high PCO_2, in which the body responds by increasing renal excretion of bases and hypoventilating to decrease alveolar ventilation in an effort to lower the pH [14]. Primary causes that contribute to metabolic alkalosis include loss of chloride-rich fluid (e.g., vomiting), severe potassium or magnesium deficiency, hypoalbuminemia, refeeding syndrome, impaired renal function, pyloric obstruction, or diuretic treatment [13]. Respiratory acidosis is characterized by low pH, high PCO_2, and compensatory high HCO_3, in which the body responds by buffering renal absorption of HCO_3 in an effort to raise pH [8]. Primary causes that contribute to respiratory acidosis include hypoventilation, gas exchange disorders (e.g., diffusion impairment, ventilation-perfusion mismatch, shunt), or an increase in CO_2 production [13]. Respiratory alkalosis is characterized by high pH, low PCO_2, and compensatory low HCO_3, in which the body responds by buffering renal excretion of HCO_3, in an effort to lower pH [14]. Primary causes that contribute to respiratory alkalosis include hypotension, fever, systemic inflammatory response syndrome (SIRS), sepsis, pulmonary thromboembolism, pulmonary parenchymal disease, or hyperventilation [13].

When monitoring a patient, acid–base status gives insight into three physiologic processes—alveolar ventilation (venous), acid–base (venous or arterial), and oxygenation (arterial). For the purpose of this chapter, we will focus on venous blood gas (VBG) analysis, as it can arguably be one of the most routinely used point-of-care tests for critically ill patients. The values needed for VBG interpretation are pH, PCO_2, and bicarbonate (HCO_3). pH is a measurement of the acidity or alkalinity of the blood (how many hydrogen molecules are present in the blood). PCO_2 is a measurement of the partial pressure of carbon dioxide in the blood and represents the respiratory component (ventilation status) of a blood gas analysis. HCO_3 is a measurement of bicarbonate (bicarb) in the body and represents the metabolic component of blood gas analysis (Table 10.2). Acid–base analysis gives the veterinary technician more information about the severity of a patient's disease based on the primary disturbance.

10.3.4 Mentation

Mentation status, or level of consciousness (LOC), is a component of an overall neurological assessment. LOC refers to a patient's arousability and responsiveness to stimuli in their environment, and relates to the degree of neurological injury [15]. Alterations in mentation are significant in critically ill patients, as they can be indicative of decreased cerebral function due to changes in cerebral perfusion pressure (CPP) [16]. When cerebral perfusion becomes compromised, cerebral blood flow is inadequate to meet the brain's oxygen demand. Although CPP cannot be definitively measured in veterinary medicine, it is calculated in human medicine using the formula CPP = MAP – ICP, where MAP refers to mean arterial pressure and ICP refers to intracranial pressure [15].

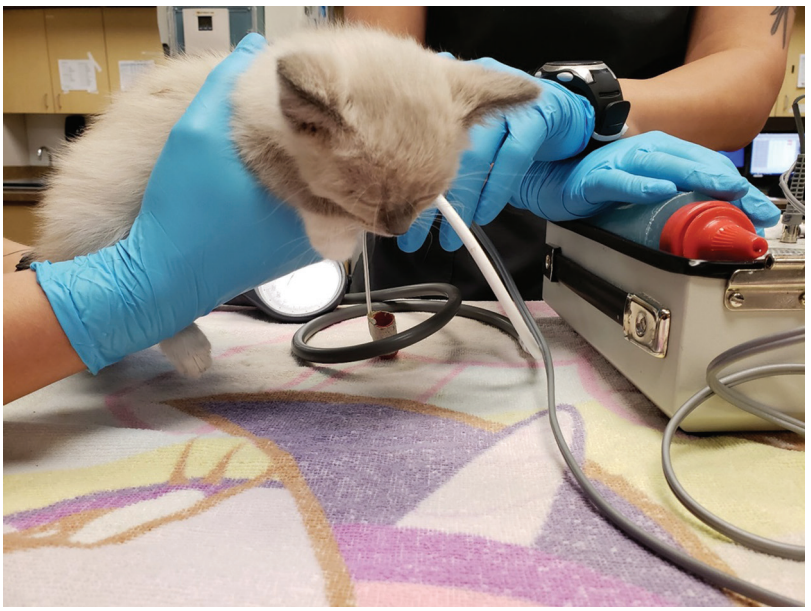


Figure 10.3 Head trauma patient with a stuporous LOC. *Source:* Courtney Waxman.

The classifications used to assess a patient's LOC are normal, obtunded, stuporous, and comatose. A normal LOC refers to a patient who is alert, aware, and responsive to their environment. An obtunded LOC refers to a patient who has a slowed, reduced, or inappropriate level of awareness and responsiveness to their environment. This LOC can also be described using the terms dull or depressed and can be further depicted as mild, moderate, or severe [15, 16]. A stuporous LOC refers to a patient who is not alert or aware of their environment and is only responsive with a strong or painful stimulus (Figure 10.3). A comatose LOC refers to a patient that is not alert, aware, or responsive to their environment, regardless of the application of a stimulus. These changes in LOC can be due to primary neurologic disease (e.g., neoplasia, seizures), neurologic complications from other diseases (e.g., toxins, hypoperfusion, and cardiopulmonary arrest), metabolic disorders (e.g., sodium imbalance, acidemia, and hypoglycemia), trauma (e.g., animal attacks, vehicular accidents, and high-rise syndrome), or from systemic disease processes (e.g., inflammation, sepsis, and hepatic encephalopathy) [15, 16].

Critically ill patients with altered mentation need to be monitored closely for progression or deterioration. When monitoring a patient's mentation, the veterinary technician can utilize coma scales to assess neurologic abnormalities. One of the most used coma scales in veterinary medicine is the Modified Glasgow Coma Scale (MGCS) (it is modified because it has been adapted from human medicine) [17]. The MGCS provides an objective means to evaluate a patient's overall neurologic status as it factors in three areas of assessment, (1) LOC, (2) motor activity, and (3) brainstem reflexes. Within each category, there are descriptions of the patient's response, with each descriptor having an associated score. Using the MGCS helps to record the progression or regression of a patient's neurologic status over time (e.g., obtain an initial score and continue with serial scoring). Use of the MGCS has also been shown to be a prognostic indicator, in which lower scores are associated with a decreased chance of survival, and higher scores are associated with an increased chance of survival [17].

10.3.5 Heart Rate, Contractility, and Rhythm

The main function of the cardiovascular system is to transport oxygen to the rest of the body, with the heart working as a pump to circulate blood [18]. When assessing cardiac function, consideration needs to be given to both the mechanical and electrical aspects.

CO represents the mechanical activity of the heart, as it is the driving force of blood volume being pumped by the heart each minute [19] (Figure 10.4). Cardiac output itself is dependent on heart rate (the number of times the heart beats per minute) and stroke volume (the volume of blood being pumped from the heart during each heartbeat). As the heart pumps, the muscle contraction and relaxation from the beginning of one heartbeat to the start of the next are known as the cardiac cycle [18]. Stroke volume (SV) is dependent on preload (the volume of blood left after contraction), afterload

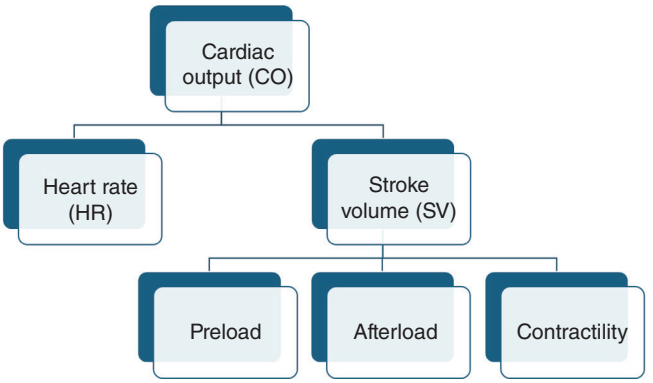


Figure 10.4 Graphic depiction of the components' cardiac output. Cardiac output is dependent on heart rate stroke volume; stroke volume is dependent on preload, afterload, and contractility. *Source:* Courtney Waxman.

(the pressure against which the heart must work to eject blood during contraction), and contractility (the strength and force of contraction) [18, 19].

The cardiac cycle represents the electrical activity of the heart and is based on the relationship between muscle cells (myocytes) and conduction cells. Blood flow moves through the heart when conduction cells deliver a synchronized electrical impulse to trigger the myocyte cells to contract [19]. A heart rhythm is generated from the normal sequence of electrical events during each cardiac cycle.

In relation to patient monitoring, understanding the concepts of cardiac physiology is important for the veterinary technician because critically ill patients have higher demands placed on the cardiovascular system. Assessment of heart rate, contractility, and rhythm involves both patient parameters and electrocardiogram (ECG). Patient parameters are used to evaluate the mechanical activity of heart function and include heart rate, cardiac auscultation, pulse rate, and pulse quality. In feline patients, the normal physiologic heart rate ranges from 150 to 200 bpm [19]. Auscultation of heart rate should include listening to both the left and right sides of the chest for any abnormal sounds. In cats, abnormal heart sounds (e.g., murmur, gallop) occur more intermittently rather than with every heartbeat and have a focal point [19]. As such, the veterinary technician should auscultate for at least two minutes along the ventral and para-sternal areas of the chest to determine if an abnormal heart sound is present [20]. The pulse rate should be palpated simultaneously with the assessment of heart rate. Pulse pressures are reflective of cardiac output to the periphery and give subjective information about stroke volume [21]. Pulse quality can be affected by both stroke volume and systemic vascular resistance (SVR) and is generally characterized as normal, weak, strong, or absent [21]. ECG is used to evaluate the electrical activity of heart function by monitoring for arrhythmias. The use of ECG can be performed intermittently or continuously based on the patient's level of critical illness. Common arrhythmias seen in feline patients include sinus tachycardia (e.g., pain, hypovolemia, anemia), atrial standstill (e.g., hyperkalemia, urethral obstruction), atrioventricular (AV) blocks (e.g., cardiomyopathies), and atrial fibrillation (e.g., thromboembolic event) [19]. Refer to Chapter 14: "Cardiology/Cardiovascular Diseases," for further information.

10.3.6 Blood Pressure

Blood pressure is defined as the force exerted by circulating blood on arterial walls [22]. Blood pressure is considered another assessment of cardiac function because it is a byproduct of appropriate CO and SVR. Blood pressure reflects appropriate peripheral perfusion and involves the assessment of three values: systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and mean arterial pressure (MAP). The SAP measurement is the peak pressure in arteries that occurs during the active contraction of the heart muscle. The DAP measurement is the base pressure in arteries that occurs during the relaxation of the heart muscle. The MAP measurement represents the average pressure in arteries and is an approximate value based on the systolic and diastolic values [18]. In feline patients, the normal physiologic blood pressure ranges are systolic between 120 and 170 mmHg, diastolic between 70 and 120 mmHg, and mean between 60 and 130 mmHg [23]. In critically ill patients, blood pressure abnormalities, such as hypotension and hypertension can lead to severe systemic consequences.

Hypotension can be defined as a systolic pressure less than 80 mmHg or a MAP less than 60 mmHg. The three general causes of hypotension include reduction in preload (e.g., hypovolemia, severe dehydration, edema), a reduction in cardiac function (e.g., cardiomyopathy, arrhythmias, cardiogenic shock), and reduction in SVR (e.g., vasodilatory disease states) [22, 23]. Hypotension is concerning in critically ill patients due to the potential for reduced organ and tissue perfusion.

Hypertension can be defined as a sustained systolic pressure greater than 150 mmHg [22]. Causes of hypertension are most commonly secondary to underlying disease processes, such as renal disease, diabetes mellitus, hyperthyroidism, hyperadrenocorticism, or pheochromocytoma [22, 23]. Hypertension is concerning in critically ill patients due to the potential for target-organ damage to the neurologic system (e.g., altered mentation, head tilt, nystagmus), ocular organs, (e.g., blindness, retinal hemorrhage, retinal detachment), cardiovascular system (e.g., murmurs, gallop, hypertrophy), and renal system (e.g., early nephron death, proteinuria) [23].

When it comes to patient monitoring, the veterinary technician can most easily assess blood pressure using noninvasive (indirect) methods, such as oscillometric or Doppler techniques. For indirect blood pressure measurement, it is important to use a cuff size that is approximately 30–40% of the circumference of the limb as well as to use the same limb (or tail) for each measurement to ensure accuracy and consistency of results. Regardless of the measurement modality, trends in blood pressure values are more important than a one-time measurement and should be assessed in consideration of other cardiovascular parameters (e.g., heart rate, pulse rate, pulse quality, mucous membrane color, capillary refill time) [21].

10.3.7 Body Temperature

Body temperature is a measure of the body's ability to maintain normal thermoregulation. Cats maintain their temperature within a range called the set point, which is determined by the thermoregulatory center in the hypothalamus. The process of thermoregulation is a balance between heat production and heat loss [24]. When core body temperature rises or falls outside the set-point, thermoreceptors within the central and peripheral nervous systems stimulate the body to either increase heat production or dissipate heat to return to the set point range [21]. In feline patients, the normal physiologic temperature range is generally accepted to be between 99.5 and 102.5 °F (37.5–39.1 °C). In critically ill patients, dysregulation of the body's normal thermoregulation, such as hyperthermia and hypothermia, can lead to severe systemic consequences.

Hyperthermia can be defined as any increase in a patient's core body temperature beyond the expected physiologic normal range. Hyperthermia is a manifestation of increased heat production at a rate that exceeds heat loss [20]. Causes of hyperthermia include a true fever (e.g., the result of an endogenous or exogenous pyrogen), inadequate heat dissipation (e.g., heatstroke), exercise-induced (e.g., eclampsia, seizures), or pathologic in origin (e.g., hypothalamus dysfunction, hypermetabolic disorders, iatrogenic) [24].

Hypothermia can be defined as any decrease in a patient's core body temperature beyond the expected physiologic normal range. Hypothermia is a manifestation of increased heat loss that exceeds heat production [20]. Hypothermia can be further subcategorized as primary, which refers to heat loss in the face of normal heat production, and secondary, which refers to heat loss that results from a clinical or disease process [20]. The cause of primary hypothermia is environmental in nature, including cold climates and submersion injuries. Causes of secondary hypothermia include neurologic disease, hypoperfusion, toxins, and the administration of drugs (e.g., anesthetics) [24].

Fluctuations in core body temperature can result in cardiovascular, neurologic, respiratory, and metabolic systemic consequences [24]. When monitoring a patient's temperature, the veterinary technician should obtain values using a rectal thermometer, as it is considered to be the most accurate measurement [20].

10.3.8 Oxygenation and Ventilation

Oxygenation and ventilation are normal physiologic processes of the respiratory system. Ventilation is the process of appropriate gas exchange. During ventilation, oxygen (O_2) is inhaled and diffuses from the alveoli to the capillary blood supply, while carbon dioxide (CO_2) diffuses from the capillary blood supply to the alveoli to be exhaled [25]. Oxygenation is the process by which the diffused oxygen within the capillary blood supply binds to hemoglobin and is delivered to bodily tissues [26]. In feline patients, the normal physiologic respiratory rate ranges from 16 to 40 bpm [25]. In critically ill patients, ventilation and oxygenation abnormalities, such as hypoventilation, hyperventilation, hypoxemia, and hypoxia, can lead to severe systemic consequences.

Hypoventilation is defined as a decreased ventilation (respiration) rate and is a manifestation of hypercapnia (CO_2 level greater than 60 mmHg). Causes of hypoventilation include sedation or anesthesia, neuromuscular disease, hypokalemia, and respiratory disease (e.g., airway obstruction, chest wall trauma, and respiratory muscle fatigue) [25, 26]. Hyperventilation is defined as an increased ventilation (respiratory) rate and is a manifestation of hypocapnia (CO_2 level less than 35 mmHg). Causes of hyperventilation include fear, stress, anxiety, pain, pulmonary disease (e.g., asthma, pulmonary thromboembolism), and heart disease [25, 26].

Hypoxemia is defined as a reduced level of oxygen in the blood, which occurs when partial pressure of oxygen (PaO_2) is less than 80 mmHg (severe is PaO_2 less than 60 mmHg) or saturation of oxygen (SaO_2) is less than 94% (severe is less than 90%) [21]. Causes of hypoxemia include a reduced fraction of inspired oxygen (FiO_2), hypoventilation, cardiovascular compromise, hypovolemia, and anemia [25]. Hypoxia is defined as inadequate oxygen delivery to meet tissue oxygen demand, resulting in low levels of oxygen in bodily tissues. Causes of hypoxia include hypoxemia, inadequate tissue perfusion (e.g., shock), methemoglobinemia (e.g., acetaminophen toxicity), and carbon monoxide toxicity (e.g., smoke inhalation) [25].

In critically ill patients, it is important to assess and monitor both ventilation and oxygenation status as separate parameters, as they represent two separate physiological processes. Assessment of ventilation and oxygenation involves the assessment of both patient parameters and diagnostic instrumentation. Patient parameters used to evaluate ventilation include respiratory rate, pulmonary auscultation, capnography, and VBG. Respiratory rate refers to the number of breaths per minute (used interchangeably with ventilation rate) and can be observed simultaneously with auscultation or before. Auscultation of the lungs should include listening to both the left and right sides of the chest, all lung fields, and abnormal lung sounds. The four primary abnormal lung sounds are pulmonary crackles, pulmonary wheezes, increased bronchovesicular sounds, and absent lung sounds [20]. Capnography is used as a direct measurement of CO_2 values, with normal end-tidal CO_2 ranging between 35 and 45 mmHg. VBG is used as an indirect measurement of CO_2 values by looking at the partial pressure of CO_2 in the blood, with normal ranging between 26 and 36 mmHg [25]. Patient parameters used to evaluate oxygenation include respiratory rate, respiratory effort, oxygen saturation, and arterial blood gas. Respiratory effort refers to the overall work of breathing and looks at how easy or hard it is for the patient to breathe normally. Respiratory effort should be observed simultaneously with respiratory rate. It is also important to note that in cats, any level of open-mouth breathing is considered abnormal and indicates severe respiratory compromise [21]. Oxygen saturation (SaO_2 or SpO_2) is used as an indirect measurement of O_2 values and evaluates the oxygen saturation of hemoglobin in the blood, with normal being above 95%. An arterial blood gas is used as a direct measurement of O_2 values by looking at the partial pressure of O_2 in the blood, with normal ranging between 95 and 115 mmHg [25].

When monitoring a patient's ventilation and oxygenation status, the veterinary technician needs to assess the values within these parameters to obtain a comprehensive picture of a patient's respiratory state. Refer to Chapter 25: "Respiratory" for further information.

10.3.9 RBCs and Hemoglobin

Red blood cells (RBCs) and hemoglobin are closely related to oxygenation. RBCs are made in the bone marrow and are dependent on the renal hormone erythropoietin. Erythropoietin is responsible for RBC generation, hemoglobin synthesis, and the release of immature RBCs (reticulocytes) into circulation [27]. RBCs contain hemoglobin and therefore are responsible for carrying and transporting oxygen molecules throughout the body. Each hemoglobin molecule has an oxygen-carrying capacity of four oxygen molecules. Maintaining RBC and hemoglobin levels is essential to maintaining adequate oxygen delivery to bodily tissues.

In critically ill patients, the most concerning disorder of red blood cells or hemoglobin is anemia. Anemia is a reduction of total circulating RBCs and is classified as either regenerative (appropriate bone marrow response) or nonregenerative (inappropriate bone marrow response) [28]. Anemia can be caused by trauma/hemorrhage, bone marrow suppression, autoimmune disorders (e.g., immune-mediated hemolytic anemia), renal disease, or severe flea/tick infestation (Figure 10.5). When anemia occurs, the body will trigger compensatory responses to increase oxygen delivery to tissues, which include increasing RBC and/or hemoglobin production, increasing blood flow, and increasing the oxygen unloading capacity from hemoglobin [27]. Clinical signs of anemia include altered mentation, weakness, tachycardia, tachypnea, poor pulse quality, pale mucous membrane color, and prolonged or absent capillary refill time [28].

When monitoring a patient's RBC and hemoglobin levels, the veterinary technician can assess patient parameters as well as lab values. Patient parameters to monitor include perfusion parameters (e.g., heart rate, pulse quality, mucous

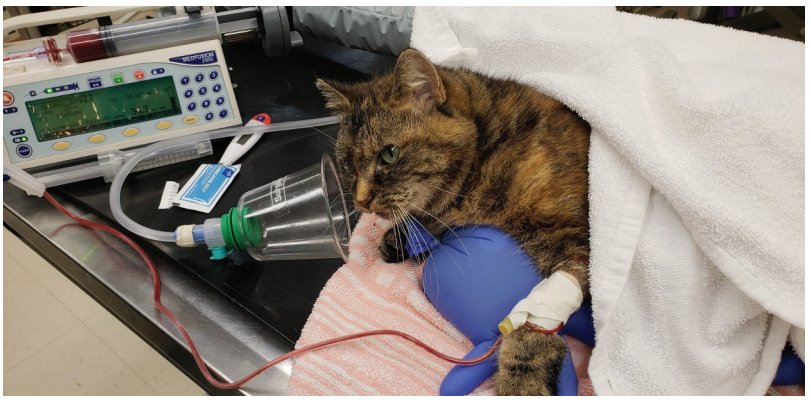


Figure 10.5 Patient with anemia from severe flea infestation who required a blood transfusion. *Source:* Courtney Waxman.

membrane color, capillary refill time), respiratory rate, respiratory effort, and mentation. Lab values to monitor include RBC concentration, hemoglobin concentration, and packed cell volume (PCV). Refer to Chapter 11: "Interpretation of Common Diagnostic Test Results" and Chapter 21: "Hematology," for further information.

10.3.10 Coagulation

Hemostasis is a complex process that prevents blood loss and bleeding. When there is vascular or tissue injury, the hemostatic system is activated and proceeds through two phases: primary hemostasis and secondary hemostasis. Primary hemostasis occurs within minutes when platelets are activated to travel to the site of injury to form a plug to stop bleeding [28]. Secondary hemostasis occurs within hours and involves activation of the clotting cascade. The clotting cascade involves various coagulation factors of the intrinsic pathway (within the bloodstream) and extrinsic pathway (outside the bloodstream) to reinforce the platelet plug and prevent continued bleeding [28].

In critically ill patients, coagulation disorders can be caused by trauma/hemorrhage, bone marrow suppression, autoimmune disorders (e.g., immune-mediated thrombocytopenia), clotting factor deficiencies (e.g., hemophilia), hepatic disease, rodenticide toxicity, or systemic disease states (e.g., sepsis, heatstroke, DIC) [28, 29]. Clinical signs of a coagulopathy (bleeding) include integumentary hemorrhage (e.g., petechia, ecchymosis, bruising), gingival bleeding, ocular hemorrhage (hyphema), bleeding from injection or insertion sites, hematemesis, hematochezia, hematuria, and pleural hemorrhage [28, 29].

When monitoring a patient's coagulation status, the veterinary technician can assess patient parameters as well as lab values. Patient parameters to monitor include heart rate, pulse quality, mucous membrane color, capillary refill time, respiratory rate, respiratory effort, and mentation. Lab values to monitor include platelet concentration (CBC and manual count), partial thrombin (PT) time, activated partial thromboplastin time (aPTT), and activated clotting time (ACT) [29]. Refer to Chapter 11: "Interpretation of Common Diagnostic Test Results" and Chapter 22: "Hematology," for further information.

10.3.11 Renal Function

The renal system (comprising the kidney, ureters, bladder, and urethra) is responsible for many functions that help maintain overall homeostasis. Its roles include fluid regulation, hormone production, and excretion of metabolic waste products [30]. The kidneys maintain the volume and composition of body fluids (water and electrolyte balance), absorb solutes (proteins, amino acids, and glucose), remove metabolic waste from the body (urea, uric acid, and creatinine), and receive approximately 20–25% of overall CO to help maintain arterial blood pressure [30].

In critically ill patients, disruption of any of the kidney's functions can result in systemic consequences, primarily acute kidney injury (AKI). AKI is defined as the abrupt (acute) inability of the kidney to regulate fluid balance, electrolyte balance, acid–base balance, or excrete body waste products [31]. Causes of AKI are based on the type of azotemia (high concentrations of body waste compounds in the blood), which can be prerenal, intrinsic renal, or postrenal. Prerenal

refers to "before" the kidney, meaning injury is caused by other physiologic or hemodynamic factors in which renal perfusion is compromised. Causes of prerenal azotemia include hypovolemia, dehydration, cardiac compromise, or vasodilatory disease processes [32, 33]. Intrinsic renal refers to direct damage to the renal parenchyma. Causes of intrinsic renal azotemia include toxins, infectious insult (e.g., leptospirosis), and neoplasia [32]. Postrenal refers to "after" the kidney, meaning there is an obstruction or impediment in the outflow of urine that prevents urine from being eliminated from the body. Causes of postrenal azotemia include urethral obstruction, strictures, prostatic disease, urolithiasis, inflammation, trauma, and neoplasia [32, 33]. Clinical signs of renal dysfunction include lethargy, hyporexia or anorexia, nausea, vomiting, uremia, pollakiuria (increased frequency of urination), stranguria (difficult urination), abnormal urine output (e.g., polyuria (PU), oliguria, and anuria), and abdominal pain [31].

When monitoring a patient's renal function, the veterinary technician can assess a variety of parameters. These include patient parameters, fluid balance, laboratory values, and urine output [21]. Patient parameters include mentation, heart rate, mucous membrane color, capillary refill time, and blood pressure [21, 32]. Fluid balance parameters include hydration status (e.g., skin turgor, mucous membrane moisture), ongoing losses (e.g., vomiting, excess urine output), and body weight. Laboratory values include renal enzymes (blood urea nitrogen, creatinine), electrolytes, acid-base, PCV, total protein, and urine-specific gravity [33]. Urine output (UOP) is an outward indicator of appropriate renal function. Normal UOP in a well-perfused, hydrated cat should be between 1 and 2 ml/kg/h [21]. Methods of monitoring UOP include collecting and measuring voided samples, weighing litterboxes using the conversation factor of 1 g equaling 1 ml, or placing a urinary catheter. Refer to Chapters 28: "Urinary and Renal" and Chapter 11: "Interpretation of Common Diagnostic Test Results," for further information.

10.3.12 GI Motility and Integrity

The GI system includes the GI tract (esophagus, stomach, small intestines, and large intestines) as well as the liver, gallbladder, and pancreas. The GI system is responsible for the absorption and digestion of nutrients and the expulsion of waste material. Normal GI function requires effective motility and an intact mucosal barrier for normal digestive activity and protection of the body from GI luminal contents [34].

There are several causes that contribute to reduced GI motility or impaired integrity. Causes of GI tract motility issues include megaesophagus, gastric emptying disorders (e.g., gastritis, foreign body, ileus, ulcers), small intestinal transit disorders (e.g., enteritis, ileus), and megacolon [34, 35]. Causes of GI tract integrity issues include hypoperfusion (e.g., shock), gastric or intestinal foreign body ingestion, gastric ulceration (e.g., foreign body, prolonged nonsteroidal anti-inflammatory use, stress), perforation (e.g., prolonged ulceration), and traumatic penetration [34, 35]. Additionally, when the GI tract becomes compromised from critical illness, there is a risk for gut mucosal breakdown and bacterial translocation into the abdominal cavity [35]. Clinical signs of GI dysfunction include hyporexia (consumption of less than 75% of resting energy requirement over three days), anorexia, nausea, vomiting, and diarrhea [21].

When monitoring a patient's GI function, the veterinary technician can assess patient parameters (including pain), GI losses (source, volume, frequency), lab values (e.g., PCV, total protein, blood glucose, electrolytes), and the need for pharmacological support [34]. Because GI tract dysfunction in the critically ill can complicate disease processes and impact patient recovery, pharmacological support is often needed [34]. Agents, such as antiemetics, gastroprotectants, and prokinetics can all be used to support the GI tract clinical signs and motility. Refer to Chapter 11: "Interpretation of Common Diagnostic Test Results" and Chapter 19: "Gastroenterology," for further information.

10.3.13 Nutrition

Nutrition is an important but often discounted aspect of caring for and managing critically ill patients. Nutritional support is essential for patients to recover from all disease processes [36]. The goals of providing nutritional support are to meet nutritional requirements, reverse metabolic consequences of lack of nutrition, and improve patient recovery time [37]. Veterinary technicians can be involved in developing a nutritional therapy plan by taking into consideration how a patient should be fed, how much to feed, what to feed, and how often to feed [38].

Enteral nutrition refers to nutrition that is provided via the GI tract and is the most physiologically appropriate method of feeding. Enteral nutrition helps to maintain GI mucosa, prevent gut bacterial translocation, and improve the immune response and wound healing [38]. If a patient is unwilling or unable to meet their nutritional requirements by mouth, enteral support should be provided using feeding tubes (e.g., nasoesophageal, nasogastric, esophagostomy; Figure 10.6). The amount to be fed is based on the resting energy requirement (RER), which is the energy that is required for a normal animal at rest [38]. Refer to Chapter 12: "General Feline Nutrition," for further information.



Figure 10.6 Patient receiving enteral nutrition via a nasoesophageal feeding tube. *Source:* Courtney Waxman.

When monitoring a patient's nutritional status, refeeding syndrome is an uncommon but potentially serious complication of nutritional support that can occur in cats that are severely malnourished with significant loss of lean body mass [36]. Reintroduction of nutrition results in a rapid increase in insulin levels and other metabolic changes that result in a shift of potassium, phosphorus, and magnesium to the intracellular space [38]. Profound hypokalemia, hypophosphatemia, and hypomagnesemia can lead to severe systemic consequences, including muscle weakness, intravascular hemolysis, and possible cardiac and respiratory failure [38]. Refer to Chapter 12: "General Feline Nutrition," for further information regarding monitoring of a patient's nutritional status.

10.3.14 Glucose

Glucose is the body's primary energy source as it is utilized by every cell. Life-sustaining activities such as neurological function, heart rate and rhythm, vasomotor tone, respiration, regulation of metabolism, and maintaining immune status are all dependent on glucose being available to cells [39, 40]. Glucose is derived from three sources, intestinal absorption from digestion of carbohydrates, breakdown of the storage form (glycogen) via glycogenolysis, and production from precursors (e.g., lactate, pyruvate, and amino acids) via gluconeogenesis [40]. Glucose homeostasis is maintained by a balance between the glucose-lowering hormone insulin and glucose-elevating hormones, glucagon (primary), epinephrine, cortisol, and growth hormone [40].

In critically ill patients, dysregulation of the body's normal glucose levels, such as hypoglycemia and hyperglycemia, can lead to severe systemic consequences. Hypoglycemia is defined as any decrease in a patient's blood glucose level below the expected physiological normal range. Causes of hypoglycemia include excess insulin (e.g., accidental overdose, insulinoma), toxin ingestion (e.g., xylitol), GI disease (e.g., malnutrition, pancreatitis), hepatic disease, hypoadrenocorticism, and sepsis [39]. Clinical signs of hypoglycemia include altered LOC, weakness, ataxia, muscle tremors, seizures, and coma [21].

Hyperglycemia is defined as any increase in a patient's blood glucose level above the expected physiologic normal range. Causes of hyperglycemia include stress, lack of insulin (e.g., diabetes mellitus, diabetic ketoacidosis), neurological disorders (e.g., traumatic brain injury), or renal disease (e.g., reduced glomerular filtration) [39]. Clinical signs of hyperglycemia include PU, polydipsia (PD), dehydration, polyphagia, and weight loss [21].

When monitoring a patient's blood glucose, the veterinary technician should assess patient parameters and lab values. Patient parameters include mentation, heart rate, and respiratory rate. Lab values of glucose are most commonly measured using point-of-care testing with a glucometer. Refer to Chapter 11: "Interpretation of Common Diagnostic Results," for further information.

10.3.15 Immune Status and Antibiotics

The immune system is the body's complex defense mechanism against invasion of microorganisms (e.g., bacteria, viruses, and parasites) that protects the body from harm, damage, or disease. An antigen is any foreign substance that when introduced to the body, stimulates an immune response. When the body detects an antigen that threatens its health, it employs various mechanisms to destroy it (e.g., leukocyte recruitment, antibodies) [41]. An antibody (also known as an immunoglobulin) is a Y-shaped protein used by the immune system in response to an antigen. Its role is to neutralize the antigen by binding to it and making the antigen inactive [41]. Dysfunction of the immune system can result in a patient being unable to mount a rapid, aggressive, and effective immune response to protect itself from disease.

The immune system of the critically ill patient can be affected by patient factors, disease factors, and environmental factors. These factors include immunosuppression (e.g., leukopenia), GI dysfunction (risk for bacterial translocation, aspiration, malnutrition), respiratory compromise (e.g., pneumonia), allergic reaction or anaphylaxis, drug suppression, autoimmune disease processes (e.g., immune-mediated hemolytic anemia, immune-mediated thrombocytopenia), wound contamination, SIRS or sepsis, infectious diseases (e.g., feline leukemia virus, feline immunodeficiency virus, calicivirus), and nosocomial infections [28, 41]. A nosocomial infection (also sometimes referred to as a hospital-acquired infection) is an infection that develops more than 48 hours after a patient has been hospitalized [42].

When monitoring a patient's immune system, the veterinary technician should assess patient parameters (including patient handling), laboratory values, and infection control strategies. Patient parameters that should be assessed include the six perfusion parameters (mentation, heart rate, pulse rate, mucous membrane color, capillary refill time, extremity temperature), body temperature for pyrexia, wounds for signs of infection (e.g., discharge, odor, heat), and appropriate patient handling [28]. Patient handling involves following thorough hand hygiene, donning exam gloves during each patient interaction, and changing exam gloves between patients. Laboratory values to assess include the evaluation of white blood cells (WBCs) through either the leukogram portion of a complete blood count (total WBC, complete differential, WBC morphology) or a manual WBC differential via blood smear [21]. If indicated, other lab values that can be assessed are culture and susceptibility. Infection control strategies include hand hygiene (e.g., washing with soap and water, antiseptic washing, using alcohol-based rubs, wearing exam gloves), environmental hygiene (e.g., cleaning of floors, clinical work surfaces, "high-touch" areas), isolation nursing (areas used for patients with known infectious disease), barrier nursing (areas used for patients with a high index of suspicion for infectious disease, known infection that's considered low contagious risk, or who need an increased level of vigilance to protect from infection), and antimicrobial stewardship [42].

Antibiotic drugs (antimicrobials) are among the most common medications prescribed for critically ill patients and are indicated when there is evidence of infection. The goal of antimicrobial therapy is to safely eliminate infection by practicing antimicrobial stewardship to minimize antimicrobial resistance [41, 43]. Refer to Chapter 8: "Introduction to Feline Pharmacology," for further information.

10.3.16 Wound Care and Bandages

In relation to critical illness, there are three primary types of wounds that patients need care for, traumatic, incisional, and insertion. The predominant goal in wound healing is to preserve viable tissue, restore damaged tissue to normal, provide an environment that promotes healing, facilitate closure, and minimize or prevent infection [44]. Wound care for traumatic sites involves carefully clipping the area around the wound, aseptically cleaning the wound, and fully lavaging to prevent further contamination [45]. Wound care of incisional sites involves daily inspection for signs of infection or dehiscence, which include redness, discharge, odor, or warmth to the touch [45]. Wound care of insertion sites involves daily care and

inspection of patient-invasive devices (e.g., peripheral or central IV catheters, feeding tubes, urinary catheters, thoracostomy tubes, abdominal drains, and wound drains).

Bandaging involves the application of dressing material to wounds, which varies based on the type of wound being addressed. The goals of bandaging are to provide a warm and moist environment to facilitate wound healing, protect the wound from additional contamination, provide compression to alleviate edema and hemorrhage, and stabilize or immobilize the injured area to prevent the disruption of the healing process [44]. For traumatic wounds, the three bandage layers include the primary layer (direct contact), the secondary layer (padding and absorbent), and the tertiary layer (securing and protectant) [45]. For incisional sites, bandages are applied as a topical dressing using only a nonadherent primary layer and adhesive tertiary layer [46]. For insertion sites, the bandage dressing will depend on the invasive device.

Monitoring of wounds includes the assessment of patient parameters (heart rate, respiratory rate, blood pressure, fluid balance, nutritional status), evaluation of the immune system response (e.g., leukogram), and daily evaluation of the wound, incision, or insertion site for signs of infection [44, 45]. Monitoring of bandages and dressings includes assessment of the patient (e.g., mobility, comfort) and daily evaluation of the bandage or dressing for signs of malpositioning, tightness, strike-through, or soiling from bodily fluids, any of which would require changing of the dressing/bandage [46]. Whenever handling any wound or bandage/dressing, the veterinary technician should always wear exam gloves. Refer to Chapter 13: "Wound Care and Bandaging," for further information.

10.3.17 Drug Dosage and Metabolism

The goal of drug therapy in critically ill patients is to induce a desired pharmacological response over time [47]. In critically ill patients, understanding the pharmacokinetics and pharmacodynamics of drugs provides a better understanding of drug therapy orders in relation to the patient's disease process.

Pharmacokinetics refers to how drugs move within the body through the processes of absorption, distribution, metabolism, and excretion. Absorption refers to the movement of a drug from the site of administration (e.g., IV, IM, SQ, and PO) to the systemic circulation. Factors that affect absorption include rate of drug absorption, extent of absorption, and bioavailability of the drug once in the systemic circulation [48]. Distribution refers to the movement of a drug from the systemic circulation to the intended site of action to produce a physiologic effect. Factors that affect distribution include regional blood flow, drug-tissue binding, transport proteins, and drug solubility [48]. Metabolism refers to the biotransformation of a drug through specialized enzymatic systems, primarily via the hepatic system. Factors that affect biotransformation include hepatic blood flow and protein binding of a drug [48]. Excretion refers to the movement of a drug out of the body, primarily via the renal system. Factors that affect excretion include renal blood flow, glomerular filtration rate, and transport proteins [48].

Pharmacodynamics refers to what a drug's physiological effect is on the body. The degree of response to a drug is determined by the concentration of the drug in the body and the affinity of the drug for its target receptors [47]. Factors that affect pharmacodynamics include receptor sensitivity, receptor binding, and biochemical interactions [48].

When it comes to monitoring drug dosage and metabolism, the factors the veterinary technician needs to assess include drug response, drug interactions, adverse drug reactions, and the drug therapy plan [20]. The patient needs to be assessed to see that the appropriate and expected response occurred following the administration of a drug (e.g., if an antiemetic is administered, the patient should no longer be vomiting). When patients are receiving multiple drugs (as is the case with most critically ill patients), each drug needs to be reviewed for compatible versus incompatible interactions with other drugs as well as interactions within the body. The patient also needs to be assessed for adverse drug reactions in which an undesirable or unexpected effect occurs (e.g., allergic reaction). Evaluating a patient's drug therapy plan involves the daily review of the patient's weight, drug orders (doses, frequency), and adjustments (e.g., recalculation based on weight changes, changes in dose or frequency for patients with hepatic or renal disease, de-escalation, discontinuation). Refer to Chapter 8: "Introduction to Feline Pharmacology," for further information.

10.3.18 Pain Control

Pain is defined by the International Veterinary Academy of Pain Management as an unpleasant sensory and emotional experience associated with actual or potential tissue damage [49]. Pain control is of critical importance because, if left unidentified or untreated, it leads to greater morbidity, mortality, and patient suffering.

The pathophysiology of pain is a neurophysiological event that involves a noxious stimulus, nociceptors (receptors of pain), and nociception (the pain pathway) [50]. Refer to Chapter 7: "Analgesic Considerations for the Feline Patient," for further information.

When it comes to monitoring critically ill patients for pain, veterinary technicians need to be able to recognize and assess pain so that it can be appropriately alleviated. Pain has traditionally been underrecognized in cats due to their natural instincts to hide or mask their pain, making it more challenging to assess [49]. Subsequently, recognition of pain in cats has shifted from evaluating classic physiological signs (e.g., tachycardia, tachypnea, hypertension) to the evaluation of behavioral signs. Behavioral signs of pain include changes in attitude or demeanor (e.g., aggression), changes in daily habits (e.g., lack of grooming, over-grooming, hiding, sleeping patterns, litterbox use), body posture (e.g., gait, hunching, lack of stretching, tail flicks), lack of movement (e.g., reluctance to jump onto furniture, cat trees, window sills), facial expression (e.g., squinty eyes, flattened ears, whisker position), vocalization (e.g., excessive meowing, growling, hissing), and restlessness [49–51]. Assessment of pain is most accurately done using pain-scoring tools because they provide a means of objectivity. A pain score helps determine if the pain is being managed appropriately or if additional pain relief therapies are needed and should be included with the evaluation of other vital parameters. When advocating for pain control, a multimodal approach should be taken. Refer to Chapter 7: "Analgesic Considerations for the Feline Patient," for further information.

10.3.19 Nursing Care

As stated previously, patient care is a fundamental role that veterinary technicians fulfill. When it comes to caring for critically ill patients, providing nursing care using Kirby's Rule of 20 requires the veterinary technician to use the checklist to ensure that all aspects of patient care are addressed. Kirby's Rule of 20 provides an organized approach to assess and monitor vital parameters and utilize critical thinking skills by evaluating the patient as a whole. Part of nursing care also includes medical record keeping and patient handoff to have effective communication between the veterinary team.

Medical record keeping (also referred to as charting) is the meticulous documentation of the care a critical patient receives. It is essential that charting be done well because a patient's medical record is considered a legal document. An accurate medical record is needed to show the patient's current and previous status and to assess future needs. Entries should be legible, free from spelling or grammatical errors, and contain detailed and straightforward statements of the medical facts related to the patient. Checkboxes are often used as a means of recording information (e.g., treatment orders, treatment sheets, discharge instructions). When using checkboxes, staff initials should be placed in the box rather than checkmarks or an "X" to allow for greater accountability. While checkboxes can save time, they lack the ability to fully describe a patient's condition and, therefore, should not be used alone. Patient specifics from a veterinary technician's assessment are an integral aspect of patient care and should be documented as a technician note in the medical record to better reflect the details of care provided. Technician notes should be made following every patient interaction to have a thorough record of a critical patient's status throughout their hospitalization.

Patient handoff is defined as the exchange of patient information between care providers [10]. Patient handoff is mostly performed at shift changes and involves communication between the outgoing and incoming veterinary technicians. The information exchanged should focus on what is pertinent to the care that is going to be provided during the next shift rather than an in-depth, detailed review of information that can be referenced in the medical record if needed. The pertinent information to include in handoff is the patient's signalment, presenting complaint (date of admission), working or definitive diagnosis, daily progress update, general attitude, diagnostics, current medications, appetite or food preference, owner communications, and advanced directive status [10]. Approaching each patient in a regular, repeatable fashion develops a routine that reduces the chance of information being overlooked or omitted. When performing patient handoff, the veterinary technician should spend around one to three minutes per hospitalized patient [10]. The ideal handoff method includes having time set aside or worked into the shift schedule, having all technicians who are involved in hospitalized patient care be present, being cage-side when discussing each patient, and taking written notes in addition to the verbal process [10].

10.3.20 Tender Loving Care

Tender loving care (TLC) encompasses all nursing care that goes above and beyond written patient care. In general, allowing the patient to see the veterinary technician and hear their voice prior to approaching the kennel helps to avoid a startled patient response. Taking a slow, gentle approach when handling patients and speaking softly and kindly can help minimize fear, stress and anxiety that can develop in a hospital setting.



Figure 10.7 Patient receiving TLC by having soft and plush bedding and rolled over to enjoy belly rubs. *Source:* Courtney Waxman.

The technician–patient relationship is greatly enhanced when patients are provided TLC. Examples of TLC include giving soft and plush kennel bedding (Figures 10.7 and 10.8), providing a place to hide (e.g., box, privacy screens), warming up food and/or hand-feeding, maintaining patient cleanliness, turning off the treatment room lights at night to allow rest, bundling treatments (when the patient's status allows), interacting with the patient during off-treatment times, providing one-on-one love and attention to promote the human–animal bond, and facilitating owner visitations. In the author's experience, approaching each patient with the mindset of treating them as a pet rather than a patient allows for more meaningful patient care experiences.



Figure 10.8 Patient receiving TLC by having a towel rolly bed. *Source:* Courtney Waxman.

10.4 Critical Thinking

Critical thinking is the intellectually disciplined process of conceptualizing, analyzing, synthesizing, and applying information that is generated by observation, experience, reflection, reasoning, and communication [10]. Critical thinking skills enable veterinary technicians to apply the concept of Kirby's Rule of 20 in an organized method to assess and monitor vital patient parameters in critically ill patients as well as provide standardized, evidence-based complete nursing care. An understanding of disease physiology, a knowledge of pharmacology, an ability to interpret diagnostic results, the skillset to perform advanced procedures, and a keen sense of observation combine to create the critical thinking skills required for critical patient care.

The responsibility of the veterinary technician is to work as part of a cohesive team for the benefit of the patient. A systematic approach to patient care is essential, and Kirby's Rule of 20 provides a framework for evaluating the patient, anticipating potential complications, and recognizing important changes in clinical status [10]. By going through the Kirby checklist, technicians can think about each parameter in relation to the patient's critical illness and in relation to each other, as many parameters are associated with others (e.g., fluid balance and acid–base, oxygenation and RBCs, electrolytes and heart rhythm, nutrition and glucose, immune status and wound care). The Kirby checklist also pushes technicians to think beyond the primary disease process and the clear parameters it involves, and think about other parameters that can be affected but are not as obvious. For example,

- Urinary obstruction clearly involves the renal system, fluid balance, electrolytes, and acid-base parameters. It can also affect the heart rhythm (atrial standstill from hyperkalemia), blood pressure (from reduced renal blood flow), RBCs (dysfunction of erythropoietin hormone production from the kidneys), nutrition (need for a low protein diet), glucose (dysfunction in solute regulation), wound care (urinary catheter insertion site), and drug dosage and metabolism (altered excretion) parameters.
- Diabetic ketoacidosis clearly involves the glucose, fluid balance, electrolytes, and acid-base parameters. It can also affect the mentation (altered LOC from hyperglycemia), ventilation (increased respiratory rate as a compensatory response to acidosis), GI motility and integrity (nausea, vomiting), nutrition (anorexia, need for a low carbohydrate diet), and renal function (PU and PD) parameters.

Critical thinking involves not just having knowledge and observational skills but asking intelligent questions and using past patient experiences to come to conclusions. Even though technicians cannot change treatment instructions, add or remove medications, or make a diagnosis, they can still be well-informed about all aspects of a patient's treatment plan, including the reasoning behind medical orders. One of the best questions to ask, which helps cultivate critical thinking skills is why. Why is this medication indicated? Why is this diagnostic test chosen over another? Why is this procedure the best option? Why has the patient developed an arrhythmia? Why would fluids be contraindicated for this patient? As we learn more about a patient, their disease process, and their treatment plan, we gain a deeper understanding of various aspects of patient care.

Critical thinking is a vital skill that technicians should be practicing every day to become a better caregiver and patient advocate.

In the veterinary hospital setting, patient care checklists can be used to optimize patient care quality and standards. Research into the use of patient checklists in veterinary medicine is still developing; however, the benefits published so far suggest that checklists can improve overall patient outcomes and reduce morbidity and mortality. Veterinary technicians are the patient's primary caregivers and are involved in assessing and monitoring critically ill feline patients. The Kirby Rule of 20 patient care checklist is a tool that veterinary technicians can use to approach caring for a critical patient. Having a thorough understanding of each of the parameters enables veterinary technicians to prioritize patient needs by assessing the overall clinical picture and applying critical thinking skills.

See the companion website for further clinical references.

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11

Interpretation of Common Diagnostics Test Results

Ann Wortinger, BIS, LVT, VTS (ECC) (SAIM) (Nutrition), Elite FFCP

TECHNICIAN TIDBITS

- Binocular, compound light, or digital microscopes are the most common.
- Red blood cell (RBC) parameters include RBC count, packed cell volume, and hemoglobin.
- RBC indices include mean corpuscular volume, mean corpuscular hemoglobin, and mean cell hemoglobin concentration.
- Feline RBCs are smaller than canine RBCs.
- Rouleaux is common.
- Albumin is synthesized in the liver.
- Globulin is a calculated value.
- Enzymes catalyze chemical reactions.
- Symmetric dimethylarginine can detect loss of kidney function sooner than blood urea nitrogen.
- Enzyme-linked immunosorbent assay is the most common immunologic test performed in-house.
- Urine-specific gravity has no units.
- Centrifugation is the gold standard for intestinal parasite detection.

One of the areas where a technician can be fully utilized is in the laboratory, whether this is running the tests for in-house analysis or submitting samples to an outside laboratory for evaluation. As we are often the first people to see the test results, understanding what we are seeing is vitally important to patient care. Routine care and maintenance of our equipment are important for the smooth running of the laboratory, and ensuring our results are as accurate as possible.

11.1 Use of a Microscope

Even in the smallest in-house laboratory, a high-quality binocular, compound light microscope is essential. It may be used to evaluate blood, urine, exudates and transudates, other body fluids, feces, and other miscellaneous specimens. It also may detect internal and external parasites and initially characterize bacteria. Ideally, the practice should maintain two microscopes. One should be used for performing routine parasite studies and procedures that use corrosive or damaging materials, such as fecal. The second microscope should be reserved for use with cytology and hematology evaluations [1].

A compound light microscope is so named because it generates an image using a combination of lenses. Compound light microscopes have many components and a light path. The mechanical stage holds a glass slide to be evaluated. The microscope should have a smoothly operating mechanical stage to allow easier sample manipulation. Left- or right-handed stages are generally available. Coarse- and fine-focus knobs are used to focus the image of the object being viewed [1] (Figure 11.1).

The compound light microscope consists of two separate lens systems, the ocular system, and the objective system. The ocular lenses are located in the eyepieces and most often have a magnification of 10×. This means that the ocular lens magnifies an object 10×. A monocular microscope has one eyepiece, whereas a binocular microscope, the most commonly used type, has two eyepieces. A binocular head is needed for almost all routine laboratory evaluations. Most compound light microscopes have three or four objective lenses, each with a different magnification power. The most common objective lenses are 6× (scanning), 10× (low power), 60× (high dry), and 100× (oil immersion) [1].

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Figure 11.1 Binocular microscope. *Source:* Trust "Tru" Katsande/UnSplash.

The total magnification of the object being viewed is calculated by multiplying the ocular magnification power by the objective magnification power. For example, an object viewed under the 40× objective through a 10× ocular lens is 400 times larger in diameter than the unmagnified object [1].

The microscope head supports the ocular lenses and may be straight or inclined. A microscope with an inclined head has ocular lenses that point back toward the user. This minimizes bending over the microscope to look through the lenses. The nosepiece holds the objective lenses and should always rotate easily and provide ready access to the objective lenses for cleaning [1].

When viewed through a compound light microscope, an object appears upside down and reversed. The actual right side of an image is seen as its left side, and the actual left side is seen as its right side. The movement of the slide by the mechanical stage is also reversed. Travel knobs are used to move the glass slide and thus the object is moved. When the stage is moved to the left, the object appears to move to the right [1].

The substage condenser consists of two lenses that focus light from the light source onto the object being viewed. Light is focused by raising or lowering the condenser. Without a substage condenser, haloes and fuzzy rings can appear around the object. The aperture diaphragm is usually an iris type, consisting of several leaves that are opened or closed to control the amount of light illuminating the object [1].

In modern microscopes, the light source is contained within the microscope. The most common light sources found on compound light microscopes are low-voltage tungsten lamps or higher-quality quartz halogen lamps. The light source can be in the base or separate and should have a rheostat to adjust intensity [1].

11.2 Care and Maintenance of a Microscope

Regardless of the features of the individual microscope, care must be taken to follow the manufacturer's recommendations for use and routine maintenance. Only high-quality lens tissue paper should be used to clean the lenses, use of other products have the potential to scratch the optics. If cleaning solvent is needed, a specially formulated lens cleaning solution or methanol can be used. Care needs to be exercised to prevent the use of excessive oil on the 100× objective or dragging the other objective lenses through the oil on a slide. The microscope should be wiped clean after each use and kept covered when not in use. The eyepiece is cleaned with lens paper [1]. Cleaning and adjustment by a microscope professional should be performed at least annually.

Locate the microscope in an area in which it is protected from excessive heat and humidity. With proper care, a high-quality microscope can last a lifetime. The microscope should be placed in an area where it cannot be moved frequently, jarred by vibrations from centrifuges or slamming doors, or splashed with liquids. It must be kept away from sunlight and drafts.

If you need to move the microscope, it is carried with both hands, one hand securely under the base and the other holding the supporting arm.

Digital microscopes are also available that allow recording of the viewed images onto a computer. This can be a helpful visual aid for many clients regarding parasites. Digital microscopes can replace one eyepiece with a camera that attaches to the computer, or the entire microscope can be digital.

11.3 Interpretation of Common Diagnostic Tests

11.3.1 Complete Blood Count

Instrumentation designed for veterinary hospital use is available to facilitate the generation of hematologic data for the complete blood count (CBC). Options are cost-effective and convenient in situations in which at least several CBCs are performed daily. Benefits of instrumentation include reduced labor investment, more complete information, and improvement of data reliability. Individual users are responsible for becoming familiar with the detailed documentation accompanying specific instruments [2].

The three basic red cell parameters, red blood cell count (RBC), packed cell volume (PCV), and hemoglobin (Hb) concentration, are necessary to see if there is evidence of anemia or RBC destruction. The red cell indices, mean cell volume (MCV), mean cell hemoglobin amount (MCH), and mean cell hemoglobin concentration (MCHC), have been used for morphological classification of anemia, but blood smear evaluation is a more reliable indicator of RBC changes. Reticulocyte count is necessary to classify anemia into regenerative and nonregenerative. It is important to remember that the reticulocyte count is not a percentage but should be evaluated as an absolute count [3].

White cell parameters include the total white cells (WBC) and those of each cell type. The differential white cell is expressed as a percentage of the total WBC count, and the absolute numbers give the actual number of each cell line found in a specific volume of blood, typically a microliter (i.e., μl). The platelets are also counted as absolute numbers by automated CBC machines and as an estimate on a manual differential. Automated counts often underestimate feline platelets because of the frequent platelet clumps found in cats [3] (Figure 11.2). The feline eosinophil has distinct red granules, which can help differentiate it from the segmented neutrophil (Figure 11.3).

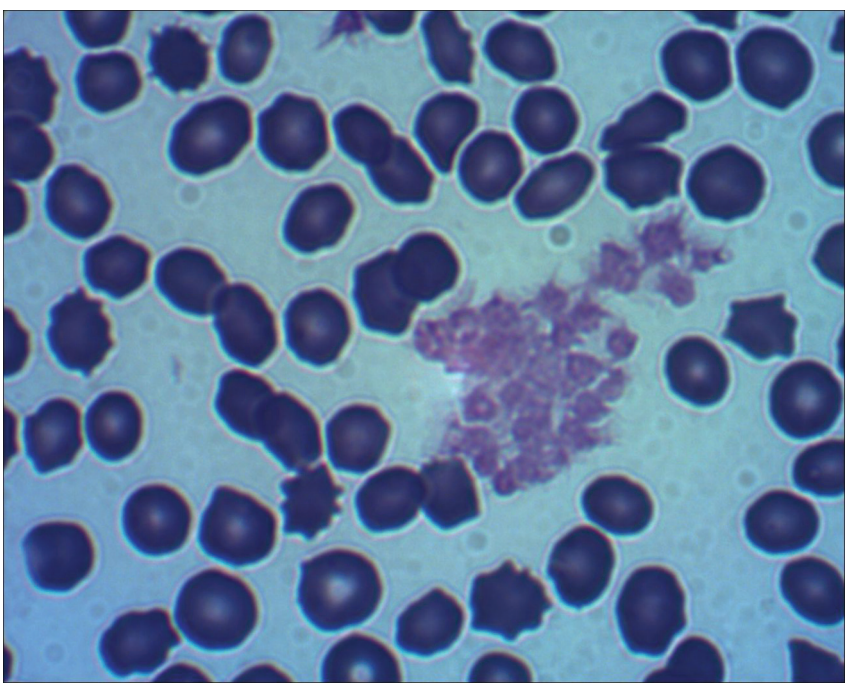


Figure 11.2 Feline platelet clumping on a differential smear. *Source:* Ann Wortinger.

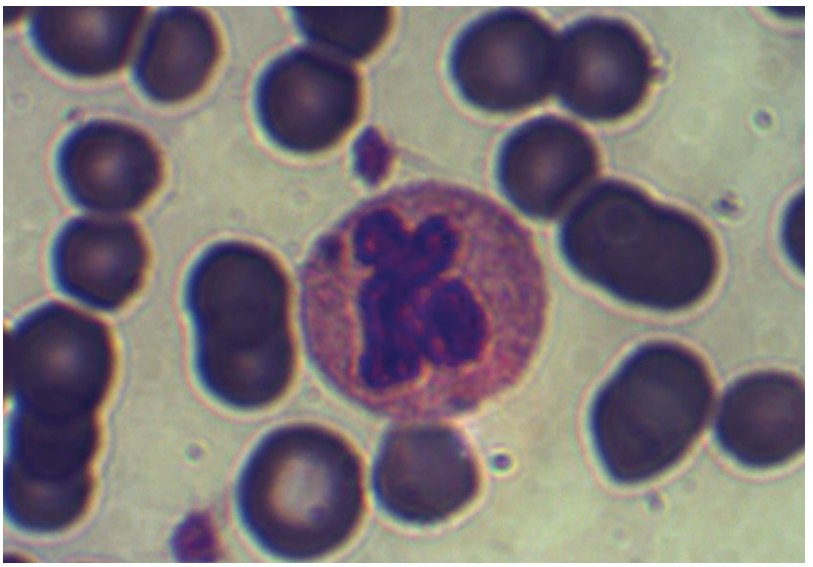


Figure 11.3 Feline eosinophil with characteristic pink/red granules. *Source:* Ann Wortinger.

11.3.1.1 Packed Cell Volume

The PCV is another vital part of the CBC. The PCV, also known as the microhematocrit (μHCT), is an expression of the percentage of whole blood occupied by RBCs. The PCV assay is usually performed with the μHCT technique [2]. After spinning in a high-speed centrifuge, the blood separates into a plasma layer, a white buffy coat composed of WBCs and platelets, and a layer of packed red cells. Measuring the RBC layer, typically using a PCV card in the capillary tube determines the PCV. Note that the buffy coat is not included in the PCV. The precision of a PCV is approximately 1%, making it a very accurate test [2] (Table 11.1).

The reason why we need to evaluate the μHCT tube when conducting a CBC even though the automated CBC machine would generate all the necessary information regarding the blood cells is to serve as a monitoring device for the automated CBC machine. Red cell data is provided as a hematocrit, and the white cell data is provided as a buffy coat assessment. Also, the CBC should include some evaluations of plasma components such as total plasma protein concentration (TP) and plasma color. The TP is important to follow because it provides valuable information regarding dehydration status or blood loss [3].

Table 11.1 Normal feline CBC and PCV values [2, 4, 5].

Test	Normal feline values
PCV	30–45%
Hemoglobin	8–15 g/dl
TS/TP	6.6–8.4 g/dl
Albumin	3.2–4.3 g/dl
Globulin	2.9–4.7 g/dl
RBC count	$6.0–10.2 \times 10^6$ cells/μl
MCV	39–55 fl
MCH	13–20 pg
MCHC	30–36 g/dl
WBC count	$5.5–19.5 \times 10^3$ cells/μl
Reticulocyte	0–0.4% (aggregate) 1.5–10% (punctate)

A normal PCV in a cat is 30–45% [2]. A low PCV may indicate anemia. There are many causes of anemia, including blood loss, neoplasia, parasitism, and chronic infection. An increased PCV also has several possible causes, including dehydration and splenic contraction in an excited, or stressed cat. PCV values may be erroneously high because of clots in the sample, failure to mix the ethylenediaminetetraacetic acid (EDTA) and blood adequately, and insufficient centrifugation time. PCV values may be erroneously low if the μHCT tube contains excessive plasma because of inadequate mixing of the sample. Sample dilution because of a low blood-to-anticoagulant ratio may also cause an artificial decrease in the PCV [2].

After determining the PCV, the plasma is evaluated for turbidity and color. An icteric, or yellow, plasma layer may be seen with liver disease or hemolytic anemia. A hemolyzed, or red, sample can happen with improper sample collection and handling or with hemolytic anemia, where the RBCs rupture and release hemoglobin into the bloodstream. A red-tinged buffy coat can be seen, especially in very sick cats or if there is an increased number of immature RBCs in the circulation. Lipemic plasma appears cloudy (turbid) and white, indicating excessive lipids, specifically triglycerides in the blood. This can occur if the blood was collected from a cat that was not fasted, or it may be pathologic, as with pancreatitis. Icterus, hemolysis, and lipemia may be quantified as slight, moderate, or marked. The width of the buffy coat should be assessed and reported as a percent of the total hematocrit tube [2].

11.3.1.2 Red Blood Cells

Feline RBCs are smaller than canine RBCs with an average size of 6 μm in diameter. Their shape is cup-shaped rather than the biconcave disc seen in dogs, with a lack of central pallor [5]. Rouleaux, or a stacking of RBCs is common in cats and is not seen as any pathology (Figure 11.4). The hemoglobin found in feline RBCs is more susceptible to oxidative injury when compared to other species. Feline hemoglobin is composed of eight oxidizable sulfhydryl groups, compared to 2–4 in other species. When this hemoglobin undergoes oxidative damage, it is denatured and precipitates onto the surface of the RBCs. We see this precipitation as Heinz bodies. Low numbers (<10%) of single Heinz bodies can be found in normal RBCs [5]. The average life span of a feline RBC is 65–76 days, with rouleaux seen commonly.

Changes in the appearance of erythrocytes occur in a variety of conditions. In general, these changes fall into one or more of the following categories: (1) changes in size, (2) changes in shape, (3) changes in color, (4) changes in cell behavior, and (5) appearance of inclusions. A variety of blood parasites can also be seen on a peripheral blood film. Most of these are found on or within erythrocytes. Parasites may also be found free of cells and within phagocytic leukocytes [6].

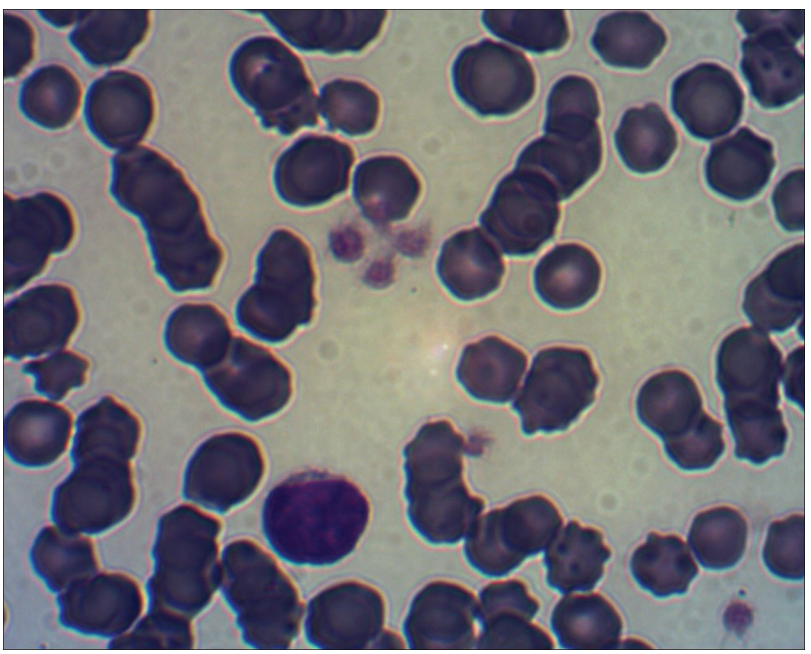


Figure 11.4 Feline erythrocytes showing typical rouleaux. This can be differentiated from agglutination by the regular single line of cells. *Source:* Ann Wortinger.

11.3.1.3 Red Blood Cell Indices

The RBC indices can be helpful in the classification of some anemias. The indices provide an objective measure of the size of the RBCs and their average hemoglobin concentration. Because these values are based on a single average RBC, the measurements obtained are very small. MCV, the average size of a RBC, is measured in femtoliters, which is 10^{-15}. Mean corpuscular hemoglobin, the average mean weight of hemoglobin in an average RBC is measured in picograms, which is 10^{-12}. MCHC is the concentration of hemoglobin in an RBC and is measured in g/dl [2].

While we are required to learn the formulas to calculate these while we are in school, in truth, if an automated CBC is done, these will be more accurately calculated by the machine.

11.3.1.4 Reticulocytes

Reticulocytes are immature RBCs that contain organelles that are lost as the cell matures. With Romanowsky-type stains (i.e., Diff-Quik), these organelles will give the cell a blue-gray color when compared to a mature RBC. When stained with new methylene blue (NMB) stain, these organelles will clump together into visible granules that are called reticulum. This reticulum can be seen as aggregates or chains (i.e., punctate) [6].

Reticulocytes give an objective measure of bone marrow production and are seen with regenerative anemia. Cats have two forms of reticulocytes, aggregate and punctate. The aggregate form is composed of large clumps of reticulum. The punctate form is unique to cats and contains two to eight singular, basophilic granules. Only the aggregate form of reticulocytes is counted during a manual count [4].

Reticulocyte count may be included with many automated CBC machines or done manually using whole blood and making a special smear [4]. The count is an expression of the percentage of RBCs that are reticulocytes. In normal, nonanemic cats, approximately 0.4% of the RBCs are reticulocytes. An equal amount of whole EDTA blood is mixed with the NMB stain and allowed to sit for a minimum of 15 minutes. A drop of the mixture is placed on a glass slide and a blood smear is made in the normal manner. The sample will be thin, and the spreader slide angle should be adjusted to compensate for this [4].

Regenerative anemia will show nucleated RBCs, Howell–Jolly bodies, anisocytosis, and polychromasia on a blood smear, and increased reticulocytes on special staining with a NMB stain. Nonregenerative anemia would show none of these signs seen with increased bone marrow production. After a substantial blood loss, it does take the bone marrow 3–4 days to show signs of regeneration [4] (Table 11.1).

11.3.1.5 Total Solids/Total Protein (TS/TP)

Using a handheld refractometer, the serum or plasma total protein level can be rapidly and reliably measured. Obtaining an accurate plasma protein reading is difficult in lipemic samples because the turbidity produces an indistinct line of demarcation on the scale. Hemoglobinemia, or hemoglobin in the plasma, caused by hemolysis can falsely increase plasma protein levels because of the presence of the heme portion of hemoglobin, acting as additional protein in the plasma. The yellow color of an icteric sample does not interfere with refractometry [2].

Total serum protein concentrations include all plasma proteins except fibrinogen and other coagulation proteins that have been removed during the clotting process. Chemical analyzers also measure total protein concentration [2].

Serum protein levels are affected by the efficiency of absorption through the intestines, the rate of protein synthesis in the liver, the rate of protein catabolism in the cat, loss through the kidneys, hydration status, and alterations in the distribution of proteins in the body. Dehydrated cats usually have elevated total protein values; overhydrated cats usually have decreased total protein values. Do not use lipemic samples, especially if the refractometric method is used [2].

11.3.2 Chemistry Panel with Electrolytes

Biochemistry profiles, or groups of tests, are routinely performed in-house or in reference labs using serum as the preferred sample type, although heparinized plasma may also be used with some analyzers. The use of plasma has the advantage of not plugging up the machine's pipettes with fibrin clots. Valuable diagnostic information can be obtained by determining the levels of the various chemical constituents in blood. The enzymes being measured are produced in association with particular organ functions or metabolites and metabolic byproducts, and these can be used to determine organ function [7] (Table 11.2).

Table 11.2 Normal chemistry values in cats [8–10].

Test	Normal feline values
Glucose	58–120 mg/dl
AlkPhos	16–65 U/L
ALT	25–97 U/L
AST	7–40 U/L
Amylase	280–1200 U/L
Lipase	0–83 U/L
Feline pancreatic lipase immunoreactivity [10]	<3.5 μg/L negative 3.6–5.3 μg increased >5.4 μg positive
Blood urea nitrogen	18–34 mg/dl
Creatinine	0.7–2.2 mg/dl
SDMA	Below 15 μg/dl
Sodium (Na)	140–159 mEq/L
Chloride (Cl)	105–130 mEq/L
Potassium (K)	3.5–6.1 mEq/L
Phosphorus (PO^4)	2.5–7.3 mEq/L
Fructosamine [8]	190–365 healthy cats 350–400 excellent control 400–450 good DM control 450–500 fair DM control >500 poor control

11.3.2.1 Glucose

The blood glucose level is used as an indicator of carbohydrate metabolism in the body, and it may also be used as a measure of the endocrine function of the pancreas, dependent on the production and response to insulin. The blood glucose level reflects the net balance between glucose production (e.g., dietary intake, conversion from other carbohydrates) and glucose utilization, which involves expended energy and conversion into other products. It also may reflect the balance between blood insulin and glucagon levels. Glucose levels can fluctuate significantly due to a variety of factors, including meal timing, nutritional status, and stress. An individual blood glucose measurement reflects the level present at the time the sample was collected and should not be used to adjust exogenous insulin administration [11].

Glucose utilization depends on the amount of insulin and glucagon produced by the pancreas.

Serum and plasma for glucose testing must be separated from the RBCs immediately after blood collection. Glucose levels may drop 10% per hour if the sample of plasma is left in contact with erythrocytes at room temperature. Even the use of a serum separator tube may not be adequate to prevent this. Mature erythrocytes use glucose for energy, and, in a blood sample, they may decrease the glucose level enough to give false-normal results if the original sample had an elevated glucose level [11].

11.3.2.2 Albumin

Albumin is one of the most important proteins in plasma or serum. It makes up approximately 60–66% of the total serum protein concentration. The liver synthesizes albumin. Albumin levels are also influenced by dietary intake, loss of renal disease, and intestinal protein absorption. Albumin functions as a transport and binding protein of the blood and is responsible for maintaining the osmotic pressure in the circulatory system [2].

11.3.2.3 Globulin

Globulins are a complex group of proteins that include all the proteins (plasma or serum) other than albumin and coagulation proteins. The globulins are separated into three major classes by electrophoresis (e.g., passing an electric current through the sample to separate it into fractions): alpha, beta, and gamma globulins. The liver synthesizes most alpha and beta globulins. The gamma globulins (immunoglobulins) are synthesized by plasma cells and are responsible for the body's immunity provided by antibodies. Immunoglobulins identified in animals include immunoglobulin G (IgG), IgD, IgE, IgA, and IgM [2]. Direct measurement of globulin is not usually performed. Globulin concentration is calculated by subtracting the albumin concentration from the total serum protein [7].

11.3.2.4 Enzymes

Enzymes are specialized proteins that catalyze various chemical reactions. Most enzymes work intracellularly at a specific pH and temperature. Enzymes are usually not present in high concentrations in the serum. Increased concentrations of enzymes in serum often indicate cellular damage. Enzyme assays usually involve measurement of the outcome of enzyme activity rather than specific measurement of the enzyme itself. Enzymes related to liver function in most mammals include phosphatases and transaminases [7].

11.3.2.5 Phosphatases

The primary phosphatases are alkaline phosphatases (ALPs). ALPs have multiple organ sources, including the liver, kidney, bone, and intestine. The extent of the increase aids in determining whether the patient has intrahepatic or extrahepatic damage. The ALP assay is most often used to detect cholestasis (e.g., slowing of bile movement through the liver) in cats. ALP levels can be increased in young, growing cats because of bone remodeling and increases in the bone isoenzyme level [7].

11.3.2.6 Transferases

This group of enzymes is found primarily in tissues that have high rates of protein metabolism, especially the kidney, liver, and muscle. In cats, the transferases of clinical significance are alanine aminotransferase (ALT) and aspartate aminotransferase (AST).

ALT is a liver-specific enzyme and a good indicator of hepatocellular damage in cats because the primary or major source of serum ALT is the hepatocyte. Damage to hepatocytes results in the release of large amount of ALT [7].

11.3.2.7 Amylase

Amylase is produced in a variety of tissues including the small intestine and the pancreas; however, cats do not produce salivary amylase. Amylase is responsible for the breakdown of carbohydrates into glucose. Increased levels of amylase can occur with acute pancreatitis, flare-ups of chronic pancreatitis, and obstruction of the pancreatic ducts [11].

11.3.2.8 Lipase

Lipase functions to break down the fatty acids of lipids. Elevations in lipase can be seen with pancreatitis; however, there are also nonpancreatic factors, such as chronic renal failure, exploratory surgery, and corticosteroid use that can cause increased levels. Almost all serum lipase is derived from the pancreas. Excess lipase is easily filtered through the kidneys, so lipase levels tend to remain normal in the early stages of pancreatic disease. Gradual increases are seen as the disease progresses [11].

Previously, serial determination of both amylase and lipase was used to diagnose and manage pancreatitis in cats. The species-specific feline pancreatic lipase immunoreactivity is a more accurate determinant of pancreatitis [11].

11.3.2.9 Kidney Function Tests

11.3.2.9.1 Blood Urea Nitrogen

The primary kidney function tests are the determination of urea nitrogen and creatinine levels. Blood urea nitrogen (BUN is the principal product of protein catabolism. Normally, all urea passes through the glomerulus in the kidney, and approximately 50% is resorbed by passive diffusion. An increase in levels of BUN (i.e., azotemia) and other nonprotein nitrogenous wastes can occur when blood flow through the kidneys alters the glomerular filtration rate or when the urinary tract is

obstructed. Dehydration will also result in azotemia because urea must be excreted in a large amount of water. BUN levels can be very dynamic and may not accurately reflect actual kidney function [12].

11.3.2.9.2 Creatinine

Creatinine is produced from the metabolic breakdown of phosphocreatine in muscle tissue. The daily rate of creatinine production is relatively constant in any animal and is dependent on muscle mass. Creatinine is also primarily cleared by the kidney. Glomerular filtration is the primary mode of elimination. Creatinine is used to evaluate renal function based on the ability of the glomeruli to filter creatinine from the blood and eliminate it in urine. Similar to BUN, if serum creatinine values are increased because of decreased renal function, this indicates that approximately 75% of the nephrons are nonfunctional. Because creatinine is less dynamic than BUN, it will more accurately reflect actual kidney function [12].

11.3.2.10 Electrolytes

Electrolytes are minerals that exist as positively charged or negatively charged particles in an aqueous solution. Positively charged particles are called cations and negatively charged particles are called anions. These particles function primarily in the regulation of acid-base and osmotic balance of the body. The primary method for electrolyte evaluation involves the use of ion-specific electrodes. Automated ion-specific instruments are readily available for in-house use as part of the chemistry panels [13].

The electrolytes that are most commonly measured are sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{2+}), inorganic phosphorus (PO_6^{-2}), and magnesium (Mg^{2+}). Electrolytes can be measured using serum or heparinized plasma. It is important to remember that different salts of heparin are available; lithium heparin, sodium heparin, potassium heparin, and ammonium heparin. Lithium heparin is the preferred anticoagulant when measuring electrolytes, as the use of other salts can contribute to a false elevation in that specific electrolyte [13].

11.3.3 Special Chemistry Tests

11.3.3.1 Fructosamine

Fructosamine represents the irreversible reaction of glucose bound to protein, particularly albumin. When glucose concentrations are persistently elevated in the blood, as occurs in patients with diabetes mellitus, the increased binding of glucose to serum proteins occurs. The finding of increased fructosamine indicates persistent hyperglycemia over 1–2 weeks. Fructosamine provides an indication of the average plasma glucose over that period [11].

11.3.3.2 Symmetric Dimethylarginine

Symmetric dimethylarginine (SDMA) is a sensitive and early marker for decreasing renal function, showing changes before those seen with creatinine, allowing earlier detection of acute kidney injury and chronic kidney disease. SDMA is an amino acid produced when protein is broken down and excreted through the kidneys. It is a renal biomarker that is specific to kidney function shown to correlate with glomerular filtration rate in cats. Unlike BUN or creatinine, it can be detected with 40% loss of kidney function, and as early as 25% loss. SDMA is less impacted by external factors, such as body condition, age, disease, and lean body mass. It is produced by all nucleated cells at a constant rate, with no apparent reabsorption in the renal tubules. Research has shown a good correlation between SDMA and glomerular filtration rate [14].

11.3.3.3 Blood Glucose Curve

Measuring blood glucose is commonly done for the management of diabetes mellitus. Previously, in-house blood curves were done, but these tests are not ideal for determining how the cat is responding to the exogenous insulin administration, as stress and not eating can negatively affect the test results. Serial blood glucose measurements using hand-help glucose monitors at home can provide more reliable readings for the in-home environment for clients and cats that are willing to do this (Figure 11.5).

More recently, interstitial glucose monitors originally designed for diabetic humans have entered the veterinary market. These are marketed as continuous glucose monitoring (CGM) and use a small probe inserted through the skin to provide continuous glucose readings for a period of up to 14 days [8]. These devices are often less expensive than the cost of an in-house glucose curve and provide much more reliable results. The technician needs to be aware that there is a lag in the readings between the value found in the interstitium and the value in the blood [8] (Figure 11.6).



Figure 11.5 An owner collecting blood for a glucose check from an ear prick. It is helpful to place a gauze or tissue under the ear flap to prevent more than one animal's blood from being collected. *Source:* Ann Wortinger.



Figure 11.6 Vinny demonstrates a continuous glucose monitor placement. *Source:* Ashley DiPrete, RVT, VTS (SAIM).

11.3.4 Blood Groups

RBC antigens are structures on the surface of RBCs that may react with antibodies in the plasma of another animal. The specific surface markers in an individual animal are genetically determined and are referred to as blood group antigens. Antigen–antibody reactions can occur with blood transfusions as a result of variations in blood group antigens between the recipient and the donor. These reactions usually result in the clumping or agglutination of RBCs, or they may manifest clinically as RBC lysis [15].

One blood group system has been identified in cats, and it has been designated the AB system. The blood groups of cats are A, B, and AB. Blood group AB is found in very few cats. In the United States, the majority of cats have group A blood. Type B blood is found in certain purebred breeds (e.g., Devon Rex, British Shorthair) and certain geographic areas among

the domestic cat population (e.g., Australia). Unlike dogs and humans, cats have naturally occurring antibodies to the erythrocyte antigen that they lack. This means that type B cats have strong anti-A antibodies circulating in their plasma, whereas type A cats have weak anti-B antibodies. Serious transfusion reaction and death can be seen when transfusing type B cats with type A blood. Thus, blood for transfusions in all cats should be selected by typing or cross-matching. Mik, which is another blood cell antigen, has also been described in cats [15].

Neonatal isoerythrolysis has been documented in type A and type AB kittens of type B queens with naturally occurring anti-A antibodies. This condition causes anti-A antibodies to be found in the colostrum that destroys the RBCs in the neonate. If the blood type of the mother is known ahead of the birth, the kittens can be blood-typed using placental cord blood, and those that are a different blood type from the mother can be prevented from nursing [15].

Several in-house cards and wand blood typing kits are available for use, as well as sending out samples to reference labs.

11.3.5 Immunologic Tests

Serologic testing is based on the ability to detect antibody–antigen interactions in the tested sample. Immunoassays usually contain monoclonal antibodies to an antigen or part of an antigen, such as a viral capsule or surface protein of a parasite, bacteria, or virus. The tests therefore detect that portion of the antigen for which the test kit manufacturer has created a specific antibody. A few tests detect circulating antibodies, rather than antigens, but these are used only when the antigen is not readily available for testing (Table 11.3).

Table 11.3 Diagnostic tests performed by reference laboratories [16].

Reference lab diagnostic tests	Methodology	Reporting	Tests
Antibody titers	The patient's serum is serially diluted to different concentrations. Diluted samples are tested for the presence or absence of antibodies.	Negative at the highest dilution where no antibody is present. 1:2, 1:40, 1:160, etc.	Common vaccinations (panleukopenia, rabies, coronavirus, calicivirus).
Polymerase chain reaction	Identification and replication of a DNA segment. Detects the presence of specific antigens.	Reported as detected (positive) or absent (negative).	Feline upper respiratory tract diseases (herpesvirus, calicivirus, chlamydia, mycoplasma) inherited disease screening, and parentage verification
Immunodiffusion	Uses an agar plate with wells cut into it. Wells contains either a patient sample, positive control, or negative controls.	The presence or absence of precipitation forms where diffusing antigens and antibodies meet in the agar. Positive or negative for antibody tested	Histoplasmosis, quantification of serum immunoglobulin IgG
Radioimmunoassay	Similar to ELISA testing except a radioisotope is used in place of the conjugate.	Detects either antibodies or antigens. The level of radiation detected corresponds to the volume of the antigen or antibody.	Feline pancreatic lipase
Immunofluorescent antibody tests	Direct and indirect methods used. Direct uses a specific antibody, and indirect uses an unlabeled antibody. Requires a fluorescent microscope for viewing.	Anti-antibodies are tagged with a fluorescent label. When fluorescence is visible, the sample is positive when fluorescence is absent, the sample is negative.	Rabies, toxoplasma gondii, Bartonella henselae
Western blot	Uses gel electrophoresis to identify and separate proteins by molecular weight and length.	A substrate reacts with the enzyme that is bound to the antibody to generate a colored substance. The results are either positive or negative.	Feline immunodeficiency virus

11.3.5.1 Enzyme-linked Immunosorbent Assay

Enzyme-linked immunosorbent assay (ELISA) tests are the most common types of immunologic tests performed in veterinary clinics. Every ELISA test has the same basic components: solid phase, conjugate, and chromogen.

The solid phase may be a microwell, wand, flow-through membrane, or chromatographic strip. Conjugate reagents are embedded in the solid phase and usually consist of monoclonal antibodies bound to an enzyme. The chromogen is a photosensitive reagent that produces a color change in the test system. If a specific antigen is present in the sample, it will bind to the antibody on the test surface. After the appropriate incubation time, the patient sample is washed away. If the antigen has bound to the solid phase, it will not be washed away. Chromogen is then added that can react with the bound enzyme–antigen–antibody complex, if present, and produce a color change in the test system [16].

The diseases most commonly tested using the ELISA method include feline leukemia virus, feline immunodeficiency virus, pancreatitis, and heartworm disease.

11.3.5.2 Rapid Immunomigration Assay

The rapid immunomigration (RIM) test, also known as immunochromatography (ICT), is similar to the ELISA method except that gold staining or latex-coated beads are used to replace the chromogen. In these test formats, the conjugate is an antibody bound to colloidal gold or latex, instead of an enzyme. The solid phase of a RIM test is a chromatographic strip. Most RIM tests require a flow solution, usually a buffered saline, to aid in the movement of the sample across the chromatographic strip. The RIM method does not use temperature-sensitive enzymes, so the test kit can be kept at room temperature, instead of requiring refrigeration [16].

The RIM test is performed by adding the patient sample to the absorptive pad on the solid phase. The absorptive pad functions to absorb the sample and filter out solid substances, such as blood cells. The conjugate is released as the sample flows onto the solid phase. The sample and conjugate then pass across two test areas. The first test area, known as the patient line, contains antibodies to the antigen that the test is designed to detect. If the antigen is present in the sample, it will bind to the antibodies on the patient line. When that occurs, the conjugate also reacts and produces a color change on the patient line. The sample and conjugate continue to flow to the second test area. The second area is a control line that contains antibodies to the conjugate. A color change is produced on this line and indicates that the test is functioning correctly [16].

RIM testing is used most commonly with the RapidVet-H IC test for feline blood typing, feline leukemia virus, feline immunodeficiency virus, and feline heartworm.

11.3.6 Agglutination Test

Agglutination tests are used for the detection of antibodies to large particulate antigens. The test requires adding a specific antigen to the test sample. If the sample contains the antibody for that antigen, agglutination (clumping) occurs.

In some agglutination tests, the antigen may be coated with latex beads to induce agglutination reactions. Agglutination tests are usually performed on a slide. Latex agglutination is commonly used to determine blood types [16].

11.3.7 Urinalysis

Because the physical, chemical, and microscopic characteristics of a urine specimen begin to change as soon as urine is voided, urine specimens should be analyzed immediately after collection. Samples left at room temperature for 1 hour or longer will have increases in pH, turbidity, and bacteria and decreases in glucose, bilirubin, and ketone levels. If specimens are left at room temperature for longer than 1 hour, cells and casts may also disintegrate, especially in dilute alkaline urine, or urine color may change because of oxidation or reduction of metabolites. If analysis cannot be done immediately, refrigeration will minimize the deterioration of the specimen. The specimen should be brought to room temperature before testing.

A complete urinalysis has the following four parts:

1. Gross examination
2. Specific gravity (SG) measurement
3. Biochemical analysis
4. Sediment examination [17]

11.3.7.1 Gross Examination

A systematic approach is vital to achieving high-quality, reproducible results. The gross examination includes an evaluation of color, clarity, odor, and volume. Normal feline urine is light to medium amber-colored, clear, and has a characteristic odor. Normal urine output for feline patients is 8–12 ml/lb (18–28 ml/kg) in a 24-hour period [17].

11.3.7.2 Specific Gravity

SG is an indicator of the concentration of dissolved materials in the urine and provides an indication of kidney function and therefore, has no units. Alteration in the concentrating ability of the kidneys is an early indicator of renal tubular damage. The preferred method for determining SG is with the use of a refractometer. SG indicator pads on urinalysis dipstick tests may be unreliable in veterinary species. SG can be measured before or after centrifugation, as long as the procedure is always performed consistently in the clinic. Normal SG for cats is 10.35–1.60, with the higher end being outside the range for many refractometers [17].

11.3.7.3 Biochemical Testing

Dipsticks can be used to perform individual or multiple biochemical tests. Each reagent pad on the dipstick contains a reagent for one specific chemical test. The reagent pad changes color during the reaction, and the color is visually compared with a color chart. Always use well-mixed, room-temperature urine samples and perform biochemical testing before adding any chemical preservatives or stains. Because dipsticks are not configured for veterinary species, some tests (e.g., SG, nitrite, leukocyte) may be unreliable with some species. Most urinalysis dipstick tests provide indicator pads for protein, glucose, ketones, pH, bilirubin, and blood [18].

11.3.7.4 Microscopic Urine Sediment

The primary purpose of the microscopic examination of urine is to determine the presence of abnormally formed elements (e.g., cells, casts, crystals) in the sample. The presence of specific formed elements usually provides detailed diagnostic information to the clinician. The examination requires 5–10 ml of fresh urine, the more urine collected the more accurate the sediment results will be. The sample should be centrifuged at low speed for approximately 5 minutes and then the supernatant poured off, leaving approximately 1 ml of supernatant with the sediment. The remaining sediment is resuspended in the supernatant and mixed gently. A drop of this suspension is then placed on a microscope slide, a coverslip is added, and the specimen is examined microscopically. The urine can be examined either unstained or stained. Although stain may be added to the sample, this often creates artifacts (i.e., crystals of stain within the urine) and can add bacteria to the sample. When a stain is needed to classify cell types, it should be added after the initial evaluation of the specimen, or two areas can be prepared on the slide, with a stained and unstained side to be examined. When viewing urine sediment, a dark field is preferred to prevent the condenser light from "burning through" the cellular elements. This can be done by lowering the condenser and closing the light diaphragm [19].

11.3.8 Urine Culture

Only specimens collected by catheterization and cystocentesis are suitable for urine culture. Free catch, or manually expressed samples will contain contamination from the external genitalia. If bacteria or WBC are found on the sediment, a urine culture would be warranted. It is always a good idea to set aside a portion of the collected sample to ensure that enough is available in the event of a positive sediment that requires culturing. Samples that have had stain added to the sediment, instead of having the stain added to the slide are not suitable for culturing because of the potential of contamination in the stain [19].

11.3.9 Feline Parasitology

Parasites can be classified as either internal, those found inside the body, and external, or those found outside of the body. Examination of feces is the typical way to detect the various intestinal parasites found in cats, though there are ELISA and polymerase chain reaction tests that are more effective in parasite detection, as they can detect the presence of parasites before eggs are present in the stool. Centrifugation of fecal samples is the gold standard of parasite detection; however, for giardia and tri trich direct fecal examination using a freshly collected sample will allow the motile forms to be better

Table 11.4 Common feline parasites [20–23, 24].

Location found	Type of parasite	Scientific name	Common name
Gastrointestinal (GI) tract	Nematode	*Toxascaris leonina* and *Toxocara cati*	Roundworm
GI tract	Nematode	*Ancylostoma* and *Uncinaria*	Hookworm
Systemic or pulmonary	Nematode	*Dirofilaria immitis*	Heartworm
GI tract	Cestodes	*Dipylidium and Hydatigera taeniaeformis (formerly Taenia)*	Tapeworm
GI tract	Protozoan	*Isospora sp.*	Coccidia
GI tract	Protozoan	*Giardia*	Giardia
GI tract	Protozoan	*Toxoplasma gondii*	Toxoplasma
GI tract	Protozoan	*Tritrichomonas foetus*	Tri trich
Systemic	Protozoan	*Cytauxzoon felis*	Hemolytic anemia
Skin	Fungal	*Microsporum canis and Trichophyton mentagrophytes*	Ringworm
Nasal or ocular	Fungal	*Aspergillus*	Aspergillosis
Ear	Fungal	*Malassezia pachydermatis*	Otitis externa
Pulmonary or systemic	Fungal	*Blastomycosis*	Blasto
Systemic	Bacterial	*Mycoplasma haemofelis*	Haemobartonella
Systemic	Bacterial	*Bartonella henselae*	Cat scratch fever
Ears	Insect	*Otodectes cynotis*	Ear mites
Skin	Insect	*Notoedres cati*	Skin mites
Skin	Insect	*Cheyletiella blakei*	Walking dandruff
Skin	Insect	*Ctenocephalides felis*	Flea
Skin	Insect	*Felicola subrostratus*	Chewing lice
Skin	Insect	*Ixodes scapularis and Ixodes pacificus*	Ticks

visualized. Direct fecal smears with staining can also detect the smaller protozoans, and cytology can be used to look for fungal spores of samples collected from the lungs, nasal cavity, and joint aspirates [20, 21] (Table 11.4, Figures 11.7–11.10).

For many fungal and bacterial parasitic diseases, ELISA, immunofluorescent antibody, and Western blot testing are usually used for diagnosis, as culturing is not possible in a clinical setting, due to the fastidious nature of these organisms [21].

For skin and ear parasitic infections, either skin scraping for mites, or direct identification from infected samples for ear mites and lice is most effective at diagnosing the parasite of concern. Some species of insects can be readily identified visually, including fleas, ticks, and if your eyesight is keen, the walking dandruff mite [22] (Figure 11.11).

11.4 Diagnostic Techniques

When running tests in-house and sending samples out for testing to a reference lab, ensuring you are using the correct sample, collected the correct way is essential to quality results. For in-house ELISA testing, the samples can vary from feces to plasma, serum, or whole blood. As this type of testing is looking for specific antigens or antibodies in the sample, using a sample where these are found is essential. First and foremost, know your tests and the sample requirements.

For fecal floatation samples, studies have shown that you will get a higher collection of eggs when using a centrifuged sample instead of a passive floatation. Especially with parasites who may not shed copious amounts of eggs, this can be very important [21].

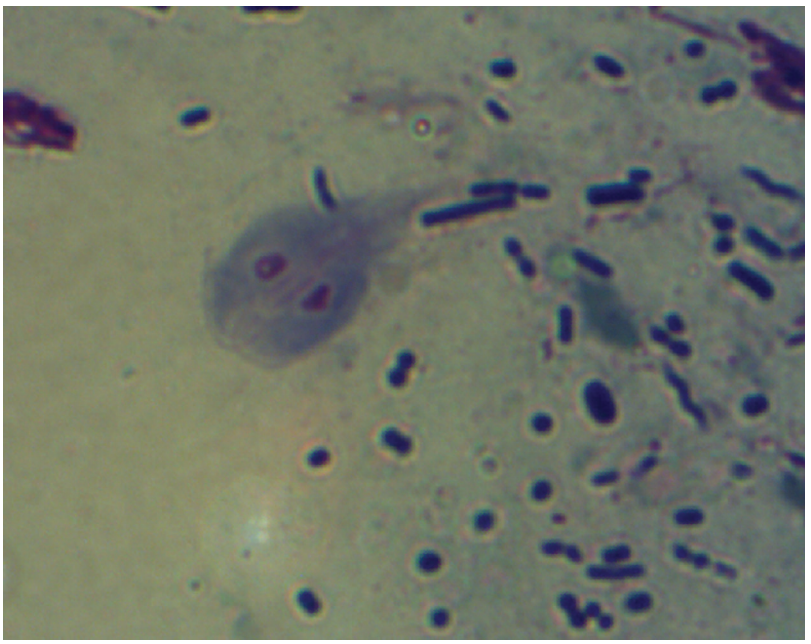


Figure 11.7 A giardia trophozoite on a stained fecal smear. *Source:* Ann Wortinger.

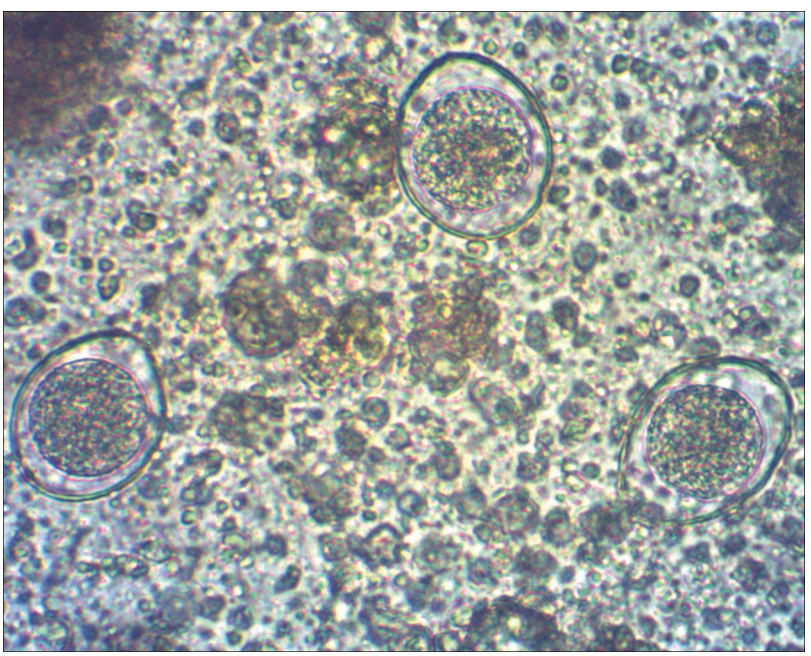


Figure 11.8 *Isospora* coccidia on a fecal floatation. *Source:* Ann Wortinger.

When bacterial cultures are required, the sample in question needs to be collected as aseptically as possible. For urine, this is a catheterized or cystocentesis collection. For the culture of cytology samples, such as bronchoalveolar lavage, or various effusions, avoiding any outside contamination is important.

When collecting blood and making a blood smear looking for *Mycoplasma haemofelis,* a parasite found on the outside of the RBCs, the time the sample is in contact with EDTA must be minimized as much as possible. Ideally, the blood smears used to visually detect the parasite will be quickly made as soon as the blood is collected, and before it is added to the EDTA.

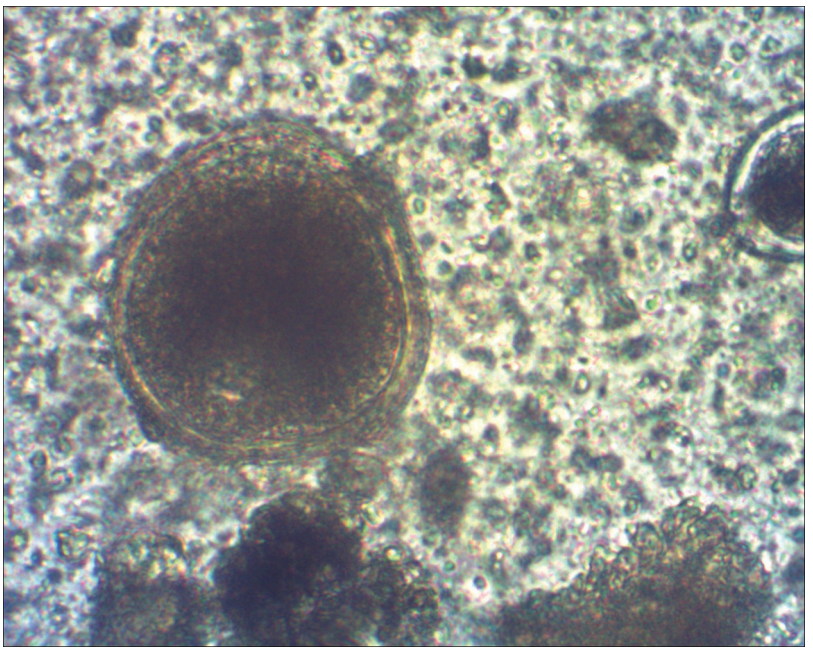


Figure 11.9 *Toxocara cati* on a fecal floatation. *Source:* Ann Wortinger.



Figure 11.10 Taenia tapeworm on fecal flotation. *Source:* Ann Wortinger.

The reason for this is that EDTA can decrease the adhesion of the parasite to the RBC outer membrane. Once the parasite has fallen off the RBC outer membrane, they are virtually impossible to detect. If you are not confident in your ability to make the blood smear quickly, add the blood to the EDTA tube, mix well 10–15 times, and quickly make your smears. This is important even with CBCs sent to a reference lab [21].

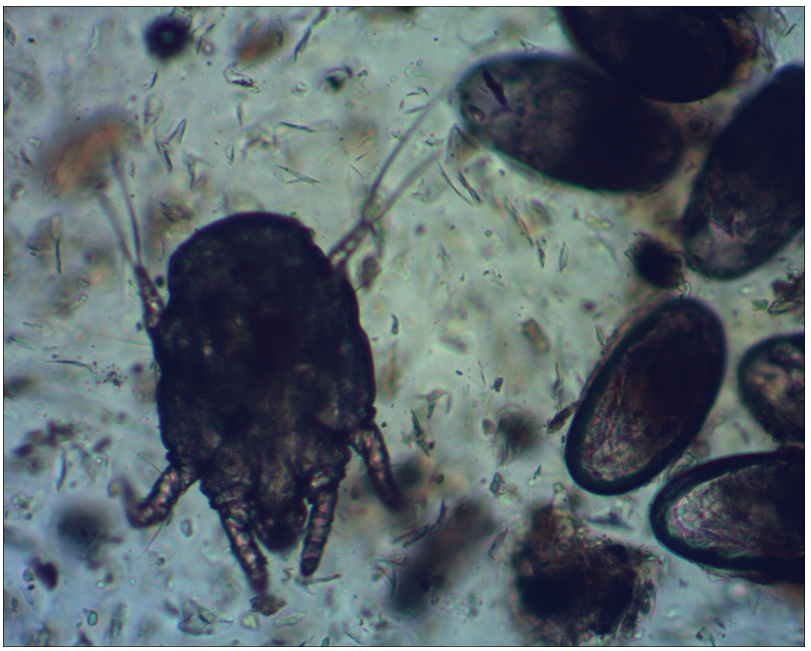


Figure 11.11 *Otodectes cynotis* mites and eggs on oil cytology. *Source:* Ann Wortinger.

Laboratory analysis of various samples can provide valuable information on the health and treatment needs of our feline patients. Ensuring that we are collecting the correct sample, running the tests correctly, and accurately identifying the findings is critical to optimal care. This includes samples that are sent out for reference laboratory identification.

See the companion website for further clinical references.

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12

General Feline Nutrition

Ann Wortinger, BIS, LVT, VTS (ECC) (SAIM) (Nutrition), Elite FFCP

TECHNICIAN TIDBITS

- Cats are obligate carnivores.
- There is no salivary amylase production.
- Hepatic glucose synthesis is primarily through the hexokinase system.
- Specific dietary requirements for cats:
  - Taurine, arginine, methionine, and cystine
  - Arachidonic acid
  - Preformed vitamins A and D
  - Increased levels of B-complex vitamins
- Lactation is the most physically demanding life stage.
- Inadequate or poor nutrition can exacerbate chronic stress conditions.
- The Association of American Feed Control Officials does not provide guidelines for geriatric cats.
- Esophagostomy and gastrostomy feeding tubes can be used long-term.

In their natural environment, cats are obligate carnivores, meaning their nutritional needs are met by eating a diet of animal-based proteins (i.e., mice and birds). Strictly speaking, cats and dogs are members of the order Carnivora and are therefore classified as carnivores. From a dietary perspective, cats and other members of the suborder *Felidae* are obligate carnivores. Domesticated cats (*Felis catus*) have evolved unique anatomic, physiologic, metabolic, and behavioral adaptations consistent with eating a strictly carnivorous diet [1, 2].

12.1 Feeding Behaviors

The evolutionary history of the cat indicates that it has eaten a purely carnivorous diet throughout its entire development [2]. Feeding behaviors that have evolved to fit this lifestyle include searching, hunting, and caching of prey as well as postprandial behaviors such as grooming and sleeping [1]. Feral or outdoor cats feeding primarily on mice, voles, and insects tend to live solitary lives when food is scarce and spread over a large area, but when food is plentiful and concentrated as with households, dumps, and farms cats can be found living in large groups [1]. Cats typically eat 10–20 small meals throughout the day and night. This eating pattern probably reflects the relationship between cats and their prey. Small rodents make up ~40% or more of the feral domestic cats' diets, with small rabbits, insects, frogs, and birds making up the remainder. The average mouse provides ~10 kcal or an estimated 8% of the feral cat's daily energy requirements (DERs). Repeated cycles of hunting throughout the day and night are required to provide sufficient food for the average cat [1, 2]. House cats typically continue this pattern by eating 10–20 small meals throughout the day and night with each meal having a caloric content of ~21 kcal, remarkably close to the caloric value of one small mouse [1, 2].

For thousands of years, the primary economic value of cats has been their hunting skills [1]. Until recently, there has been little or no selective breeding done to alter their behavior or looks. The predatory drive is so strong in cats that they will stop eating to make a kill. This behavior allows for multiple kills, which optimizes food availability [1]. Supplemental feeding may reduce the time spent hunting, but otherwise will not alter hunting behavior [1].

Cats are very sensitive to the physical form, odor, and taste of foods. They consume live prey beginning at the head; this head-first consumption is dictated by the direction of hair growth on the prey [1]. Food temperature also influences acceptance by cats. They do not readily accept food served at either temperature extreme but prefer food near body temperature (~18°C, 101.5°F) as would be found with freshly killed prey [1]. House cats accustomed to a specific texture or type of food may refuse foods with different textures; this is known as a fixed taste preference. An individual cat's preferences are often influenced by early experiences (good or bad). Many cats will choose a new food over a diet that is currently being fed. The reverse is true in new or stressful situations, such as illness or hospitalization, where cats tend to refuse novel foods. This can be important when trying to switch foods or forms of food fed [1].

12.2 Anatomic Adaptations

Cats have adapted physiologically to the life of a hunter. Their visual acuity is greater than that of dogs. In addition, their sense of hearing is well developed—their ears are upright, face forward, and have 20 associated muscles to help them precisely locate the sound. Their highly sensitive facial whiskers and widely dispersed tactile hairs are thought to help them hunt in dim light and protect their eyes [1]. Sharp and dagger-like, their retractable claws are ideal for capturing and securing prey, yet they are easily retracted to decrease noise when stalking [1].

Cats have the same number of incisors, canine, and carnassial teeth as do dogs, but have fewer premolars and molar teeth. Additionally, their teeth have pointed crowns, providing little grinding surfaces [1]. As is typical of carnivores, their jaws offer little lateromedial and craniocaudal movement, limiting grinding movement. The scissor-like carnassial teeth are ideal for delivering the cervical bite used to sever the spinal cord and immobilize or kill prey [1].

Their stomachs are smaller and simpler than that seen in dogs, with a smaller glandular fundus. The glandular fundus of the stomach is where the first step of chemical digestion occurs. Because cats do not consume large meals, the stomach is less important as a storage reservoir [1].

Intestinal length, as determined by the ratio of intestine to body length, is markedly shorter in cats than in omnivores and herbivores. The ratio for cats is 4:1, meaning that the intestinal length is four times longer than the length of the cat; for dogs, this is 6:1, and for pigs 14:1 [1]. Cats do have greater villus height in their intestinal lining, improving their absorptive capacity over that of dogs, so that overall, they are only ~10% less efficient in digestion, especially with complex starches or fibers even with their shorter intestinal length [1].

12.3 Physiologic Adaptations

Cats are not able to adapt to varying levels of carbohydrates in their diets due to various changes in the digestive and absorptive functions of the intestine. Salivary amylase, the enzyme used to initiate digestion of dietary starches, is absent in cats, and intestinal amylase appears to be exclusively derived from the pancreas. These enzymes were not necessary for a prey-based diet with minimal starch content [1, 3]. The level of pancreatic amylase is only 5% that of dogs. The sugar transporter in the intestine is nonadaptive to changes in dietary carbohydrate levels. Disaccharide activity (i.e., the brush border enzymes responsible for sugar digestion) is also non-adaptive, and only ~40% of that is found in dogs [1, 3]. These changes evolved because cats had little natural carbohydrate intake and it was not necessary to have systems intact that were not of little use to the animal.

Despite these adaptive changes, cats can still use carbohydrates in their diets, with a sugar digestibility of ~94% a few exceptions. Lactose digestion declines sharply in kittens after 7 weeks of age. This is due to a decrease in intestinal lactase activity that is typical in mammals. Most adult cats can consume small amounts of milk without problems, but larger amounts (>1.1 grams/kilogram of body weight) can lead to signs of bloating, diarrhea, and gas [1].

Excessive levels of dietary carbohydrates can negatively impact diet digestibility. With elevated levels of dietary carbohydrates, decreases in protein digestibility are seen due to a combination of factors including reduced fecal pH caused by incomplete carbohydrate digestion and increased microbial fermentation in the colon with increased production of organic acids [1, 3]. Cats have a vestigial cecum and short colon, which limit their ability to use poorly digestible starches and fiber for energy through bacterial fermentation in the large bowel [1]. The primary end-products of bacterial fermentation, the short-chain fatty acids acetate, butyrate, and propionate, are present in relatively high concentrations in the bowel of cats, providing increased energy for the colonocytes [1].

12.4 Metabolic Adaptations

12.4.1 Energy

The liver of most animals has two active enzyme systems for converting glucose to glucose-6-phosphate (the first step to forming glycogen, the storage form of glucose within the cells); hexokinase and glucokinase [1]. The glucokinase system is used primarily when a large load of glucose is received by the liver as would be seen with a high carbohydrate meal. Cats have very low liver glucokinase activity and therefore limited ability to metabolize large amounts of simple carbohydrates by this route. Blood glucose levels in carnivores are more consistent with less postprandial fluctuations because glucose is released in small continuous boluses over a longer period of time as a result of gluconeogenic catabolism of proteins [1]. If the protein is not included in the diet, endogenous body muscle and organ tissue will be used for energy. Cats did not need to handle large carbohydrate loads and therefore only use the hexokinase system for glucose metabolism. Adult cats rely primarily on gluconeogenesis, lactic acid, and glycerol for the maintenance of blood glucose [1]. The cat liver lacks fructokinase, or the enzyme that is responsible for breaking down the monosaccharide fructose, typically found in fruits.

12.4.2 Water

Domestic cats are thought to have descended from the small African wildcat (*Felis silvestris lybica*), a cat naturally found in the deserts of Africa. Because of this ancient relationship, cats today maintain this adaptation to a drier environment. Cats seem to be less sensitive to the stimulus of thirst and can survive on less water than dogs [1, 2].

With this decreased response to thirst, cats may ignore minor levels of dehydration (up to 4% of body weight). They can compensate for this reduced water intake by forming highly concentrated urine [1]. Cats adjust their water intake based on the dry matter content of their diet rather than the moisture content. They consume 1.5–2 ml of water/g of dry matter in their food. This 2:1 ratio of water to dry matter is similar to that of their typical prey [1]. Practically, this means that cats consuming a dry food diet will consume about half the amount of water through their diet and drinking, compared to cats eating a canned food diet [1].

12.4.3 Essential Nutrients

To be essential, an organic compound or non-organic element is not produced in sufficient quantities to support the life of that animal [4]. As an obligate carnivore, cats have dietary requirements of these essential nutrients: preformed vitamins A and D, and niacin, the amino acids taurine, methionine, cystine, and arginine, and the n-6 fatty acid arachidonic acid [4].

12.4.4 Protein

Protein metabolism in cats is unique; this is apparent because of their unusually high maintenance requirement for protein and nitrogen in the diet as compared to dogs or other omnivores. Cats have both a higher basal requirement for protein and an increased requirement for essential amino acids [1, 3]. Cats depend on protein not only for structural and synthetic purposes but also for energy. They will continue to use protein in the form of gluconeogenic amino acids for the production of energy, even when inadequate protein is consumed in the diet [1]. Although these changes impair the cat's ability to conserve protein when dietary sources are limited, their natural diet ultimately conserves energy by eliminating the cost of enzyme synthesis and degradation [1].

Four amino acids have special needs for cats. They are taurine, arginine, methionine, and cystine. Cats do not have a specifically higher requirement for any specific amino acid; instead, this increased requirement is due to the high activity of hepatic enzymes that remove amino acid groups from proteins, so that the resulting ketoacids can be used for energy or glucose production (gluconeogenesis). Unlike omnivores, cats have a limited ability to downregulate the activity of these enzymes when low-protein diets are fed [1, 3].

In 1986, the National Research Council (NRC) recommended a minimum of 240 g of protein/kg in the diets of growing kittens and 140 g of protein/kg in the diets of adult cats. This is equivalent to 26% of metabolizable energy (ME) in the diet for kittens and 21% of ME for adult maintenance. Keep in mind that these are minimum recommendations, and they assume a highly digestible protein source is provided in the diet [5].

12.4.5 Taurine

Taurine is a sulfonic amino acid, which is found abundantly as a free amino acid in the natural diet of cats, particularly small rodents, birds, and fish. It is an essential amino acid for cats and is not incorporated into proteins or degraded by tissues, but is essential for the conjugation of bile salts, vision, cardiac muscle function, and the proper function of the nervous, reproductive, and immune systems [1, 4]. Cats can only conjugate bile acids with taurine to make bile salts, an essential component of fat digestion. Taurine continues to be lost in the gastrointestinal tract through this conjugation with bile. This, coupled with a low rate of synthesis, contributes to the obligatory requirement for cats [1, 4].

A carnivorous diet supplies abundant taurine; however, cereal and grains supply only marginal or inadequate levels of taurine for cats [1]. Therefore, diets based on these types of protein sources may be lacking or limited in taurine. Taurine is either more available or better retained by cats fed dry food diets. Because of the widespread uses of taurine within the body, changes from deficiency can be seen in virtually all body systems [1]. Three syndromes have been identified related strictly to taurine deficiency: feline central retinal degeneration, reproductive failure with impaired fetal development, and feline dilated cardiomyopathy [1]. Clinical signs of taurine deficiency occur only after prolonged periods of depletion (from 5 months to 2 years) [1].

12.4.6 Arginine

Cats are unable to synthesize sufficient orthenine or citrulline for conversion to arginine, which is needed for the urea cycle. This cycle is important for the production of urea from toxic ammonia [1]. Without arginine, the urea cycle cannot convert ammonia to urea and ammonia toxicity occurs. This can occur after consuming just one meal that is deficient in arginine. Signs of ammonia toxicity include vocalization, emesis, ptyalism, ataxia, apnea, and cyanosis with death within 2–5 hours. The natural diet for cats is high in arginine through the natural protein provided [4]. Cats have lost the flexibility to eat foods with a more limited amino acid profile, making cats completely dependent on dietary sources for this amino acid [4]. Arginine deficiency can be seen in experimental diets, but also with cats fed certain casein-based human enteral products [1].

12.4.7 Methionine and Cystine

Methionine is an essential sulfur-containing amino acid for cats; this species has a higher requirement than dogs or other omnivores. Methionine and cystine are considered together because cystine can replace up to half of the methionine requirement in cats. Methionine is needed to synthesize cysteine, a non-essential amino acid; however, cysteine cannot be converted to methionine [1, 3]. Cystine is formed from the joining of two molecules of cysteine by a disulfide bond. Cystine is also required for the production of hair and felinine, an amino acid found in cat urine. Felinine is found in the largest amounts in intact male cats and is thought to be a pheromone used for territorial marking [1, 4]. Cystine can replace up to half of the methionine requirement in cats; methionine tends to be the first limiting amino acid in many food ingredients [1].

Even though methionine and cystine are found in abundant amounts in animal flesh, methionine tends to be the first limiting amino acid in many food ingredients [1]. Approximately 19% of food must be composed of animal protein to meet the methionine requirements for kittens [1].

Nutritional deficiencies are possible, especially in cats fed homemade, vegetable-based diets or human enteral diets. Clinical signs of methionine deficiency include poor growth and crusting dermatitis at the mucocutaneous junctions of the mouth and nose [1, 4].

12.4.8 Fat Metabolism

Fats in the diet provide not only a concentrated source of energy but also a source of fat-soluble vitamins and important fatty acids [3]. The essential fatty acids are polyunsaturated fats from the n-3 and n-6 families. Linoleic (n-6 family) is essential for both cats and dogs, whereas arachidonic acid (n-6 family) is essential only for cats [3].

Cats have a limited ability to synthesize arachidonic acid from linoleic acid [3]. A dietary source is especially important during demanding life stages such as gestation, lactation, and growth. Arachidonic acid is abundant in animal tissue but is absent in plants. If consuming meat-based diets, this is not usually a concern [1].

12.4.9 Vitamin Metabolism

Vitamin A occurs naturally only in animal tissues; in plants, it is found as β-carotene and the carotenoids. The cat is unable to convert β-carotene to retinol (vitamin A) because of a lack of intestinal enzymes necessary for the conversion, and therefore this species requires a dietary source of pre-formed vitamin A [3]. It is necessary for the maintenance of vision, bone, and muscle growth, reproduction, and healthy epithelial tissues. Because vitamin A is a fat-soluble vitamin and is stored in the liver, deficiencies are slow to develop and are only seen in cats with severe liver failure or gastrointestinal disease resulting in fat malabsorption [1, 4].

Cats also lack sufficient enzymes to meet the metabolic requirements for vitamin D photosynthesis in the skin; therefore, they require a dietary source of vitamin D [1]. The primary function of vitamin D is calcium and phosphorus homeostasis, with particular emphasis on intestinal absorption, retention, and bone deposition of calcium [4]. Vitamin D is found in abundant amounts in animal fats, and primary vitamin D deficiency has only been identified in cats fed experimental diets [1]. As with vitamin A, deficiency is rare and slow to develop [1, 4].

Vitamin A and D are found in plentiful amounts in animal fats. This fact is important not only for the provision of fuel for energy but also for increasing palatability and acceptance of food [4].

Cats require increased amounts of many dietary water-soluble B vitamins, including thiamin, niacin, pyridoxine (vitamin B6), and in certain circumstances cobalamin (vitamin B12). They are unable to convert sufficient amounts of tryptophan to niacin (vitamin B3) due to the high activity of enzymes, which results in the degradation of the precursors used for its synthesis [4]. While they have the metabolic pathway for this conversion, the high activity of enzymes exceeds the rate of niacin synthesis, making this a requirement [1]. The requirement for niacin and pyridoxine is four times higher than that for dogs [1, 4].

Because most water-soluble B vitamins are not stored (except cobalamin, which is stored in the liver), a continually available dietary source is required to prevent deficiencies [4]. Deficiencies are rare in cats eating appropriate diets because each of the B vitamins is found in high concentrations in animal tissue [1, 4].

12.5 Fixed Taste Preferences and Food Aversions

When feeding kittens, it is important to expose them to a variety of flavors and textures of foods. The food types fed during the kitten's first 6 months of life can influence their pattern of food preferences long into adulthood [1]. Cats can develop fixed taste preferences as adults and will readily refuse foods that they have not previously been exposed to during their kittenhood. This can pose additional challenges as the cat ages, and dietary modifications to the diet may be necessary for disease management.

Food aversion is a learned behavior, usually associated with a negative experience, which can be emotional, physical, or physiologic [1]. Typically, aversions develop when cats consume food immediately after an episode of nausea or vomiting. This can mean a food that was regularly consumed before an incident will no longer be eaten. Clinically aversions may develop following gastrointestinal upset caused by various diseases or drugs [1]. Aversions have been documented to last up to 40 days in cats. It is important to remember when introducing a diet in the hospital that antiemetics and antinausea medications should already be on board before offering any food, and in some instances, a "sacrificial food" may need to be fed so that an aversion does not develop in the hospital to the long-term desired food. Food aversions can also be seen with force-feeding or syringe feeding of a diet either in the hospital or by the owners. Seldom can sufficient calories be administered to justify force-feeding, and the physiological and physical trauma will have long-lasting consequences. The use of short-term and long-term feeding tubes is significantly less stressful for the cat, the veterinary staff, and the owner.

12.6 The Association of American Feed Control Officials Life Stages

Association of American Feed Control Officials (AAFCO) recognizes four different life stages for cats when looking at nutrient requirements. These include gestation and lactation, including pregnancy, growth of kittens, adult maintenance, and food formulated for all life stages [6]. You will notice that senior or geriatric is not a recognized life stage. While we recognize this as a stage of life, nutritionally, there is no way to provide guidelines for all cats during this phase, as the various disease processes and comorbidities that occur as a cat ages can have dramatic effects on their nutritional requirements.

12.7 Reproduction and Neonatal Nutrition

The feeding objectives for reproduction focus on optimizing the health and body condition of the queen, ensuring a positive reproductive performance, and ensuring optimal kitten health and development [7]. Ideally, the queen and tom will be in optimal body condition, current on vaccinations, and treated for internal and external parasites [7]. The majority of unowned or outdoor cats may not meet these criteria before breeding occurs.

In cats, energy intake parallels weight gain, which occurs linearly, rather than primarily near the end of the pregnancy [3, 7]. This linear weight gain may be one of the first indicators of pregnancy. Mean weight gain during pregnancy is ~40% of the pre-mating weight [7]. Estimated energy intake increases 25–50% above maintenance to between 90 and 100 kcal/kg body weight/day [3]. A queen that is significantly underweight can experience poor lactation, and an inability to maintain body condition while nursing [7]. For the overweight queen, stillbirths, dystocia, and the need for cesarean sections occur more commonly [7]. Meeting these increased nutrient and energy demands can usually be accomplished by feeding a diet designed for growth such as kitten food. The queen should be transitioned to a kitten diet once the pregnancy has been confirmed.

Lactation is considered the most physically demanding life stage with regard to energy and protein requirements, which may exceed the NRC recommendations [3, 7]. Milk production should begin immediately after parturition, with colostrum being produced during the first 24–72 hours [7]. The amount of milk produced will vary based on the size of the litter, and the stage of lactation, with peak lactation occurring between 3 and 4 weeks of age [7]. However, peak energy demands for the kittens occur around week 7. As kittens have usually started the weaning process, this energy intake includes that obtained from nursing, but also what they can consume on their own [3, 7].

Depending on the size of the litter, a queen may consume 2–3 times her DER during lactation. Many foods formulated for adult maintenance do not provide sufficient calories to meet these increased energy requirements [2]. Ideally, a nutrient-dense diet should be available for the nursing queen. Diets that are formulated for growth (i.e., kitten food) are recommended to provide enough energy and nutrients. The feeding volume will likely need to be increased throughout lactation, as the kittens grow [2].

Weaning typically begins around 5–6 weeks of age, as the kittens become more active and begin to explore their surroundings. Most breeders want to have the kittens weaned by 7–9 weeks of age so they can be transferred to their new homes [2]. For our backyard kitten litters, if the mother is still available, nursing may continue well past this age. However, it is unlikely that the kittens are obtaining much milk, and this is seen primarily for comfort.

12.8 Orphaned Kitten Nutrition

An orphaned kitten does not receive sufficient maternal care for survival from birth to weaning [8]. To increase survivability, either these kittens can be fostered by another nursing queen or their care can be taken over by a caregiver who can meet their physiologic and nutritional requirements [8].

When the care is provided by a person, the nutritional needs are met with a milk replacer. While AAFCO provides guidelines for feeding pregnant queen and for the growth of kittens, no such guidelines have been provided for the nutritional requirements of milk replacers [9]. Ideally, at a minimum, orphaned kittens will have received colostrum from the queen, but many times this is not possible, or we are unable to verify if this has occurred.

Newborn kittens require ~24 kcal of (ME per 100 g of body weight [9]. Ideally, the milk replacer being fed will be as close to the queen's milk as possible. However, with no AAFCO guidelines, this may not always be the case. Table 12.1 demonstrates the variability of nutrients and calories in milk replacers available for orphaned kittens. Monitoring kitten weight daily will provide a good indicator of the quality of the milk replacer. Minimally, kittens should gain 7 g/day [8].

Weaning and the transition from a milk replacer to kitten food will begin around the same age as with nursing kittens, though there may be some developmental delays that occur. Do not attempt to wean a kitten from the bottle who is not yet interested in canned or dry kitten food. Kittens will develop at their own rate, not necessarily when the calendar says they should.

Table 12.1 Composition of milk replacers compared with queens' milk [9].

Product	kcal/ml	Guaranteed analysis, %	Metabolizable energy, %[a]
Queen's milk*	1.21		
Protein		10.72	43.8
Fat		2.78	27.6
Fiber		0.5	
Moisture		79	
CHO		7.0	28.6
Cat milk replacement, powder (vet worthy) https://vetworthy.com/milk-replacement-cat/	0.87		
Protein		42	32.25
Fat		25	46.63
Fiber		0.5	
Moisture		5	
CHO		26.4	21.12
Foster care kitten milk replacer (breeders edge, breedersedge.com/product/foster-care-kitten-milk-replacer)	0.9		
Protein		32	20.30
Fat		44	67.78
Fiber		0.2	
Moisture		5	
CHO		18.8	11.92
Kitten milk replacer (KMR), powder (PetAg) https://www.petag.com/products/kmr-kitten-milk-replacer-powder	0.83		
Protein		40	30.44
Fat		28	51.75
Fiber		0.6	
Moisture		5	
CHO		26.4	19.64
KMR, liquid (PetAg) https://petag.com/products/kmr-kitten-milk-replacer-liquid	0.83		
Fat		5.2	51.28
Fiber		0.8	
Moisture		82	
CHO		5	20.30
Milk replacement with opti-gut for kittens, powder (NutriVet) https://nutri-vet.com/cat-health/cat-vitamins/milk-replacement-powder-for-kittens	2.0		
Protein		30	19.78
Fat		40	64
Fiber		0.5	
Moisture		5	
CHO		24.5	20.3

(Continued)

Table 12.1 (*Continued*)

Product	kcal/ml	Guaranteed analysis, %	Metabolizable energy, %[a]
Mother's milk: canine and feline food supplement, powder (Wysong, wysong.net/products/mothers-milk)	NA		
Protein		49	43.25
Fat		17	36.44
Fiber		4	
Moisture		7	
CHO		23	20.30
Well and Good. Milk replacer powder for kittens (PetCo) https://www.petco.com/shop/en/petcostore/product/well-and-good-kitten-milk-replacer-powder	0.39		
Protein		42	32.18
Fat		25	46.52
Fiber		0.2	
Moisture		5	
CHO		27.8	21.30

NA—not available
* ME was calculated by the author, from guaranteed analysis.

12.9 Kitten Nutrition

When a queen is available to feed the kittens, our primary goal is to ensure that she is receiving enough nutrition to support both her and her kittens. We can do this by providing food that meets the AAFCO guidelines for gestation and lactation to the queen until the kittens are fully weaned [8]. When feeding kittens, it is important to expose them to a variety of flavors and textures of foods. The food types fed during the kitten's first 6 months of life can influence their pattern of food preferences long into adulthood [1].

Well-fed kittens are vigorous and have good muscle tone. As with orphaned kittens, weighing the kittens will help to ensure that they are receiving enough nutrition. The composition of the queen's milk will change as the kittens age, with weaning beginning around 3–4 weeks, and the kittens being fully weaned from the queen between 7 and 9 weeks [8].

The AAFCO defines a kitten as being from weaning until at 10–12 months of age [6]. During this period of rapid growth, energy requirements will remain high [10]. Until the kittens have reached a size where they can consume enough calories, ad-lib feeding is recommended, or multiple small meals frequently (i.e., every 2–4 hours) [4]. Regular monitoring of body condition can act to ensure that the kitten is consuming enough food and that the feeding schedule is appropriate [4]. We can also use body condition scoring (BCS) to prevent obesity from developing in our growing kittens.

At 10–12 months of age, the kitten can gradually be transitioned to an adult-maintenance diet. As with any diet transition, this should be done over 7–10 days to allow the gastrointestinal microflora to adjust to the change in nutrient composition. If the change is within the same product line, there is usually no problem with changing foods.

For many shelters and rescues, early neutering, sometimes as young as 8 weeks old, has become normal. There is no evidence that the age of neutering alters the growth rate of these kittens; however, we do know that neutering does decrease the energy requirements, by as much as 25% [10]. Therefore, early neutering, without an adjustment in the amount fed, can contribute to the risk for obesity as the kitten matures (Figure 12.1).



Figure 12.1 Seven-week-old foster kitten. The kitten is well muscled, and the fur is clean as would be expected for this age of foster kitten. *Source:* Ann Wortinger.

12.10 Young Adult Nutrition

Once a kitten has reached their full adult size, between 10 and 12 months of age, it is considered an adult [11]. Some of the larger breeds of cats, such as the Maine Coon cat, may not reach their full adult size until 18–20 months of age and could benefit from the extra nutrition provided by kitten food, as long as they do not become obese.

A young adult is between 1 and 6 years of age [11]. These cats have the most broadly defined life stage and have the greatest ability to tolerate or compensate for a variety of dietary variations [12]. Ideally, we will see these cats yearly and be able to perform a physical exam and evaluate responses to their nutrition and environment.

AAFCO does provide guidelines for the maintenance of adults, but this information does not take into consideration the environment in which the animal lives (i.e., indoor, outdoors, or both), their activity level, the number, and type of housemates, or their neuter status [6]. Alterations in the amount of food being fed, the feeding method and the type of food provided should be discussed at every visit, even for wellness exams, with adjustments being made as needed.

Inadequate or poor nutrition can exacerbate chronic stress conditions caused by overcrowding or poor ventilation [12]. Much work has been done looking at ways to reduce stress for indoor cats, including providing access to multiple levels within the house, outdoor resting areas, visual barriers, quiet hiding spots, and access to multiple feeding and litter areas [13] (Figures 12.2 and 12.3).

While calculating the DER for adult cats can be tedious, relying on the feeding information found on commercial pet foods does not address the needs of that individual cat. The feeding volume provided to the cat should be based on their current and ideal body conditions, not simply on their age, size, or weight [12]. Activity level can have a major effect on the number of calories a cat requires. While young and active, the number of calories over resting energy requirements (RER), can be as much as two times; as the cat matures, this can go as low as 1.0 × RER. It is best to calculate the actual caloric requirement for each cat individually and adjust as needed based on the body condition score (Table 12.2).



Figure 12.2 Example of indoor enrichment for cats, providing multiple levels and textures to interact with. Note the inclined "off-ramp" off the bottom right shelf, the author's blind cat uses this to exit the climbing structure. *Source:* Ann Wortinger.



Figure 12.3 Poppy and Dusty enjoying their climbing structures. Note that Dusty is blind (bilaterally enucleated), and readily uses all the climbing structures provided in the house, with the slight modification of the off-ramp. *Source:* Ann Wortinger.

Table 12.2 Formula(s) for calculating RER in adult maintenance in kcal/day, using body weight (BW) in kilograms [14].

Feline
$70 \times (\text{BW [kg]})^{0.75}$
$(30 \times \text{BW [kg]}) + 70$

12.11 Mature Adult Nutrition

The mature cat is seen as an adult between the ages of 7 and 10 years [11]. The transition between a young adult and a mature adult is primarily due to the presence of age-related diseases, as well as behavioral, physical, and metabolic changes related to aging [15]. Changes in nutrition are directed at instituting appropriate nutritional management of diseases and reducing various risk factors for common age-related diseases.

As cats age, they become less active and have reduced lean body mass. This alone can contribute to obesity as a cat ages [15]. Age-related changes include reduced digestive function, immune response, glucose tolerance, renal function, smell, taste perception, and numerous other changes [15]. Some of these we can measure, such as renal function, or glucose tolerance; others are less obvious, including a decreased food intake due to changes in smell and taste.

Cats age at different rates, and there are no AAFCO Guidelines above those for maintenance. Continuing to monitor weight and body condition scores is one of our most valuable tools to help monitor our older adult cats. While a change in diet may not be required as cats age, we do need to recognize how decreased energy output can contribute to the development of obesity in our older cats.

Dietary protein should not be restricted in healthy mature adult cats [15]. While reducing the protein content in diets designed for cats with renal failure has shown improvement in blood work and slows disease progression, other nutrients have also been modified in this subset of cats. Higher-protein diets also have the additional advantage of increasing palatability. We know that as cats age, their taste becomes less acute, and a more palatable diet may help with maintaining weight in these cats [15]. At this time there is no clear consensus as to when to introduce lower-protein diets to mature cats, and no preventative measures have been seen with providing lower-protein diets to otherwise healthy cats [15].

12.12 Geriatric Nutrition

Our senior or geriatric cats include those who are 10 years of age and older [11]. However, the AAFCO does not provide guidelines for geriatric cats but instead includes them within the maintenance group [6].

The challenge with older cats is that some will require no dietary adjustments until their late teen years, while others will develop a number of conditions that may benefit from dietary adjustments. There is no "one size fits all" approach here for cats, and it is not against the rules for a single cat to develop multiple problems as they age.

As with our older adult cats, the nutritional goal with geriatric cats is to maintain optimal nutrition to allow normal BCS and weight, minimize associated disease risk factor management, and identify, and slow down the progression of certain chronic diseases [15]. The age-related changes identified for mature adult cats will become more numerous and will increase in severity as these cats age into geriatrics [15]. While not all cats will develop all of these age-related changes, and their progression may not be linear, we do know what to look for, and how to address these changes.

The rate at which a cat ages is highly variable, providing a greater diversity in their individual needs than with any other life stage. Our older cats tend to be less adaptable to environmental and physiologic changes, and they have a decreased physiologic reserve to withstand these changes.

Water is an essential nutrient for any life stage but becomes more important as a cat ages. Aging impairs thirst sensitivity, and with the decline in renal function common in this age group, increased water loss may be seen with decreased urine concentrating ability [15]. These conditions can predispose an older cat to dehydration. Chronic dehydration can impair normal metabolic processes and exacerbate subclinical disease [15]. Multiple ways can be used to encourage an older cat to increase their water consumption, including switching from dry food to a canned diet, adding water to a canned diet, using pet fountains, or offering water to which a broth or juice (i.e., tuna or clam juice) has been added. As with all life stages,



Figure 12.4 Lily at 18 years old, with International Renal Interest Society (IRIS) stage 3 chronic renal failure (CRF). Her significant loss of muscle mass is easy to see. *Source:* Ann Wortinger.

readily available, clean, fresh water is critical. For cats with increased mobility issues, they may no longer readily climb stairs, or jump on counters, and their food and water may need to be placed in more accessible areas.

As cats age, we see a loss of lean body mass and a decrease in activity, which can cause a corresponding decrease in their basal metabolic rate and energy requirements [15]. Even without a change in their weight, we can see a shift in weight from muscle mass to increased fat stores in our older cats. While some of the loss of lean body mass can be attributed to a decrease in activity, cachexia, and sarcopenia are also common in these cats.

Sarcopenia is the loss of muscle mass and function associated with aging, not in conjunction with an identified disease process. This is usually associated with decreased activity, and not with a decrease in appetite [16]. Cachexia is a multifactorial syndrome characterized by progressive weight loss, which is often, though not always, accompanied by anorexia. Unlike weight loss seen with starvation or simple anorexia, cachexia is distinguished by a loss of adipose tissue with accompanying loss of lean body mass, primarily muscle [17]. Cachexia can be seen in older cats with cancers, cardiac disease, renal disease, and other profound illnesses and injuries [16]. Loss of 25–50% of the lean body mass compromises the immune system and affects muscle strength, with death resulting from infections, pulmonary failure, or both [16] (Figure 12.4).

12.13 Feeding Tubes: Uses, Indications, and Placement

General guidelines for initiation of nutritional support include the loss or anticipated loss of more than 10% of the body weight, anorexia of greater than 3 days duration, trauma, surgery, severe systemic infiltrative disease, increased nutritional loss through diarrhea, vomiting, draining wounds or burns associated with decreased serum albumin [18]. Other issues that must be considered include gastrointestinal tract function, whether the patient can tolerate tube or catheter feedings, the physical or chemical restraint required to place the tube or catheter, venous accessibility, whether the patient is at risk for pulmonary aspiration (i.e., megaesophagus), availability of nursing care and equipment, and client cost. Typically, the primary veterinarian can place most feeding tubes less expensively than a specialist and have the patient in a better physical and nutritional plane to withstand anesthesia.

12.13.1 Body Condition Scoring

The body condition scores used for healthy animals often do not apply to sick animals. When an animal is physiologically stressed, lean body mass (i.e., protein) is its preferred energy source; in contrast, healthy animals use stored fat for energy. This results in increased body protein catabolism [16, 19].

A patient may present with increased body fat but be at serious risk of malnutrition-associated complications caused by protein catabolism [16]. Careful examination, including palpation of the skeletal muscles over bony prominences (e.g., scapula, hips, vertebrae, and cranial crest) can identify muscle wasting consistent with increased protein catabolism. Other indicators of poor nutritional status include edema and ascites, which reflect low plasma protein levels secondary to malnutrition or disease. Poor hair coat and skin conditions can also result from inadequate food intake or micronutrient deficiencies (e.g., zinc) [16].

12.13.2 Where to Start

The gut is the safest and most natural route for administering nutrients. Maintaining the intestinal mucosa may also help to prevent bacterial translocation from the gut to the rest of the body. This is best accomplished with enteral feeding [16]. Voluntary oral intake is the preferred route for enteral nutrition; however, patients must be able to consume at least 85% of their calculated RER for this method of feeding to be effective [16, 19].

If a patient is unable or unwilling to eat voluntarily, tube feeding should be considered. Tube feeding, however, is limited by diet selection. In most instances, only liquid or gruel diets can be fed through the tube because of the small diameter. In addition, tubes can become clogged and must be flushed regularly with water [20]. Because anesthesia is not required for placing a nasoesophageal tube, this is the easiest to insert. However, only a liquid diet can be administered, and the tube can become easily clogged. Flushing the tube frequently with water can decrease the incidence of clogging but can also cause fluid overload in the stomach and dilute the calories administered.

If a patient is to be anesthetized for surgery, placing an esophagostomy or gastrostomy tube should be considered. Both tubes have a larger diameter that can accommodate slurry or gruel diets, but they may also become clogged. In addition, patients can vomit up esophagostomy tubes and prematurely remove gastrostomy tubes. Gastrostomy tubes are usually placed using an endoscope, but non-scope procedures are available. Jejunostomy tubes require surgical placement, and like with a nasoesophageal tube, only liquid diets can be used (Figure 12.5).

Tube location should be checked before each feeding by gently applying negative pressure through aspiration to the end of the feeding tube. This will allow residuals to be measured, ensuring adequate gastric motility, and confirming tube location. Gastric residuals can only be checked in nasogastric tubes and gastrostomy tubes. Esophagostomy tubes should not have any residual as they are in the esophagus, and the jejunum due to its size has a relatively small holding capacity; therefore, measuring residuals would be of little value [20]. Radiographs can also be used to verify tube location if there is any doubt; contrast agents are usually not necessary as most tubes are radio-opaque (Figure 12.6).

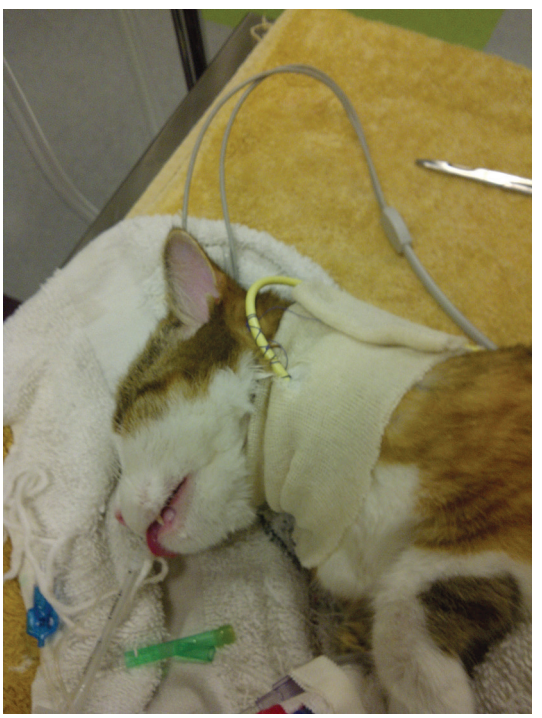


Figure 12.5 Twelve-year-old DSH with an esophagostomy tube placed secondary to anorexia from cancer. *Source:* Ann Wortinger.

12.13.3 Appropriate Diets

Commercial pet foods are specifically designed to meet the dietary needs of cats and contain ingredients (i.e., taurine, carnitine, glutamine) not usually present in liquid or parenteral diets [16, 19]. The principal difference between human and animal liquid enteral diets is the extent to which the ingredients are subjected to hydrolysis and the protein content [16]. For example, most human enteral diets contain 14–17% protein, which is insufficient for cats. In addition, arginine and methionine levels in human enteral diets tend to be too low [19].

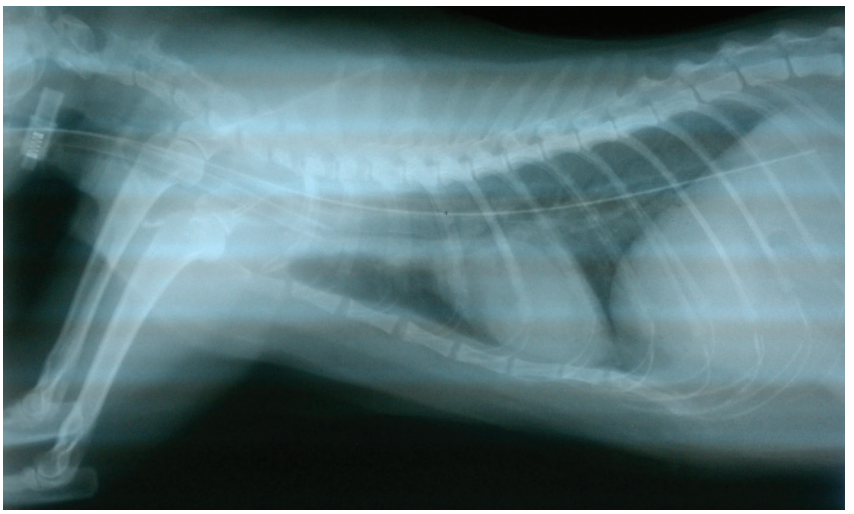


Figure 12.6 Lateral radiograph of an esophagostomy tube showing correct placement. *Source:* Ann Wortinger.

Table 12.3 Recommended levels of fats, protein, and carbohydrates in critical care diets would be [16] (percent of energy requirements [ME], not of dry matter).

Species	Protein, %	Fat, %	Carbohydrate, %
Canine	20–30	30–55	15–50
Feline	25–35	40–55	15–25

Table 12.3 provides the recommended levels of fats, protein, and carbohydrates in critical care diets. Pediatric or growth diets are often recommended because they are highly digestible, have high fat and protein content, and are very palatable [16]. Meat-based baby foods contain 30–70% protein and 20–60% fat. However, because they are deficient in calcium, vitamin A, and thiamine baby foods should not be used as the sole dietary source [16].

12.13.4 How to Start Feeding

Because nutritional support is not an emergency procedure, reinitiating feedings should be started slowly [16]. Food intake should be gradually increased over 2–3 days until the estimated caloric intake is met. If the patient shows discomfort, vomits, or becomes distressed, the diet as well as the route and rate of delivery need to be reassessed.

Generally, 50% of the RER divided into multiple small meals is offered on the first day. If this is well tolerated, then 100% of the RER can be fed the next day. If feedings are not well tolerated, the increases should be more gradual over the next 2–3 days. Smaller meals tend to be tolerated better because they do not cause distension of the stomach and subsequent delayed gastric emptying or aggravate nausea by stimulating the vomiting receptors in the stomach [16, 19].

Multiple veterinary recovery diets are available in a gruel form that passes easily through most of the larger bore feeding tubes (12 fr and higher). Sometimes adding as little as 1–2 tablespoons (15–30 ml) of water to the can of food will greatly increase ease of passage. If needed, homemade gruel diets can be prepared from commercial diets. The disadvantage of this would be not knowing the caloric amount found in each ml of the final mixture, or the final volume achieved after mixing. These diets also tend to fall out of suspension after they have been mixed with water.

Typically feeding can be started within 12 hours from tube placement; a stoma around the tube insertion site needs to start forming before feeding. A complete feeding plan should be made for each animal with written feeding directions given to the owner [16, 20].



Figure 12.7 The cat from 12.5 at home beginning her diet transition from e-tube to oral feeding. *Source:* Ann Wortinger.

12.13.5 What Tubes to Use

The best feeding tubes for prolonged use are made of polyurethane or silicone. For short-term feeding, usually less than 10 days, polyvinyl chloride (PVC-red rubber) tubes can be used. These are not appropriate for long-term feeding because they tend to become stiff with prolonged use, causing additional discomfort for the cat. Silicone is softer and more flexible than other tube materials and has a greater tendency to stretch and collapse. Polyurethane is stronger than silicone, allowing for thinner tube walls and a greater internal diameter, despite the same French size. Both the silicone and polyurethane tubes do not disintegrate or become brittle in situ, providing a longer tube life [19, 20]. The French unit measures the outer lumen diameter of a tube and is equal to 0.33 mm [16].

12.13.6 Diet Transitions

Although diet transitions may occur while the cat is hospitalized, typically it is done 2–6 weeks after discharge from the hospital. The transition depends on the diet being fed, the condition of the cat, its response to therapy, and the comfort level of the owner. As with diet initiation, proceed with the transition slowly. For example, when shifting from a support diet to a maintenance diet, each dietary change should represent an additional 1/2 of the current diet every 3–4 days, resulting in a transition phase of 12–16 days. If a problem develops at any stage, the owner should be instructed to revert to the last diet combination that worked (Figure 12.7).

Regular technician exams are recommended after hospital discharge to continue to monitor the cat's recovery and prepare for future tube removal. In certain conditions, such as cancers and terminal diseases, feeding tubes can be used long-term or until the animal passes. Esophagostomy and gastrostomy tubes are the best tubes for long-term care (Figure 12.8).

12.14 Diagnostic Techniques

In all things nutrition, being able to calculate energy requirements and being comfortable in explaining these to owners is paramount. Table 12.2 covers the calculation of resting energy requirements (RER); DER are calculated from the RER but utilize the animal's activity level to supply any extra calories required for daily maintenance. This is called the Life Stage Factor and can be found in Table 12.4.

Once you have calculated RER and DER, you can use this information to get an estimate of the amount of food to be fed to the animal. For obese adult cats, do not be too surprised when you see the difference between what they need and what they are currently consuming!



Figure 12.8 This cat presented with a BCS of 2/5 and is undergoing treatment for an oral squamous cell carcinoma. She lived for another year, was able to transition to a low-profile gastrostomy tube, and the oncologist at her death commented that she was the fattest oral SCC she had ever treated. *Source:* Ann Wortinger.

Table 12.4 Life stage factors used to calculate daily energy requirements [21].

Life stage—feline	Energy requirement
Growth	2–3 × RER
Late gestation	2–3 × adult RER
Intact adult	1.4 × RER
Neutered adult	1.2 × RER
Critical care/hospitalized	1.0 × RER
Weight loss/obese	0.8–1.0 × RER
Overweight/inactive	1.0 × RER
Lactation	2–6 × RER

To make our lives a little easier, the Pet Nutrition Alliance (https://petnutritionalliance.org) provides an online calculator where you can plug in the cat's weight, BCS, neuter status, and how many calories are in the desired food, and it will calculate all the fun stuff for you! https://petnutritionalliance.org/resources/calorie-calculator?type=cats.

12.14.1 Example

Dusty is a 10-year-old f/s Domestic Short hair with a life stage factor of 1.2. Her current weight is 8 kg, with a BCS of 3/5. Her owners are feeding a dry food that has 350 kcal/cup and splits one can of canned food so that Dusty receives ½ of a can once daily that has 100 kcal/can. Treats are minimal and will not be deducted.

$$\begin{aligned} \text{RER} &= (\text{wt in kg} \times 30) + 70 = 3.6\ \text{kg} \times 40 = 178\ \text{kcals/day} \\ &= 70 \times (\text{body wt in kg})^{0.75} = (3.6 \times 3.6 \times 3.6\surd\surd) \times 70 = 182.9\ \text{kcal/day} \\ \text{DER} &= \text{RER} \times 1.2 = 213.6 - 219.48\ \text{kcals/day} \end{aligned}$$

Dry food = 350 kcal/cup
Canned food = 100 kcal/can, ½ can = 50 kcal/day
213 − 219 kcal − 50 kcal (canned food) = 163 − 169 kcal available for dry food
163 − 169/350 = 0.46 − 0.48 cups/day.

Note: *Notice how when we get to the final feeding volume, the amount comes out nearly the same for both calculations! Use the formula that is most comfortable for you!*

This will be rounded up to ½ cup/day and fed as ¼ cup twice daily.
Daily feeding recommendation:

½ can once daily
¼ cup of dry twice daily

For all feeding recommendations, remember that these numbers are estimates! The body weight and BCS should be continually checked to ensure that the calculated estimates are meeting the cat's needs. If this is not the case, adjustments in feeding volumes can be increased or decreased.

We should all be prepared to make a nutrition recommendation for every patient at every visit. Sometimes this will be as easy as saying "Petie looks great and is thriving on his current diet. You are doing a great job!" Often this is not the case, and we need to be able to explain to clients what the cat's nutritional needs are for that life stage, as well as to be able to make an informed decision as to the food that is being fed. Following the World Small Animal Veterinary Association's Guidelines https://wsava.org/Global-Guidelines/Global-Nutrition-Guidelines can provide us with the tools and resources to make the best recommendations for our patients.

Nutrition is one of the areas where a technician can truly shine. Once the doctor has diagnosed the problem and determined a treatment, the technician can come in and calculate the feeding amount, plan the diet transition, and help monitor the response to the diet. All of our patients must eat, and a technician should be involved in all dietary recommendations, diet discussions, and feeding plan implementations. Go out there and feed!

See the companion website for further clinical references.

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13

Feline Wound Care and Bandaging

Kelly M. Foltz, BA, AAT, CVT, LVT, RVT, VTS (ECC)

TECHNICIAN TIDBITS

- Common emergency room wound presentations in felines include vehicular trauma, bite wounds, lacerations, projectile injuries, and ruptured abscesses.
- Most wound management techniques in veterinary emergency medicine are extrapolated from human wound care recommendations.
- If wound culture is needed, samples should be taken after lavage since those collected prior may not accurately reflect the microorganisms in the wound.
- It is important for the person performing exploration and debridement to observe the aseptic technique; this includes sterile gloves, gown, cap, and mask or face shield plus draping the site with sterile drapes.
- Wound management in cats is best undertaken holistically, considering multiple factors including the type of wound, patient temperament, analgesic protocol, need for nutritional support, bandaging or dressing technique, and the patient's emotional and environmental needs.
- Supplies for a simple padded bandage include a nonadherent pad or pads to place over any open wounds, porous white tape to make stirrups, a tongue depressor, cast padding (2 or 4 inch depending on patient size), minimally elastic cling gauze, and elasticated cohesive wrap for the tertiary layer.

Soft tissue and orthopedic wounds comprise a significant proportion of feline emergency room (ER) visits and due to their smaller size, polytrauma is over-represented in these patients. Optimal management of the wounded feline patient requires a deep understanding of wound types, normal wound healing processes, infection prevention, topical therapies, and bandaging techniques. In addition, veterinary technicians contribute to successful outcomes in these patients through knowledgeable triage and prompt initial interventions, provision of comprehensive analgesia, and nutritional support with an emphasis on the individual patient's preferences and behavioral needs. Cats are not small dogs, and technicians are encouraged to pair their didactic knowledge of wound physiology and treatment modalities with empathy and creativity in the support of the patient's comfort. "Thinking slow to go fast" is an ideal mindset to adopt when working with a feline wound patient (discussed below).

13.1 Etiology of Feline Wounds

The reported percentage of pet ER visits due to trauma varies with estimates ranging from 12 to 13% of total visits for both dogs and cats. Free-roaming animals, intact males, and young animals are more likely to experience trauma than those kept indoors or who are neutered/spayed [1]. "Trauma" comprises any bodily injury that occurs due to accident or external forces and can be further classified as blunt, penetrating, polytrauma (multiple types affecting multiple body systems), soft tissue, or orthopedic; in felines, trauma presentations run the gamut from crushing injury, high rise syndrome, other falls, motor vehicle trauma, fracture(s), gunshot wounds, contusions, lacerations, bite wounds, and impalement or stabbing. Bite wounds may comprise up to 15% of feline trauma presentations and are the second-most common cause of feline trauma, following vehicular accidents [2] (Figure 13.1). Keeping this in mind, other common ER "wound" presentations in felines are closely associated and include burns (thermal or chemical), abrasions, lacerations, gunshot and other projectile injuries, impalement, and other penetrating injuries. While decubitus ulcers and diabetic wounds are less commonly seen in cats, they do occur and are frequently complex.



Figure 13.1 A feline patient attacked by a dog. Note the extensive bruising that results from being shaken; even without penetrating wounds, this type of trauma can cause extensive internal injury. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

There is a vast body of research devoted to human wound management; in contrast, there are fewer evidence-based resources for veterinary professionals, although the body of literature is growing. Consequently, many wound management techniques for felines are adapted from human medicine, and the quality of evidence supporting their use in small animal patients varies [3, 4]. Cats present unique challenges in the management of complex wounds due to their size, conformation, normal behaviors (for example, grooming and toileting), the potential for site contamination (from the environment, urine or fecal soiling, or the patient's oral biome), and financial resources of the client. Physiologic differences exist between cats and dogs that are pertinent for veterinary technicians to understand when caring for cats with wounds [3, 5, 6].

The Veterinary Committee on Trauma (VetCOT) has made progress in the establishment of comprehensive databases on veterinary trauma and the accreditation of veterinary trauma centers; while the epidemiology of veterinary trauma (including wounds) warrants further exploration, projects like VetCOT enable analysis of larger data sets than many smaller research projects can offer [7]. As an example, a 2023 VetCOT retrospective analysis of 3,895 feline trauma cases recorded in the registry during a 30-month period between 2017 and 2019 found that more cats presented for blunt trauma than penetrating [7].

13.2 Wound Physiology

In the body, trauma is a complex process modulated through the immune system, nervous system, pain receptors, coagulation cascade, and innate inflammatory responses. The nature of trauma determines the extent of organ, soft tissue, and orthopedic injury. Normal physiologic responses are designed to minimize further injury, restore homeostasis, preserve perfusion, and ultimately result in healing [8, 9]. When a wound occurs, the sympathetic nervous system releases catecholamines and cortisol resulting in an increase in heart rate, greater cardiac contractility, increased glucose delivery to the brain, and higher blood pressure due to vasoconstriction. Persistent increases in catecholamines lead to activation of the renin-angiotensin-aldosterone system and secretion of vasopressin. In turn, water is retained through the renal system to preserve circulating blood volume. Blood flow, initially routed to skeletal muscle and away from the splanchnic circulation, is rerouted back to the brain, heart, and lungs and away from the GI tract and kidneys. Activation of the clotting cascade occurs if vascular endothelium has been damaged; in turn, bleeding carries clotting factors and platelets to the site of injury so that a clot can form, leading to the repair of any vascular defects. At the same time, cytokines are released along with acute phase proteins; these specialized chemicals signal between immune cells that "cleanup" is needed, inducing white blood cells (WBCs) to migrate from the circulating pool to the site of injury [8, 9]. Another function of cytokine signaling is to potentiate healthy inflammation that ensures an adequate response is mounted via heat, edema, and serum leakage that

disables or relocates pathogens and dead cells. Once immune cells are recruited and migrated to the site via chemotaxis, they begin actively consuming bacteria and other pathogens that may have colonized the wound [3].

If any of these responses become dysregulated, the potential for systemic inflammatory response syndrome (SIRS) is increased—for example, if inflammation were to persist past a healthy interval or pro-inflammatory cytokines were to proliferate and anti-inflammatory cytokines were unable to turn them "off." It is important for veterinary technicians to understand the difference between persistent inflammation and infection, as the two conditions are different although they can occur simultaneously. Due to their smaller size, polytrauma is much more common in cats than dogs; for example, a dog bite may cause pulmonary contusions, a pneumothorax, rib fractures, and extensive bruising or a road traffic accident may result in traumatic brain injury, pelvic fractures, bladder rupture, and pulmonary contusions [1, 2, 7, 10]. Some researchers refer to the initial injury as the "first hit" that then determines secondary responses in the body that are considered the "second hit(s)," including hypotension, infection, blood loss, shock, and sepsis [11, 12]. Hospital-associated infections, anesthesia-related complications, and iatrogenic injuries (fluid overload, etc.) also fall under the category of "second hits."

There are specific vocabularies that are employed to discuss wound classification (explained below), phases of healing (enumerated later in this chapter), types of fractures (included in the section on wound classifications), and microbial populations on and in wounds. When discussing the microbial population of a wound, the terms contamination, colonization, critical contamination, infection, and biofilm are used [3, 13, 14]. Contaminated wounds have bacteria on the surface that can be dislodged via irrigation or removed via debridement [3, 13, 14]. Colonized wounds have populations of bacteria or other microbes replicating within the wound that does not adversely impact healing; in contrast, critically contaminated wounds are colonized with replicating microbes that negatively impact healing [3]. As in contaminated wounds, lavage and debridement are effective at removing microorganisms from colonized and critically contaminated wounds but topical antiseptics may be necessary for successful management of critically contaminated wounds. Infected wounds have replicating microbial populations that are of sufficient size and virulence to cause a localized or systemic infection characterized by pain, edema, erythema, purulent exudate, fever, and lethargy that may require systemic antimicrobial use to eradicate [3, 12–14]. Biofilm is an important consideration in the management of all wounds and indwelling medical devices, as it makes management with antimicrobials more difficult [3, 13]. Biofilm is an adhesive matrix of polysaccharides, proteins, and other organic polymers that coats wounds, catheters, and drains, trapping and supporting colonies of bacteria and in some cases protecting them from the action of antimicrobials [13]. Debridement or removal of the medical device is the only resolution for biofilm.

13.3 Wound Classification

Principles of wound management are based on the appropriate classification of the wound, the normal phases of healing, and the optimal intervention techniques for each type of wound. There are four wound classifications based on how contaminated the wound is: clean, clean contaminated, contaminated, or dirty (also referred to as "infected" [8–10]). "Clean" wounds are atraumatic and have been created purposefully using sterile instruments under surgical/aseptic conditions (for example, the incision made for an exploratory laparotomy, [8–10]). "Clean contaminated" wounds are created under surgical conditions and involve the intentional incision and manipulation of hollow organs that contain contaminated or potentially contaminated material; however, contamination is easily resolved or controlled (for example, enterotomy or cystotomy, [8–10]). "Contaminated" wounds comprise most wounds seen in the veterinary ER: those recently sustained, caused by trauma, and likely to be contaminated from the environment or another anima's mouth (for example, a bite wound, degloving, or impalement) or surgical wounds with major breaks in aseptic technique have occurred (i.e., ruptured pyometra or incisional dehiscence of an enterotomy site, [8–10]). Figure 13.2 shows a feline



Figure 13.2 A feline patient with a large contaminated soft tissue wound. Note the discolored, necrotic tissue around the irregular edges of the site. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

patient with an extensive contaminated soft tissue wound. The most contaminated wounds are classified as "dirty" or "infected;" these are wounds with extensive infection, purulent exudate, and/or tissue that is obviously devitalized, necrotic, visibly soiled, or populated by larvae (i.e., abscess, penetrating thoracic wound with necrotic lung, myiasis, etc. [8–10]). By classification, "dirty" wounds contain more than 10^5 bacterial organisms per gram of tissue although this is rarely evaluated or confirmed at the time of care [3, 10, 11].

Open fractures are also considered wounds and are classified as Grade I, II, or III by the extent of soft tissue damage and etiology of the fracture [10]. Grade I open fractures have a small opening in the skin caused by bone penetration. In contrast, Grade II fractures have an opening in the skin with surrounding soft tissue trauma caused by the fracture, and Grade III fractures have an open site with extensive soft tissue trauma in conjunction with a high degree of bone comminution (fragmentation) [10]. Figure 13.3 shows a community cat that was presented to the ER with an old, open fracture of the left femur.



Figure 13.3 A community cat that was presented to the ER with an old, open fracture of the femur. Note the visibly dry and pale bone, desiccated marrow, and wound exudate surrounding the fracture site. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

13.4 Wound Healing

The normal wound healing process is comprised of three phases: inflammation, repair/proliferation, and maturation [3, 4, 8–10]; some sources cite a fourth phase in between inflammation and proliferation (debridement) [10]. This text is based on the three-phase model. Each phase is accompanied by specific physiologic responses designed to bridge to the next phase; however, phases are not clearly delineated in a way detectable to the observer's naked eye and occur regardless of the etiology and classification of the wound [10].

Wound healing in feline patients differs in critical ways from wound healing in canines [3, 5, 6]. A study published in 2006 found that the tissues of the subcutis likely play a larger role in the second-intention healing of feline wounds than canine wounds of similar size and location [6]. In this study, delays in healing were documented in both species but cats experienced greater delays in both granulation tissue formation and wound contracture [6]. The researchers expressed concern that extensive debridement of subcutaneous tissues as part of wound management had the potential to negatively affect healing and predispose patients to infection. A prior study in 2004 by the same research group (Bohling et al.) noted other key differences between cutaneous healing in dogs and cats, summarized here: incisional strength of first intention closure was weaker in cats than dogs, cats produced less granulation tissue than dogs, feline granulation tissue was peripheral in orientation rather than central, feline wounds were overall slower to heal, and it appeared that feline wounds closed primarily via contracture of the edges rather than contracture from the center and epithelialization as in dogs [5]. Veterinary technicians should understand that the inflammatory phase of wound healing (described below) may be weaker in cats than in dogs and that this in turn affects subsequent stages like epithelialization; also of note, feline granulation tissue may be more fibrous and less vascular in nature than canine granulation tissue [3, 5, 6]. Table 13.1 includes the onset and average duration of wound healing phases in small animals.

Table 13.1 Wound healing phases, their onset, and average duration.

Phase of wound healing	Onset	Average duration
Inflammation	Time of injury	5 days
Proliferation/repair	3–5 days after injury	2–4 weeks
Maturation	16–20 days after injury	Months–years

Adapted from [3, 8–10].

13.4.1 Phase One: Inflammation

Phase one, inflammation, begins when the wound is sustained and lasts for up to 5 days afterward. As soon as the skin is breached and vessels are transected, bleeding begins. Hemorrhage transports red blood cells, platelets, and WBCs to the site of the injury. Platelet aggregation, blood coagulation, and clot formation are instigated by blood vessel endothelial damage. Vasoconstriction follows hemorrhage to minimize bleeding and permit the delivery of inflammatory mediators to the site via plasma [8–10]. These include complement, histamine, growth factor, leukotrienes, and prostaglandins to the site by plasma. WBCs are present, in part, to mitigate bacterial and other antigen colonization of the site. Vasoconstriction is followed within 5–10 minutes by vasodilation that encourages further clot formation; ultimately, this vasodilation will also encourage scab formation [8–10]. Clot(s) serve as a framework for endothelial cells, fibroblasts, and WBCs to colonize and infiltrate the wound to perform phagocytosis and enzyme release that removes extracellular debris from the site. The same follows a cellular "schedule" where neutrophils arrive approximately 6 hours after injury, monocytes approximately 12 hours after injury, and within 24–48 hours after arriving, the monocytes have become macrophages that are able to remove bacteria, dead tissue, and other foreign material via a variety of means [8–10].

13.4.2 Phase Two: Proliferation

Proliferation (phase two) begins 3–5 days after the initial injury and persists for 2–4 weeks [8–10]. Proliferation/repair involves neovascularization or angiogenesis (growth of new capillaries at the site), growth of fibroblasts and myofibroblasts, collagen synthesis, granulation tissue formation, and epithelialization (skin replacement). Capillary repair is essential for the formation of granulation tissue that in turn enables further epithelialization. New skin is present within 4–5 days after the initial injury with early contracture noted by days 5–9 [8–10]. The location of the wound may influence the duration of proliferation, with wounds of the extremity reliant on extended epithelialization versus those on the thorax and trunk that heal primarily by contracture [3].

13.4.3 Phase Three: Maturation

The final phase, maturation, begins approximately 16–20 days after the initial injury and may last for years. During maturation, the site contracts, and remodels before assuming its final revised form; the resulting scar will only be 80% as strong as the original tissue [8, 10].

13.5 Approach to the Feline Trauma Patient

The approach to the feline trauma patient is similar to the canine trauma patient with some key differences. While some feline wounds are minor, such as a ruptured abscess or superficial laceration, a large or severe wound may indicate wider trauma [14]. All feline wound patients should be triaged and assessed immediately by a qualified staff member. When taking a history in the lobby or at the vehicle, a 2–3 minutes synopsis should suffice with an emphasis on questions like, "When was your cat last normal? Did you witness the injury? How long ago did the wound occur?" In general, open-ended questions that allow a client to describe events or behaviors are preferred to closed end, "yes or no" questions; however, if a cat is badly injured, time may not permit an emphasis on open-ended questions so technicians should use their best judgment in the moment. If possible, one technician can move the patient to the treatment area while another stays behind to take a more detailed history. It is optimal to obtain CPR consent or a clear do not resuscitate (DNR) status from the client when the patient arrives so that time will not be wasted if resuscitation is needed. Additional questions can be asked later once stabilization has begun (examples below in Table 13.2).

Under normal conditions, low-stress handling techniques that are respectful of the cat are prioritized [15]. In a truly emergent situation, veterinary technicians may need to prioritize efficiency and speed over a more gradual and cat-led approach, but this is never an excuse for rough or disrespectful interactions. The cat should be assessed comprehensively and rapidly; this may require that it be removed from the carrier, unwrapped from bedding, or placed on a table rather than allowed to exit a carrier of its own volition or be examined in the location it chooses (in a sink, under a chair, in the client's lap, etc. [15]). Technicians should use caution since the cat may be in pain or distress. An enclosed area is ideal. The American Association of Feline Practitioners (AAFP) has published extensive guidance on respectful interactions and optimal clinical environments for cats [15].

Table 13.2 Sample detailed history questions for the feline trauma patient. A rationale is included for each.

Sample detailed history questions for the feline trauma patient	Rationale
When was your cat last normal?	Has the client observed any changes that may indicate the trauma is not new?
When did you first note the injury?	Speaks to acuity of the injury.
Does your cat go outdoors? If so, are they supervised?	This will rule in or out a variety of scenarios; for example, if the cat does not go outdoors, vehicular trauma is unlikely.
Did you notice anything out of the ordinary at home	If the cat is an indoor cat, disarrayed furniture or broken items can give clues to the nature of the trauma.
Does your cat have any history of heart disease?	This may help fluid therapy and anesthesia planning.
Have you rendered any pre-hospital care at home or given any medication?	If the client has been given over-the-counter or veterinary medication(s) that may complicate care, such as aspirin or NSAIDs, it is better to know asap.
Is your cat up to date on vaccines?	Should the cat bite personnel, this will be pertinent; in the case of animal bite wounds, the answer will be essential for ruling out rabies exposure.
When did your cat last eat?	If the cat requires general anesthesia on an emergency basis, it may be helpful to estimate how long it has been fasted.
What are your goals for treatment today?	This question is essential to align care teams and clients around expectations and priorities.
Please tell me what concerns you most today.	This question gives clients the opportunity to share concerns about finances, patient quality of life, survival odds, or worries about disfigurement and/or long-term pain.

In a broad sense, there are two types of feline wound patients: stable and unstable, although a seemingly stable patient's status can change rapidly. When a cat is presented to the ER with wounds and/or a history of trauma, it is imperative to proceed with a rapid primary survey to assess key cardiac, neurologic, and pulmonary functions [12, 16, 17]. For the detailed approach to triage of the feline emergency patient, the reader is directed to Chapter 17: "Emergency and Critical Care." Analgesics or sedatives can be administered intramuscularly, oral transmucosal (OTM), or subcutaneously as desired [18]. The reader is directed to Chapter 7: "Analgesic Considerations for the Feline Patient" for further information on analgesic selection for the feline patient. If necessary, oxygen is supplemented via flow by (with or without a mask) or via an oxygen cage, depending on what the cat will tolerate. If the cat is alert and responsive but in respiratory distress, quickly classifying the patient's level of consciousness will suffice as a rapid neurologic assessment, reserving a detailed neurologic exam for later. If the cat is placed in an oxygen cage, observation of its movement in the cage will suffice to assess the gait and get a broader sense of neurologic function. At the time of the primary survey, interventions may be undertaken in response to life-threatening abnormalities such as bandage placement to control hemorrhage, protect exteriorized organs, or re-establish negative pressure in the thorax [16, 17, 19].

Continuing to handle the cat for venipuncture, catheter placement, radiographs, etc., may result in cardio-pulmonary arrest so if in doubt, oxygen should be supplemented as soon as possible, and the cat should be left alone to decompress. Human goals and schedules do not always equate to success when evaluating the emergent feline patient and when working with cats, it is optimal to "think slow to go fast." In other words, emphasize a methodical approach to gathering supplies, plan to over-communicate with colleagues, plan ahead, and strategize next steps to ensure that nothing is left out or overlooked. This will save time and discomfort for the patient once restraint and clinical procedures begin.

All feline wound patients should be evaluated for shock with the understanding that shock presents differently in feline and canine patients [10, 11]. Unlike canines, compensatory mechanisms such as tachycardia and hyperdynamic signs such as bounding pulses and injected mucous membranes may not be seen in felines. Cats in shock may present with either an elevated, normal, or abnormally slow heart rate (HR <160); in addition, hypothermia and hypotension (systolic BP <90 mm Hg) are strongly supportive of shock in this species [10, 11]. Hypothermia affects vascular tone, and cats should be carefully warmed prior to the administration of aggressive fluid therapy. Due to their small size and smaller circulating blood volume, cats are more likely to experience hypovolemia and anemia due to hemorrhage from wounds or cavitary bleeding. In addition, cats that have been shaken, as in a dog attack, may have internal hemorrhage that is not



Figure 13.4 Right lateral radiograph with contrast introduced into the urethra with uptake in the colon, indicating a probable urethral tear. Evaluation of bladder patency is an important element of the secondary survey when assessing a feline trauma patient. *Source:* KM Foltz CVT, LVT, RVT, VTS (ECC).

apparent from the extent of their exterior wounds [7, 10] (Figure 13.1). Occult cardiac disease is common in cats and each feline patient should be auscultated carefully before, during, and after fluid resuscitation to monitor for a gallop rhythm, heart murmur, or altered lung sounds that may indicate underlying disease. Fluid resuscitation for shock should be undertaken carefully in feline patients [11].

If the primary survey establishes that the patient is stable, the rest of the exam can be conducted in a quiet, well-lit area on a softly textured surface. The cat may feel more secure if it is kept in the bottom of its carrier until it absolutely must be moved [15]. The secondary survey comprises a thorough head-to-tail physical examination that includes an oral exam, ocular examination, comprehensive orthopedic and neurologic examinations, abdominal palpation, and detailed evaluation of any wounds. Bladder size should be evaluated via palpation and/or ultrasound since urinary tract herniation, tear, rupture, and uroabdomen are documented sequelae to trauma. Figure 13.4 shows a right lateral radiograph where the cat likely has a urethral tear, as the contrast agent has been taken up by the patient's colon rather than the bladder. Imaging, including contrast cystourethrography, can be conducted along with wound care and fracture stabilization once the patient has been fully evaluated and initial interventions made.

The role of pain in wounds should not be overlooked; early and appropriate analgesia is provided through a multimodal approach to enhance patient comfort, improve healing, enable optimal coping, and ensure tractability [18]. Opioid drugs (such as buprenorphine, fentanyl, hydromorphone, and methadone) form the basis of analgesic planning since they can be titrated, delivered as a constant rate infusion, and reversed or partially reversed [16, 18]. Nonsteroidal anti-inflammatory drugs such as robenacoxib can be added once hypovolemia is corrected and kidney function is evaluated but are not first-line drugs [18]. In addition, other drugs such as ketamine or gabapentin have a role in multimodal pain relief and anxiolysis. Gabapentin has recently been shown to improve stress behaviors in hospitalized cats and may be a good adjunct for cats who require extended hospitalization and associate handling with pain [16, 18, 19]. Butorphanol provides mild analgesia and muscle relaxation but is not sufficient analgesia for patients with extensive wounds or fractures [18].

13.5.1 Triage of Feline Wounds

First aid for emergent wounds is paramount; due to the potential for contamination and zoonosis, personnel should always wear gloves and other Personal Protective Equipment as needed when examining and cleaning wounds (gown, mask, goggles, face shield, etc.) [10, 12–14, 16, 17, 20]. As noted, primary and secondary surveys of the patient are performed to identify potentially life-threatening injuries to major body systems; if deficiencies of the cardiovascular,

pulmonary, or neurologic systems are noted, interventions are made before wound evaluation and care occurs. Common interventions include active warming, fluid therapy, or pressor agents for shock; others include oxygen supplementation, thoraco- or abdominocentesis, blood transfusion, or stabilization of increased intracranial pressure. Reliable vascular access is essential for the administration of fluids, analgesics, antibiotics, and drugs that may be required for comprehensive wound cleaning, exploration, and/or bandaging [10]. Early administration of analgesia makes handling and initial interventions easier and more comfortable for the patient [18].

If the patient has sustained penetrating trauma and a foreign body is protruding from the wound (for example, an arrow, a blade, a stick, etc.), the object should not be removed or the site manipulated until the patient has been stabilized, as hemorrhage or organ rupture may result [8]. In the case of an open fracture, the principle is similar; the site and surrounding soft tissue should not be manipulated, bone pushed back into the wound, or soft tissue pulled to cover the exposed bone since excessive handling prior to imaging can worsen comminution or bleeding [10]. If the site permits, any exposed bone should be covered with sterile water-based lubricant and a sterile wrap until further evaluation can take place. Removal of penetrating foreign bodies in wounds should be delayed until controlled and sterile conditions can be guaranteed [10].

If the wound is actively hemorrhaging, direct pressure is applied by hand or with a pressure wrap [8]. If bleeding is not controlled with pressure, vessels may require visualization, and ligation or application of a topical hemostatic compound to the site is elected. If the distal extremity is hemorrhaging, a tourniquet or a blood pressure cuff inflated to 200 mmHg can be used above the bleeding, but dwell time must not exceed 1 hour before the device is checked and removed lest significant iatrogenic injury occurs [10]. Open wounds should be kept clean and moist, especially if the patient will be moved around the hospital (to imaging, from ward to ward, etc.) before comprehensive wound care can occur. This is best accomplished with a sterile water-based lubricant copiously applied to the site; alternatively, sterile normal saline-soaked gauze or laparotomy pads are applied to the site and covered with a soft, padded bandage [10, 16–18, 21]. All bandage materials should be clean, and the clinician will indicate if they prefer the contact layer to be sterile.

Penetrating chest wounds represent considerable risk to the patient due to the loss of negative pressure within the thoracic cavity and contamination while penetrating abdominal wounds pose similar risks related to contamination, laceration or puncture of organs, and potential for debris in the wound tract. It is imperative that penetrating chest wounds be sealed to restore negative pressure within the thoracic cavity before respiratory compromise leads to arrest. These should be covered immediately with a glove, patch of plastic wrap, or occlusive adhesive dressing (any clean impervious, soft, and flexible item that will form a good seal over the defect) before the chest is wrapped with a circumferential padded bandage [21]. Abdominal wounds, even if potentially not full-thickness or extending into the peritoneal cavity, should also be covered/bandaged immediately until more thorough exploration can occur. Figure 13.5 shows a kitten that has been eviscerated due to a dog bite; following vascular access and stabilization (including analgesia), the exteriorized viscera should be lubricated and covered with a sterile bandage before the kitten is placed in a cage or moved to imaging.

Once the patient has been stabilized and wounds covered, laboratory testing, imaging, and other evaluations should proceed [10, 16, 17, 20, 21]. It has been said that there is a "golden period" after being sustained during which wounds are



Figure 13.5 This kitten has been eviscerated due to a dog bite. As soon as vascular access, shock therapy, and analgesia have been established, the exposed viscera of this kitten should be lubricated and covered with a sterile bandage. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

most optimally closed; however, this period has varied from 6 to 10 to 12 and up to 20 hours depending on research design, patient population, wound type, and results. In relation to the idea of a "golden period" and out of a desire to minimize antimicrobial colonization of wounds, veterinary teams are usually focused on providing wound care as soon as possible after the patient's presentation to the ER. However, a staged approach is preferable since there are significant risks to the patient if sedated or anesthetized wound care is undertaken prior to stabilization [10]. A common scenario results when wound care is started before a patient is hemodynamically stable or reliably normothermic, leading to protracted shock and hypothermia associated with general anesthesia and wound lavage/irrigation. Wounds may also be more extensive than initially thought, leading to extended anesthesia times. The "think slow to go fast" guidance applies to wound care just as pertinently as it applies to physical examination and pre-sedation checklists are recommended to ensure that all equipment, materials, and personnel are prepared prior to starting a procedure.

13.6 Wound Care and Management

13.6.1 Goals of Wound Management

The ultimate goals of wound management in small animal clinical practice are to optimize the body's innate wound-healing processes by maintaining adequate moisture, facilitating the formation of healthy granulation tissue, protecting the site, and preventing infection [3, 4, 10–12, 16, 17, 18, 20–22]. Some wounds are straightforward while complex wounds may require days, weeks, or even months of management coupled with staged surgical procedures before they are fully healed. Wounds that did not receive appropriate early care or cleaning, are infected, involve multiple layers of soft tissue, or are located over high motion or bony sites such as the elbow or antebrachium may require long-term specialist management.

When caring for a wound patient in the clinic, the site should be evaluated at a minimum once daily to check for signs of infection and/or necrosis, monitor response to topical dressings and antibiotic therapy, perform cleaning and debridement, and replace bandages [10, 12]. Patients with bandages, incisions, and/or drains should be reevaluated every 6–8 hours for signs of infection, inflammation, dehiscence, or failure [12]. Ultimately, many wounds require surgical closure, but this should not be attempted until it has been ascertained that the site is free of infection and underlying tissues are healthy. Delayed primary closure is in no way pejorative. In the interim, there are a variety of bandaging techniques, topical dressings, and treatment modalities available that enhance the healing of open wounds in small animal medicine.

Appropriate multimodal analgesia and antibiotic therapy are not optional, especially given the historic pattern of oligoanalgesia in feline patients [15, 23]. Wounds are painful, and a balanced, multimodal analgesic plan is recommended including opioids, nonsteroidal anti-inflammatory drugs (NSAIDs), adjuncts such as gabapentin or ketamine, and non-pharmaceutical therapies like heat, cold, photobiomodulation, and hyperbaric oxygen [14, 15, 24, 25]. In support of evolving concerns around antimicrobial resistance, antimicrobial choice should be driven by culture and sensitivity results whenever possible. Following current guidelines, empirical antimicrobial choices are made based on documented evidence of active infection paired with a thorough understanding of the drug's ability to penetrate the affected tissue, its spectrum of action, and microbial species most likely to be found in the wound. Bite wounds are likely to develop infection due to the oral microbiome and tooth shape of both cats and dogs; species that are commonly cultured from bite wounds include *Staphylococcus, Streptococcus, Escherichia*, and *Proteus* [4]. Empirical management with broad-spectrum antimicrobials is converted to targeted therapy based on culture results, if possible, particularly if healing is prolonged. Critically important and high-priority antimicrobials should not be used as first-line, empirical drugs [26]. When considering infection control for feline wounds, the use of topical agents that have antimicrobial properties, such as sugar, silver, or honey, and commitment to solid principles of wound care like strict observance of aseptic technique, exemplary hygiene and husbandry practices, and copious lavage may preclude the need for systemic antimicrobial use [4, 27–32]. See Chapter 8: "Introduction to Feline Pharmacology," for further reading on antimicrobial stewardship. Veterinary technicians are uniquely positioned and empowered to advocate for the rational use of antimicrobials in this patient population.

13.6.2 Wound Care

Initial cleaning of a wound begins with protecting the wound from further contamination during evaluation as mentioned above. Sterile, water-based lubricant is introduced into the wound in copious quantities before the surrounding fur is clipped in a wide margin with a sharp #40 clipper blade. The edges are shaved manually with a wet/prep razor blade.

If the wound is on an extremity, the clip should be circumferential to enable evaluation of all surfaces. If the wound is large, shallow, and extensively contaminated with organic matter (grass, dirt, gravel, leaves, or other debris), following the initial lubrication and clip it can be lavaged with lukewarm tap water to remove gross debris; alternatively, large pieces of debris can be removed by hand with fingers or thumb forceps [3, 10, 13, 16—17, 20, 22]. This technique is not used for deep or penetrating wounds, as forceful lavage may drive debris deeper into the site [14]. Smaller wounds are typically lavaged using tepid sterile saline or lactated ringer's solution.

The goals of lavage are to dislodge debris, break up biofilm, flush away contaminants, and rehydrate tissues [10, 12–14, 16, 17, 20, 22]. Research has been conducted sporadically and on a small scale to determine the optimal lavage solutions, volumes, and techniques with inconclusive results. The best lavage protocols in small animal practice are grounded in research but overall, veterinary medicine's approach to lavage has been influenced by habit, anecdote, and assumption. It is important to maximize the available evidence supporting some choices over others; for example, sterile equipment and gloves should be used. Hypertonic or hypotonic solutions should be avoided in preference to a balanced, isotonic crystalloid solution without the addition of disinfectants, detergents, or antibiotics [10, 12–14, 16, 17, 20, 22]. Lavage should be copious but not excessive since tissue edema will negatively impact healing.

Many techniques have been advocated for the irrigation of wounds, including the use of warmed bottle irrigation saline, tepid tap or drinking water, and use of a fluid bag attached to a three-way stopcock; with this method a 20–30 ml syringe and 18g IV catheter are used to draw up aliquots of saline or LRS and lavage the site with a target pressure of 6–8 psi [10, 13, 22]. Higher pressure risks driving debris and bacteria further into the wound and lower pressures may be inadequate to clear adherent bacteria from the site. Technicians may find that there are strong opinions in their practice about the optimal technique for wound lavage without a corresponding degree of evidence-based, peer-reviewed literature to validate those opinions; in these cases, an emphasis on "avoiding harm" in the absence of clear proof of "doing good" may have to suffice. LRS is an appropriate choice since there is research indicating that both tap water and normal saline are potentially toxic to fibroblasts, a cell line essential for wound healing [10, 13, 22]. A sterile 2-inch or longer IV catheter with the stylet removed is helpful for the lavage of deeper wounds since it is atraumatic (unlike a needle) and can be inserted far into the site.

Regardless of the technique, lavage fluids should be warm but never hot due to the risk of patient hypothermia (if cold) or tissue damage (if hot). It has often been said that "dilution is the solution to pollution," so generous lavage is preferable to a conservative approach; some practitioners advocate for a minimum of 500–1000 ml [13, 22]. Chlorhexidine scrub or povidone-iodine scrub can be used to clean intact skin surrounding the site but should *never* be used in open wounds, on disrupted skin, over exposed mucosa, or on damaged tissues due to their documented tissue toxicity [10, 12]. Well-diluted povidone-iodine solution (never scrub) is preferred for facial lacerations near the eye(s) or periorbital wounds such as eyelid lacerations due to the keratotoxicity of chlorhexidine. If wound culture is needed, samples should be taken after lavage since those collected prior may not accurately reflect the microorganisms in the wound [3, 12, 13, 22].

Following lavage, the wound is explored and debrided if necessary. It is important for the person performing exploration and debridement to observe the aseptic technique; this includes sterile gloves, gown, cap, and mask or face shield plus draping the site with sterile drapes [10, 12, 21]. Sterile instruments are used for wound exploration, bandage changes, and wound closure. A sterile instrument is used to probe deeper wounds and gauge dead space that may surround a seemingly small entry defect. Unidentified and unaddressed dead space predisposes the patient to abscesses or seromas (pocketing accumulation of serum). Following wound exploration, any necrotic tissue is removed either as en bloc debridement (enlarging the wound under controlled surgical conditions by removing a wide margin of damaged tissue) or by layered debridement (excision of one layer of devitalized tissue at a time), unless an alternative method of debridement is required such as mechanical debridement (the use of adherent dressings to remove devitalized tissue with each bandage change) or larval debridement (the use of sterile, purpose bred, and lab-reared medical maggots to consume necrotic tissue) [4, 10, 12].

13.6.3 Wound Closure

Following lavage, exploration, and debridement, simple wounds are closed. Asymmetric wound edges may be trimmed to enhance apposition prior to closure. Most complex wounds are not closed when sustained but are maintained for a period sufficient for the extent of tissue damage to "declare itself" (waiting a span of days for devitalized tissue to become apparent). During this time, the site is protected with bandages and checked daily for signs of widening necrosis; further debridement is performed daily until the site appears healthy enough to close. Wound closure is classified by the time frame in which closure occurs. The type of closure selected depends on the size of the wound, its severity, the site, the type of debridement employed, and the degree of contamination [10, 12]. There are four types of wound closure: primary/first intention closure,

delayed primary closure/third intention/tertiary closure, secondary closure, and second intention healing [10, 12, 21].

Primary closure is used for wounds that are sutured closed within hours after the trauma occurs [10, 12]. Figure 13.6 shows a surgical incision representing primary closure. Delayed primary closure occurs 3–5 days after the initial injury but prior to the development of granulation tissue, and is recommended for mild-moderately contaminated wounds that may benefit from additional lavage and debridement before closure [10, 12].

Secondary closure is used after granulation tissue has developed (i.e., after the 3–5-day window for delayed primary closure); it is recommended for contaminated/dirty wounds [10, 12]. Second-intention healing is the most protracted type of wound closure since it provides no surgical closure and relies on the body to produce a new granulation bed, progress through all stages of wound healing, and regrow skin. It is generally reserved for wounds situated in awkward areas that cannot be closed, some burns, or degloving wounds on the extremities where there may be insufficient quantity and elasticity of skin to achieve surgical closure [10, 12]. While many wounds might in time heal via second intention, there are distinct advantages to the other types of closure including reduced risk of infection, less pain, less risk of site contracture that might affect mobility, and less disfigurement. Table 13.3 compares types of wound closure and the type(s) of wounds for which each is used.



Figure 13.6 Surgical closure at the site of an excised vaccine-associated sarcoma. This represents the primary closure of a clean wound, as the incision was created under controlled sterile conditions and closed the same day. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

Surgical skin flaps (repositioning a nearby portion of partially excised skin to cover a wound without excising it completely), fish skin bandages, and skin grafts (complete excision of skin from one part of the animal's body for placement over a wound on another part of the body) are speciality approaches to difficult wounds. Skin grafting success rates may be enhanced by the concurrent use of negative pressure wound therapy (see section "Emerging Modalities") [3].

13.6.4 Topical Preparations in Wound Care

Topical treatments are effective adjuncts in the management of complex wounds, particularly those that require time for a healthy granulation bed to form, desiccated wounds that require additional moisture for healing, and dirty/infected wounds. Optimal wound healing requires a finessed approach to topical agents and bandaging since not all are appropriate for every stage of wound healing; for example, an agent that promotes moisture may impede oxygenation necessary for proliferation and repair or one that is designed to inhibit bacterial colonization may also be cytotoxic to fibroblasts and myofibroblasts [4, 10].

Table 13.3 Types of wound closure and their intended uses.

Type of wound closure	Timeframe in relation to injury	Intended use
Primary	Within hours of injury	Clean, uncomplicated, minimally contaminated.
Delayed primary	3–5 days following injury	Mild to moderately contaminated, prior to formulation of granulation tissue; would benefit from additional lavage or debridement.
Secondary	>5 days after injury	Contaminated, visibly dirty, or older wounds, after the formation of granulation tissue.
Second intention	Days to weeks after injury	Burns, degloving wounds, wounds that cannot be closed by surgical means.

Products readily available to the small animal practitioner include alginates, honey, hydrogels, hydrocolloids, and sugar in addition to other ointments (triple antibiotic, silver sulfadiazine [SSD], etc.) [4, 10]. Alginates (also known as calcium alginates) have hydrophilic ("water-loving" or water-attracting) properties that enhance granulation tissue formation. Hydrocolloid dressings are occlusive dressings designed to reduce contamination, stimulate collagen development, and retain fluid in the tissues; however, they may encourage exuberant granulation and allow bacteria already present in the wound to proliferate [3, 4, 10]. Hydrogels are manufactured as gels or as gel-impregnated sheets that are placed over a wound and are designed to retain fluid in a wound, enhance granulation, and encourage contracture; their use may result in smaller scars [4, 10]. It is important to monitor bandages closely that incorporate any dressing designed to attract or retain fluid, as failure to do so can increase the risk of infection, macerate or soften tissues unnecessarily, and cause discomfort for the patient.

Honey and sugar have been used in human and veterinary wound management for centuries, are easy to find, and inexpensive. Both have antibacterial properties through osmotic gradients that dehydrate microorganisms, reduce wound edema, accelerate sloughing of necrotic tissue, aid in maintaining moisture, attract macrophages, provide nutrition for cells, and provide a mild debridement effect. In addition, honey naturally contains hydrogen peroxide at a very low concentration that is believed to adversely affect bacteria in wounds along with proteins, carbohydrates, amino acids, fatty acids, and vitamins [4, 8, 27–32]. Both are recommended for dirty and contaminated wounds. Table sugar is more practical for deep wounds since it can be poured into the site and honey is useful for large wounds since it can be spread on [4]. Care should be taken to prevent contamination of the sugar or honey container. While any type of honey can be used, Manuka honey has been documented to have specific advantages over other honey [8, 27, 29, 30]. Manuka honey is monofloral honey sourced from bees pastured on *Leptospermum scoparium* trees; in addition to the other properties of honey described here, it also contains methylglyoxal (MGO), a compound shown to inhibit the growth of multiple drug-resistant organisms such as *Staphylococcus aureus, Pseudomonas aeruginosa*, and *Escherichia coli* [8, 29, 30]. Typically, Manuka honey is labeled with a "unique Manuka factor" score (UMF) that reflects the concentration of MGO, its precursor compound, and other unique components like Leptosperin [29, 30]. Commercially produced, irradiated, medical-grade honey products (impregnated gauze, gel, etc.) are widely available from both human and veterinary medical suppliers. When considering the peer-reviewed evidence for and against the use of honey in wound management, it is important to consider not only the quality of evidence but study design, the type of honey, and whether the effectiveness of the honey was studied in vitro (in a laboratory setting) or in vivo (in animal or human patients) [27–32].

Bandages placed over topical agents like hydrocolloids, sugar, or honey require close monitoring and frequent changes due to increased wound exudate. While moisture is advantageous in the early stages of wound healing, it can be an impediment to healing in later stages and may allow bacteria to proliferate in the absence of oxygen if an occlusive dressing is left in place for too long [3]. Sugar and honey should be used until healthy granulation tissue is seen, at which point their use can be discontinued [4, 10, 31].

13.7 Bandage Techniques

When caring for a feline patient with a bandage or bandages, extra attention to comfort and mobility is key [15, 33]. Most cats resent being fitted with a bandage and many find them either paralytic or a source of great frustration; cats may roll, kick, thrash, self-harm, or refuse to stand and walk normally depending on the location and type of bandage. It is as important to ensure that any bandage placed on a feline patient is appropriately padded and not overly tight as it is to ensure that the bandage remains clean and dry. Special care should be taken to ensure that coaptation devices are available for the bandaged patient that support normal behavior like grooming, eating, and toileting. For example, a cat with a modified Robert Jones limb bandage may appreciate a low-sided litter pan such as a cafeteria tray or baking sheet that makes entrance and egress easier [33] (Figure 13.7). A cat with a chest wrap may find it difficult to assume a natural posture for eating; elevated bowls or hand feeding may be helpful for this patient. If possible or desirable, infant or toddler t-shirts, infant onesies, or other "clothing" items can be used to protect bandages and surgery sites rather than an Elizabethan collar; if an Elizabethan collar is necessary, a soft, flexible style is preferable to a rigid one. If a clothing item or an Elizabethan collar is used, care should be taken to keep it scrupulously clean since cats have a keen sense of smell and are sensitive to odors. An E-collar crusted with old food or litter may result in food aversion or inappetence. These patients appreciate supplemental grooming as part of their nursing care plan, particularly areas they cannot reach easily due to their bandage or those that are covered by the bandage [33].

Until a wound can be closed, it must be protected from the environment and the patient, particularly if topicals are used [10]. Other goals of bandaging include maintaining moisture in the wound, creating conditions that are optimal for healing, stabilizing fractures, and preventing infection [4, 10, 12]. There are almost as many types of bandages as there are types of wounds; this section will focus on the padded bandage, wet-to-dry bandages, and tie-over bandages.



Figure 13.7 A cafeteria tray makes a good litter pan for feline patients with bulky limb bandages. This bandage has become soiled and should be changed as soon as possible. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

13.7.1 Padded Bandages

A simple padded bandage with or without a splint or cast is appropriate for many wounds and simple fractures depending on their location, although if the wound is very large, highly exudative, mechanical debridement is used, or it is on a part of the body where a conventional padded bandage cannot be used (stifle, inguinal or axillary fold, etc.), an alternative bandaging method is usually selected [12, 34]. Options include combinations of wet-to-dry, tie-over, and/or polyurethane film bandages. Splints and casts are not appropriate for the long-term resolution of complex fractures but are recommended for simple, closed fractures and fracture stabilization until surgical fixation can occur (open, comminuted, etc.) [10, 12, 34].

The simple padded bandage is probably the most used in veterinary medicine [10, 34]. It consists of three layers: the primary or contact layer that touches the skin, the secondary or absorbent layer that consists of padding, and the tertiary or support layer that protects the inner layers from the external environment while providing structure [10, 34]. Padded bandages can be used with or without the application of pressure to stabilize fractures and minimize edema, with or without a splint or casting material, and may incorporate sterile or nonsterile dressings and topical medications. Supplies for a simple padded bandage include a nonadherent pad or pads to place over any open wounds, porous white tape to make stirrups, a tongue depressor, cast padding (2 or 4 inch depending on patient size), minimally elastic cling gauze, and elasticated cohesive wrap for the tertiary layer [10, 12, 34]. Elastic tape is optional. It is helpful to ensure that cast padding is snugly rolled, and that cohesive wrap has been loosened somewhat prior to beginning.

To place a lightly pressurized padded bandage, the animal is placed in the most optimal position (standing or in lateral recumbency, depending on the area of the body to be bandaged) with the area of interest supported by an assistant in a normal physiologic position. For limbs, it is particularly important for patient comfort and correct healing that the limb is neither hyper-flexed nor hyperextended [10, 12, 34]. First, the nonadherent pad or pads are placed over any open wound(s) as the primary/contact layer; then, if placing the bandage on a distal extremity, two equal lengths of white tape are placed on the lateral and medial aspects or dorsal and palmar/plantar aspects of the limb and foot. Approximately half the length of the tape should touch the patient's skin while the other half extends past the foot. The adhesive ends can be stuck to one other (tabbing the tape is helpful) or attached to either side of a tongue depressor until needed. With the assistant gently holding the patient's toes rather than the stirrups, cast padding is wrapped around the limb starting at the patient's toes and working distally to proximally, taking care to overlap the padding by approximately 50% with each pass [10, 12, 34]. When bandaging the thorax, it may be helpful to pass cast padding through and around the forelimbs to keep the bandage from sliding caudally with patient motion. If bandaging the abdomen in male animals, the bandage should allow for normal urination without soiling the bandage. Regardless of the site being bandaged, the application of cast padding is repeated until it is of sufficient thickness to meet therapeutic goals. It should be placed smoothly, without creases, bunches, or wrinkles that may cause uneven pressure on the underlying tissue. In general, the more padding is placed, the more pressure can be safely applied by the elastic layer [12, 34]. Padding should always extend past the tertiary layer to protect the patient from the pressure it exerts.

Following the application of cast padding, cling gauze is applied in the same fashion beginning at the toes, working distal to proximal, and again leaving padding visible at the top and bottom of the bandage [10, 12, 34]. It is important to apply this

layer with even tension as uneven pressure can have significant negative consequences for perfusion of the underlying tissues. For a limb bandage, once the gauze is in place, the opposing stirrups are peeled off the tongue depressor and reflexed back onto the limb so that the adhesive surface is in contact with the gauze; when used on a limb bandage, stirrups provide proximal pressure that in theory prevents the bandage from sagging distally [10, 12, 34].

Once the stirrups are in place, cohesive elastic material is applied starting at the toes and working proximally, taking care to leave padding visible at the top and bottom of the bandage. The elastic material can be placed without tension as a protective layer by simply laying it over the secondary layer or tension can be incorporated in the application by stretching the material around the limb during placement to compress the secondary layer [10, 34]. Some technicians add a single strip of elastic tape at the top of the bandage with 50% of the width on the skin and 50% on the bandage as a measure to prevent debris from migrating into the bandage, while some add a cuff of elastic tape at the distal end of the bandage to cover visible cast padding and keep it clean. Once the bandage is complete, the technician should check all edges, top, and bottom for adequate padding and comfort—the bandage should be snug but never tight. If the foot is incorporated, the third and fourth digits should be visible and there should be room between the toes to insert one finger to the depth of the first knuckle.

A modified Robert Jones bandage is constructed with a similar technique but with significantly more padding and longer stirrups; this type of bandage is used to stabilize fractures of the distal extremity between the time of injury and surgical repair, so more padding is needed to protect the limb from the high tension placed on the secondary and tertiary layers [10, 34]. The modified Robert Jones is a heavy and cumbersome bandage, and many feline patients struggle to move naturally when wearing one. Care must be taken that the weight of the bandage does not create painful traction on the limb.

If a splint is used in conjunction with a padded bandage to provide additional support or fracture reduction/bone alignment, it is best placed between the secondary and tertiary layers [10, 12, 34]. It is important to ensure that any excess splint material is trimmed as needed and that the cut end is well padded to prevent laceration or pressure sores associated with patient movement. Depending on the type of splint, the foot may be entirely incorporated into the bandage, or the toes may be visible/accessible. Common types include the spoon splint (so-called because it is shaped like a spoon) and the Mason meta splint or quick splint [12]. Splints should not be confused with casting, where fiberglass or other casting tape is softened in warm or hot water, shaped to fit the patient while pliable, and then dried and trimmed before being incorporated into a bandage. Casts are placed between the padding and supporting layers, much like splints. Casting provides more customization than ready-made splint products and is often used for the stabilization of specific types of fractures or in patients where a correctly sized or appropriate style of splint is unavailable.

Poorly constructed or damaged bandages result in disaster from pressure necrosis, nonhealing wounds, devitalization of the toes, and sealed-in contamination [10]. In addition, the elastic elements of a bandage may tighten if they get wet. For this reason, any patient fitted with a bandage should wear an E-collar and the bandage should be covered with a specialized bandage protection sleeve or other homemade protection device such as a dry, cut-down IV fluid bag whenever walking outside. Water bowls, bedding, and litter boxes should be monitored closely, and patients watched to ensure that they are not introducing water or urine into their bandage(s). Patients should not be bathed for the duration of any treatment that requires a bandage. While hospitalized and following discharge, the bandage and site should be checked twice daily at a minimum for slippage, moisture, discharge, odor, edema, pain, heat, or abnormal coolness of the toes that could indicate complications. While it may be inconvenient for clients, soiled or wet bandages must be changed even if this requires a return trip to the ER or the primary care veterinarian. Limb amputation has been required in animals that did not receive appropriate care following a bandage becoming wet.

13.7.2 Wet-to-dry Bandages

Wet-to-dry bandages are indicated for deep, dirty, and/or highly exudative wounds. They employ sterile gauze or laparotomy pads soaked in sterile saline to pack the wound; these are then covered with a padded or adhesive bandage and are often used as part of a tie-over bandaging technique [4, 10, 12]. Wound exudate is wicked from the site through the damp layer and into the padding, which becomes less moist over time. When the padding is removed, dead tissue is also removed because it has adhered to the formerly damp layer; however, healthy tissue can also be damaged when a wet-to-dry bandage is changed [12]. These bandage changes can be uncomfortable for patients so appropriate analgesia or anesthesia should be used [10, 12]. Wet-to-dry bandages are generally for in-hospital use and a patient should not be discharged with one in place unless the animal is returning to the clinic daily for bandage changes.

13.7.3 Tie-over Bandages

Tie-over bandages are ideal for deep, large wounds in sites with high motion or where mild stretching of the skin is desirable prior to closure (Figure 13.8). In a tie-over bandage, stay sutures are placed around the periphery of the wound before the site is packed with sugar, sterile absorbent material like laparotomy pads or gauze, or both. Additional sterile material (usually laparotomy pads) is placed over the packing before the umbilical tape is laced over the top through the stay sutures. If desired, a portion of the drape or a huck towel can be placed between the packing and the ties for additional protection and the entire bandage covered with an adhesive film or sheet dressing such as Ioban™, Tegaderm™, or Hypafix™. When the bandage is changed, the umbilical tape ties are removed, the packing taken out, and the wound is checked, debrided, and lavaged if needed before the packing and ties are replaced. The stay sutures hold the packing in place, enable the bandage to be changed with less discomfort for the patient, and as noted mild skin stretching can performed over time, making eventual closure easier. A tie-over bandage can be maintained for several days while a wound declares itself and granulation tissue is developing or while healthy tissue is encouraged in a dirty or necrotic wound. Like a wet-to-dry bandage, a tie-over bandage is best monitored in the clinic. Common complications include damage to the stay sutures, dislodgement of padding, and patient damage.



Figure 13.8 A tie-over bandage in the groin of a cat. Note the surgical drape material covering the packing material; it is situated under the umbilical tape and then the entire site is covered with iodine-impregnated adhesive film. *Source:* KM Foltz, CVT, LVT, RVT, VTS (ECC).

Film bandages provide a cost-effective barrier between wounds and the environment [10]. In addition to their utility over flatter areas such as the abdomen or lateral thorax, they can be used over high-motion areas, such as joints, and provide a reliable method to protect medical device insertion sites such as central and PICC lines, chest tubes, and abdominal drains. Products such as Tegaderm™ + Pad, Primapore™, Hypafix™, and Kliniderm™ may be appropriate as the sole protection for smaller wounds and are also effective over incisions. Many of these products come with or without integrated nonadherent padding and care should be taken to select the right application for the need; for example, film without padding should not be used over incisions or wounds since sutures, staples, or healthy tissue might be removed along with the film during dressing changes.

13.8 Wound Drains

If a wound is deep, exudative, or contains a large amount of dead space, a drain is desirable. Drains are classified as active or passive [10, 12, 21]. The most common active drain used in small animal medicine is the Jackson-Pratt or suction grenade [8, 19]. A Jackson-Pratt drain is a ported bulb (resembling a hand grenade, hence the name "grenade drain") attached to a long segment of tubing that terminates in a heavily fenestrated, soft, hollow paddle (Figure 13.9). The fenestrated end is surgically placed into the wound's dead space using an aseptic technique before the wound is closed. The bulb is "charged" by opening the port, rolling up the reservoir, and squeezing out as much air as possible before re-sealing the port. The gentle negative pressure created by the bulb extracts fluid from the wound and encourages contracture of the dead space. Over time as the bulb fills, the negative pressure becomes exhausted, and the grenade must be emptied at intervals via a syringe to re-charge the drain. Fluid production can be quantified and cytologic examination performed if needed, although cytology results should be evaluated with caution due to the dwell time and potential contamination of fluid. The drain is removed when fluid production has tapered off.

In contrast, the most common exemplar of passive drainage is the Penrose drain, a segment of soft hollow tubing that is placed into a wound's dead space [10, 12, 21]. Fluid travels down the drain and exits the wound via gravity flow. Penrose

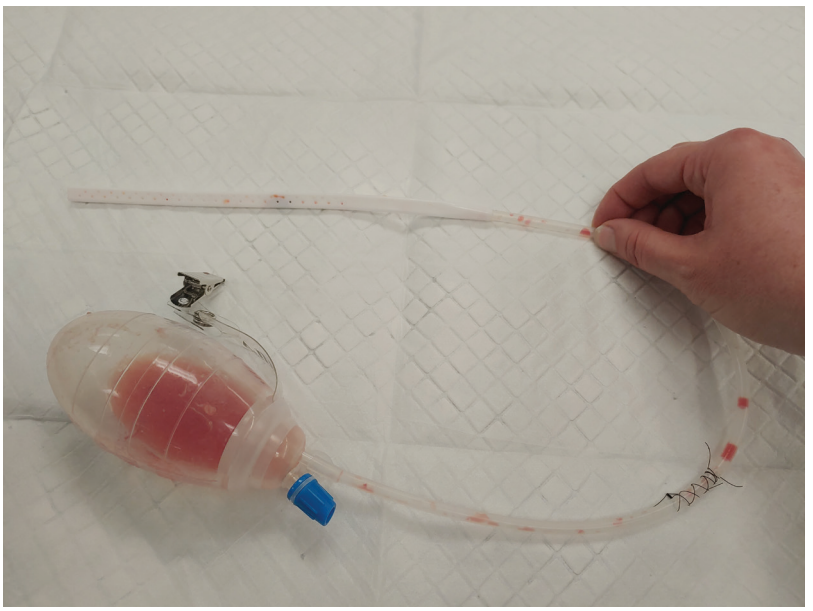


Figure 13.9 This Jackson-Pratt drain has been removed from the patient to show the fenestrated portion that is placed in the wound. The collection bulb gives this active drain its other name, "grenade drain." *Source:* KMF Foltz, CVT, LVT, RVT, VTS (ECC).

drains may predispose the patient to bacterial infection more than active drains, although both have the potential to introduce environmental contamination into the wound. If used without a bandage to cover them, Penrose drains can be messy and are at risk of patient removal. Drain sites should be monitored closely and always handled with gloves and aseptic techniques.

13.9 Emerging Wound Management Techniques

New wound management techniques are constantly emerging in veterinary medicine. Of particular interest within the past decade are negative pressure wound therapy (NPWT), hyperbaric oxygen therapy (HBOT), and photobiomodulation or laser therapy [3, 10, 24, 25]. NPWT uses a portable, low-power suction unit attached to tubing that is surgically placed into a lavaged and debrided wound before being surrounded by sterile open-cell foam; the foam, tubing, and wound are then covered with an adherent occlusive dressing before the suction unit is activated [3, 10]. A reservoir in the suction unit retains wound exudate for disposal. NPWT is believed to stimulate granulation tissue formation, enhance closure of dead space, provide mild skin stretch, and facilitate the removal of contaminated exudate [3]. In addition, some evidence exists that NPWT may modulate inflammatory cytokine signaling [3].

Optimal pressure settings for NPWT in cats have been identified at −125 mm Hg; therapy should not be paused for more than 2 hours/day at the risk of causing bacterial proliferation that can lead to infection [3], a point of consideration and importance if there are difficulties troubleshooting the system (for example, if leaks are detected). Therapy can be provided in continuous mode or intermittent mode with continuous mode preferred as more comfortable for patients. Dressing changes are required every 3–4 days based on functionality, although they should be checked several times a day along with the pressure gauge and suction setting [3].

NPWT has been recommended for large, infected, and/or chronic wounds and has resulted in shorter times to closure in some studies [3, 10]. It is also a good choice for deep decubitus ulcerations, degloving wounds, and surgical dehiscence of the abdomen ("open abdomen" management). It is not a good choice for patients with coagulopathy, neoplastic wounds, or wounds with exposed vasculature [10]. NPWT only works when a totally airtight seal can be achieved and maintained around the entire perimeter of the wound, and changing the dressings on a NPWT patient requires sterile supplies and general anesthesia. It is also important to note that due to the nature of NPWT, epithelialization cannot occur while it is in use; once any wound infection is controlled and a healthy granulation bed is noted, NPWT should be discontinued in favor of other bandaging or dressing techniques, surgical closure, a wound

flap, or skin graft [3, 10]. NPWT requires expertise, extended hospitalization, and financial investment by the client. It is not available in all facilities [3, 10].

HBOT involves putting the patient in a specialized chamber that delivers pressurized oxygen at 100% (room air is 21% oxygen at sea level); the increased pressure gradient increases the amount of oxygen dissolved in plasma that can then be moved to tissues [10]. HBOT may enhance angiogenesis, aid in fibroblast proliferation, and assist WBCs in the oxidative destruction of bacteria. Most of the information available on HBOT is extrapolated from an extensive study performed in human patients with burns and nonhealing wounds. HBOT is not widely available but is becoming more accessible in specialty hospitals. Clients should be aware that HBOT requires specialized equipment, staff training, time, and sequential sessions.

Photobiomodulation uses micro doses of red and near-infrared light to penetrate tissues; exposure to the light spectrum is believed to increase cellular ATP production, decrease inflammation, and aid healing [10, 24]. There is evidence to support the use of some types of photobiomodulation, but many variations of the available technology exist; for this reason, consumers should be cautious when selecting a method and choose a practitioner with active certification from a reputable training organization. Veterinary technicians can pursue advanced training in these techniques.

13.10 Burn Care

While less commonly sustained than other types of trauma in veterinary medicine, thermal burns can have a severe and wide-ranging impact on patients. Thermal burns result from a variety of mishaps, including exposure to stovetops, barbecue grills, campfires, boiling water, car engines, hot oils or fats, and house fires. Other burn etiologies include improperly used warming devices (such as hot water bottles, rice socks, and heating pads), exposure to caustic chemicals, radiation therapy, and improperly grounded surgical cautery. The management of moderate to severe burns represents significant emotion, time, and financial commitment for both pet families and veterinary healthcare teams.

Veterinary technicians may have heard the terms "first-, second-, third-, and fourth-degree" burns in association with human healthcare. While these terms are older, they are still widely in use and considered appropriate for this text [35]. Burns are classified according to two variables: the depth of the injury (layers of skin affected) and the total percentage of body area that has been affected [35], abbreviated as TBSA (total body surface area). To understand burn classifications, it is helpful to review the normal structures of the skin. Moving from the surface into deeper tissues, the layers are as follows: epidermis (the most superficial layer), dermis, and hypodermis. The dermis contains the superficial and middle plexuses where glands and hair roots are located, while the hypodermis contains deep plexus and panniculus muscles [35]. The deep or subdermal plexus also contains the vascular supply (capillary beds) that supplies the upper layers with oxygen, nutrition, and waste removal. Table 13.4 delineates the layers of integument affected by the four burn classifications [8]. TBSA >20% involved in burns indicates a guarded prognosis and increased risk of systemic derangements like SIRS, sepsis, multiple organ dysfunction syndrome (MODs), and AKI. TBSA >50% is linked with a poor prognosis in human patients; in veterinary patients injured to this degree, it is not unreasonable to discuss humane euthanasia with clients based on quality of life [35].

The physiology of burns is somewhat different than other wounds; since skin retains heat as part of the injury, it may take several days before the true extent of damage is visible and there is ongoing injury to the tissue during this time [35].

Table 13.4 Burn classifications and the associated layers of skin affected descriptors of the clinical presentation of each classification.

Burn classification	Dermal layers injured	Clinical presentation	Also known as
First degree	Epidermis	Erythema, dryness, pain on palpation	Superficial
Second degree	Epidermis, variable depth of dermis	Plasma or serum oozing, hair may or may not be present, discolored skin (yellowish or brown), decreased sensation on palpation	Partial thickness
Third degree	Epidermis and dermis	Leathery or charred skin, no sensation on palpation	Full thickness
Fourth degree	Epidermis and dermis	Similar to third-degree but bone, muscle, and tendon are involved or damaged	Full thickness

Adapted from [8].

In addition, severely burned skin forms eschar (a thick plaque or scab of dead tissue) that acts as a cap to retain purulent exudate and may mask the depth of underlying damage. Incredibly large volumes of fluid can be sequestered in burns and lost through exudate leading to electrolyte abnormalities, protein loss, anemia, and hypovolemia. Burn patients are also at an increased risk of upper airway occlusion due to edema and inflammation, multiple organ dysfunction, infection leading to sepsis, and disseminated intravascular coagulation due to microthrombi formation [35].

Due to the extended time needed for burns to reveal the extent of damage, many cannot be closed within the first week of being sustained and must be managed as open wounds. Principles of wound care described earlier in the chapter still apply to burns: commitment to sterile technique, moisture retention in the site without encouraging infection, commitment to sequential debridement and bandage changes on a regular schedule, and intelligent use of topical therapies [35]. In contrast to other topicals, aloe vera cream is recommended for use in the first 24 hours, SSD on sequential days, and honey throughout until a healthy granulation bed forms. SSD can be used in the early management period and throughout the repair/proliferation period. Like honey, its use may result in increased exudate from the site requiring diligent monitoring and changing of bandages [35]. Veterinary technicians should be aware that SSD may change color or discolor surrounding skin as a normal consequence of use; "purulent" exudate at a burn site may actually be related to the use of topical SSD and not infection or skin necrosis.

Wound management in the feline presents many opportunities for veterinary technicians to use their skills and lead as patient advocates. In addition to the practical matters of first aid, clipping/cleaning, lavage, and bandage placement, technicians also use their knowledge of wound classification, physiology, anesthesia, and analgesia to support these patients in positive outcomes. When caring for a cat with wounds, a comprehensive approach should be adopted that takes into consideration the type of injury, patient's temperament, emotional needs, the need for coaptation devices, and response to therapy. Technicians can provide additional comfort through emerging modalities of wound management such as certification in HBOT and photobiomodulation.

See the companion website for further clinical references.

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14

Cardiology/Cardiovascular Diseases

Kristie Garcia, LVT, VTS (Cardiology)

TECHNICIAN TIDBITS

- The technique used to check the blood pressure of a patient should be recorded and repeated each time for the same patient. Using the same size cuff, on the same limb, in the same position is important to accurately assess trends.
- When attempting to locate the sound of the pulse through the Doppler, small changes in both the position and the pressure of the probe should be attempted as troubleshooting techniques.
- The author prefers the tail in cats as they are able to hide under a towel, owner, or technician while blood pressure readings are obtained to reduce stress. The cuff size selection is the same as when using a leg, and the cuff is placed at the base of the tail.
- Handling the dyspneic patient can most often be successful by wrapping the neck/scapula area with a blanket. Rolling the blanket to create a wide, soft "collar" allows the technician to control the head while providing some security.
- Chemical restraint is always a possibility in cardiology cases, advocate for it! Just because they have heart disease, it does not always equate to "no sedation."
- A palatable treat is a good distractor for the feline patient experiencing anxiety while undergoing an echocardiogram.
- Sedation for a consult of a stable patient or a patient in distress can include butorphanol intravenously and gabapentin orally. These are often chosen in the cardiology department, while ketamine is to be avoided.
- A helpful way to recall where the electrocardiogram leads are to be placed is to remember "Smoke over Fire" and "snow over grass." This describes the leads placed, black front leg and red lead back leg for the left side, white lead on the front leg, and green lead on the back leg for the right side.
- When placing an intravenous catheter in a cat with heart disease or congestive heart failure, patience is rewarded. Priming the catheter with saline will result in a gentler flash, pause again before advancing and feeding the catheter into the vessel.
- When drawing blood from these cats, patience is needed. A slow gentle steady pull in the syringe plunger will be more successful for getting a sample and cause less vessel trauma than repeated aggressive pulls on the plunger.

"The smallest feline is a masterpiece"

– Leonardo DaVinci

Our roles as veterinary technicians can include understanding a wide variety of species and their levels of care. Cats are an irreplaceable accentuation to the lives of their families as well as the veterinary staff. From the tiniest kitten to the stoic elderly old orange boy, each cat enriches our days in the clinic, mostly for the better. We love their biscuits, toe beans, and happy motors. As veterinary technicians, we can usually understand if they are relaxed or fearful in the hospital. Where they are challenging for us is in their ability to hide their diseases for a long time. This chapter will focus on the cardiovascular diseases most commonly found in cats and will equip the veterinary technician to be a strong advocate for these amazing patients.

To appreciate changes to the heart and lungs from disease, understanding normal anatomy and physiology is necessary. The physiological operation of the heart has an electrical and mechanical cooperation that works together. The electrical component of the cat's heart is the same as all mammals. Made up of the sinoatrial node (SA node), atrioventricular node (AV node), and the Purkinje system, the electrical stimulation of the myocytes causes the contraction of the muscle in organized waves. We can assess these electrical waves for any abnormalities by attaching leads to the patient and looking at their electrocardiogram (ECG). These electrical waves through the myocytes cause them to contract. This contraction of tissue causes pressure changes in each chamber of the heart to push blood forward (Figure 14.1). The heart consists of four chambers and four valves. The top chambers of the heart are the left and right atria. The bottom two chambers are the left and right ventricles that are separated from the atria by the mitral and tricuspid valves. The mitral valve separates

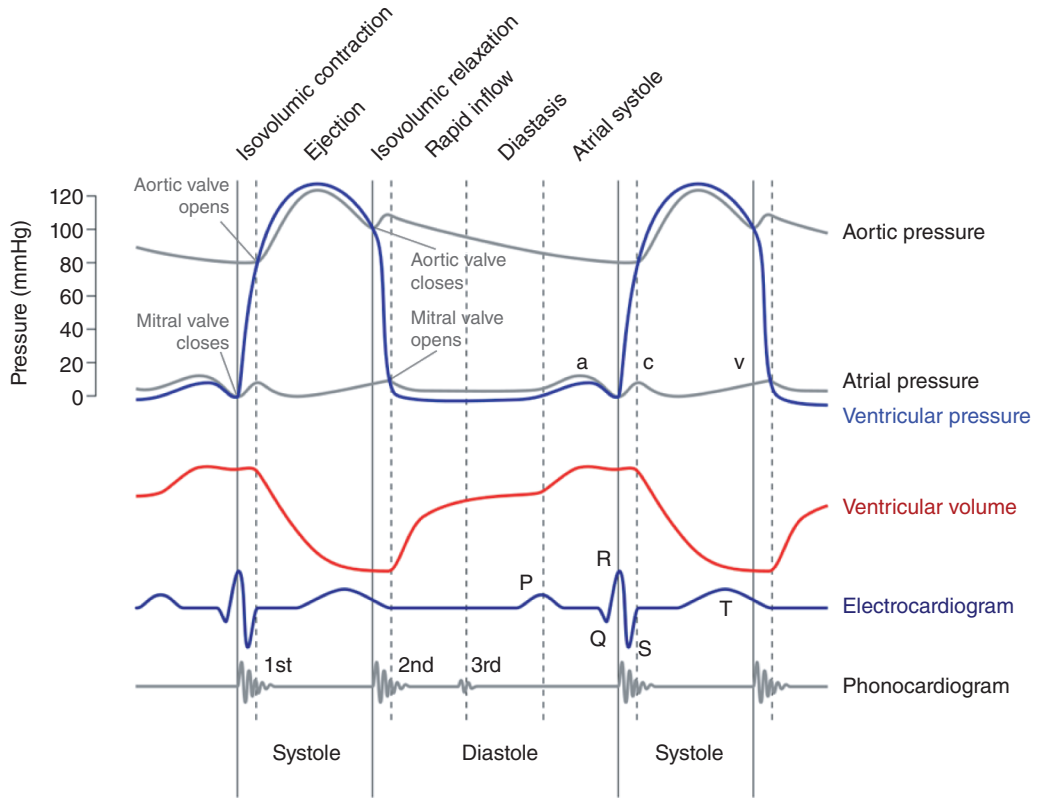


Figure 14.1 Wiggers diagram. This image shows the coordination of the heart valves, chamber pressures, and ECG. *Source:* Artwork by Daniel Chang. Licensed under the Creative Commons Attribution-Share Alike 4.0 International License.

the left atrium and ventricle, and the tricuspid valve separates the right atrium and ventricle. The aortic valve is where the blood leaves the heart from the left ventricle out to the body, while the pulmonic valve is where the blood leaves the right ventricle to the lungs. The pressures in each of the chambers of the heart as well as the lungs must work together to propel blood forward (Figure 14.2).

The pressure in the right atrium will be 0 mmHg as the blood returns from the body into the chamber. When the right atrium contracts, the tricuspid valve opens, and the pressure rises to 5 mmHg in the right atrium as the blood travels to the right ventricle. The right ventricular pressure is <5 mmHg as the blood enters and reaches 25 mmHg as the ventricle contracts to force the blood out into the lungs. The pressure in the pulmonary artery (PA) and lungs is 25 mmHg. As the newly oxygenated blood returns to the left heart from the lungs, the left atrial pressure is <10 mmHg. The atria contracts, opening the mitral valve, increasing the left atrial pressure to 10 mmHg and the blood enters the left ventricle. As the ventricle contracts, the blood is forced out into the aorta and to the body at 120 mmHg to reach all the organs and tissues [1, 2].

14.1 Patient History and "History Gathering Questions"

A thorough patient history is important when approaching the diagnosis and care of the cardiac patient. Any underlying disease, diagnosed or not, will affect the response to therapy for heart disease. Knowing all the medical history with any past or current therapies is important for high-quality patient care. Cats with heart disease can hide it well for a long time. Asking the owner what their concerns are could include valuable information. Asking for a list of current medications or supplements will also help get a full history. Some examples of questions to ask the client are listed below.

- Are there behavior changes you have noticed?
- Is their appetite normal?
- What are the current medications your cat is taking?

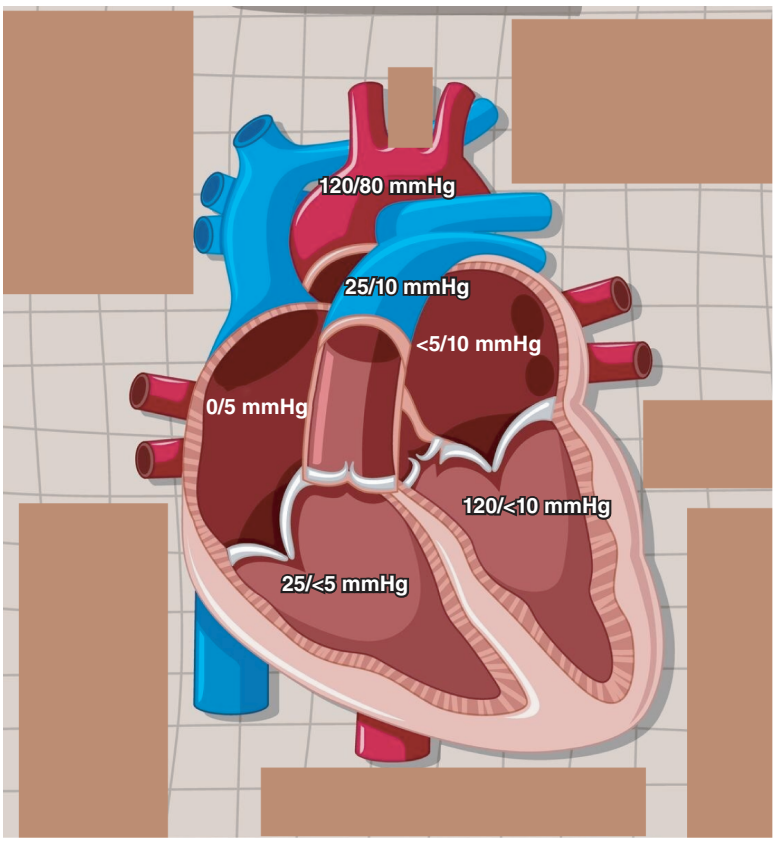


Figure 14.2 Heart anatomy with the chamber pressures. *Source:* Freepik.com.

- Has anyone from our office called and changed the doses of medications you are giving "kitty" over the phone?
- Have you gotten any new pets?
- Have you had "kitty" since they were a kitten?
- Is there anything concerning you about "kitty" today?

Asking questions while sitting or leaning to their level and making eye contact will relax the room, and they may be able to give a more thorough history and not leave out details thinking they are not important. Having a pet with heart disease, if you are the client, is terrifying and it is the veterinary technician's job to validate their fears and equip them to know what to expect and how to recognize clinical changes at home. When we are speaking to these clients, it must be clear to them that their cat is the only patient on our minds. In the current climate of veterinary medicine, it is hard to quietly focus on one client and patient. The author encourages the veterinary technician to make a conscious effort to not feel guilty about taking too long, feeling rushed when taking a history, or discussing how a patient has been doing for a recheck appointment. Spending this time to be thorough will benefit both the staff and the client. The client's anxiety is felt by their pet; therefore, it is to everyone's advantage to have a calm conversation [2, 3].

14.2 Clinical Signs

Coughing is not typical with CHF in cats. Cats that present with a cough should be worked up for lung disease or asthma. Heartworm disease will cause cough in cats. A feline patient presenting to the clinic in respiratory distress is a critical patient. Triaging these patients to assess if they are dyspneic from CHF vs. lung disease is a challenge to the entire staff. Cats do not make this an easy assessment. Clinical signs of a cat with CHF are increased respiration and effort along with tachycardia. The clinical signs of a cat presenting with lung disease are increased respiration rate and effort, the subtle difference is their heart rate may not be fast, or as fast as a patient with CHF. A cat with CHF may have a murmur and/or a gallop but not always. A cat with lung disease such as pneumonia may have a fever, whereas a cat with CHF will not likely have a fever. That said, a cat with myocarditis may have a fever and CHF. As stated above, cats presenting with difficulty in

breathing are a challenge! Ideally, a thoracic radiograph and/or an echocardiogram would be available for diagnostics with the patient stable enough to have them performed. A cat with a history of a cough is a valuable detail when trying to sort out what to treat, the lungs or the heart.

14.3 Physical Examination Findings

Cardiovascular physical examination of cats can be challenging as their hearts are so small and their heart rates are fast. Auscultation of heart and lung sounds is a pivotal part of the physical exam. Normal heart sounds consist of the closure of the valves. The normal "lub-dub" sounds of the heart are called S1 and S2. S1 is the mitral and tricuspid valve closing, and S2 is the sound of the aortic and pulmonic valves closing. To hear the mitral valve in the cat, the stethoscope is placed on the left side near the fifth or sixth intercostal space near the sternum. The tricuspid valve is heard on the right side a little higher by the fourth or fifth intercostal space. The aortic and pulmonic valves can be heard on the left side at the second or third intercostal space. Any aortic sounds will be more dorsal, and the pulmonic sounds will be closer to the sternum (Figure 14.3). Hearing a "squish" sound in place of the sharper valve sound is the indicator of a heart murmur.

A heart murmur is the sound of turbulent blood flow through the heart. Identifying the reason for the turbulence and the underlying cause of the murmur requires further diagnostics. The area of auscultation and the loudness of the murmur are described in the medical record as part of the physical exam. For example, "a grade III/VI left parasternal systolic murmur is ausculted" describes turbulent blood flow through the heart possibly through the mitral valve. Murmurs can be caused by turbulent blood flow through the heart, because of anemia, fever, fast flow, or heart disease. The sources of the murmur



Figure 14.3 This is an image of a calm auscultation. The stethoscope is left parasternal with moderate pressure. *Source:* Kristie Garcia, LVT, VTS (Cardiology).

require an echocardiogram to diagnose. The murmurs are graded I–VI/VI. The grade of the murmur does not correlate to disease severity. A cat can have a loud murmur with minimal to no heart disease while a cat with a soft murmur may have advanced disease.

There are third and fourth heart sounds often heard with heart disease in the cat. The sound that is most commonly associated with heart disease is the gallop. This third heart sound (S3 or S4) is associated with blood rapidly filling the ventricles and hitting dilated or stiff heart walls. Ausculting S4 is associated with underlying diastolic heart disease, such as hypertrophic cardiomyopathy (HCM). S3 is associated with dilated cardiomyopathy (DCM). While listening to these patients, differentiating between S3 and S4 is not necessary as they both sound like a gallop. The echocardiogram is the gold standard in making the final diagnosis. In addition to the heart and lung sounds, the mucous membranes (MM) are checked as well as the body position. A relaxed and sternal cat may seem more stable than a laterally recumbent cat, but this may not always be true. Cats can hide their diseases well, and this is frustratingly true of heart disease.



Figure 14.4 This is a cat with CHF demonstrating a dyspneic body position. *Source:* Kristie Garcia, LVT, VTS (Cardiology).

A cat that is having difficulty in breathing shows this more subtly than other species. While a dog may be visibly distressed if dyspneic, the cat may be quietly sternal with their front elbows abducted, or "popped" out, to help them expand their lungs (Figure 14.4). Their respiration rate and effort may be increased but not as obvious as in other species. If a cat is open-mouth breathing as a result of CHF, they are quite critical, and their care should be prioritized [3–5]. See Chapter 25: "Respiratory for Further Information Regarding Physical Examination Findings," for a patient with respiratory concerns.

14.4 Specific Nursing Care Considerations

When these patients are hospitalized as a result of end-stage heart disease, the nursing care should include a "less is more" approach. Ensuring the stress level is as low as possible is important for getting them home to their families. Advocating for some sedation in addition to their needed therapy is an important role of the veterinary technician. A cat in need of hospitalization will likely have low blood pressure, poor cardiac output, and/or arrhythmias. This can make IVC placement a challenge. Being patient and not rushing or putting personal ego aside to ensure the least amount of trauma to the vessels and the patient must be considered. These vessels and patients are not ideal for learning IVC placement.

Since cats are so good at hiding their heart disease, the veterinary technician should be aware that a patient having a routine procedure or surgery should be watched closely if they are on fluids. A cat with no murmur or gallop would not necessitate a cardiology evaluation or thoracic radiographs, but there is a minority of cats that are not clinical for heart disease and yet have significant disease. Keeping this in mind, the veterinary technician should keep an extra ear on those cats getting intravenous (IV) fluids. This is meant literally using auscultation skills to assess the heart and lung sounds of these patients, which makes the veterinary technician a valuable patient advocate. Physical examination findings consistent with a cat becoming fluid overloaded are first tachypnea and then tachycardia. Seeing these changes and bringing them to the attention of the veterinarian could be the difference between stopping the fluid overload and avoiding congestive heart failure and battling a patient with heart failure needing extra hospitalization and more aggressive therapy. It is rare, but about 22 out of 1000 cats will die suddenly from heart disease they did not show clinical signs for [4, 5].

14.5 Cardiovascular Diseases

14.5.1 Congenital Diseases

Congenital heart disease refers to birth defects in the heart that may be present in a kitten after birth. There are a few common defects that happen as a result of the heart not fully developing completely in all the chambers and major vessels.

A common congenital heart disease in the cat is a ventricular septal defect (VSD). This is caused by a hole between the left and right ventricles. A normal heart structure should not have any communication between these chambers. These patients will have a loud murmur on the right side. This is because the left heart has a much higher pressure and abnormal flow of blood, or the "jet" through the VSD is from left to right. This defect is one where if there is a loud murmur/thrill, the prognosis improves. To create a loud murmur or high enough pressure to create a thrill that can be felt on physical exam, typically means the VSD is small. The same applies to an atrial septal defect (ASD); however, since the atrial walls are so thin, a murmur may be heard but cannot be attributed to an ASD without further diagnostics (Figure 14.5). A "jet" refers to the abnormal blood flow through a defect as it is measured during an echocardiogram. This "jet" of blood can be measured and converted into pressure. Pressures measured in various parts of the heart during different stages of heart disease aid in the treatment and prognosis.

Pulmonic stenosis (PS) and subaortic stenosis (SAS) refer to the narrowing of the right and left outflow tracts. These valves lead blood away from the heart via the major vessels to the lungs and the body. The narrowing may be caused by the valve itself or the vessel walls may be hypoplastic. The result of these narrowed outflow tracts is hypertrophy of the ventricles that need to work harder to push blood forward. In turn, this can result in diastolic failure and then eventually lead to CHF (Figure 14.6).

A patent ductus arteriosus (PDA) is a vessel connecting the aorta to the PA. When the kitten is in utero, this vessel serves as a bypass for blood to skip the lungs and be oxygenated by the mother. When the kitten is born and begins to breathe, this vessel should close off within hours and force blood into the PA only and then to the lungs. When this vessel remains patient, the heart becomes volume overloaded by recirculating blood and can quickly progress into CHF.

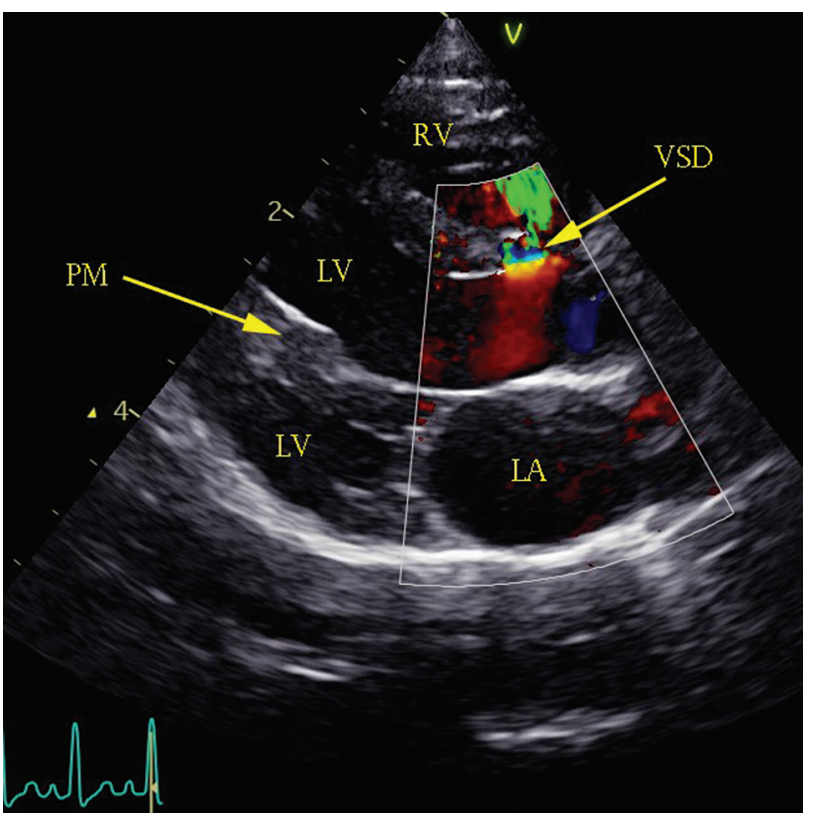


Figure 14.5 This is an echocardiogram image with color flow. The color flow highlights the abnormal blood flow through the intervertebral septum. *Source:* H. Edward Durham Jr.

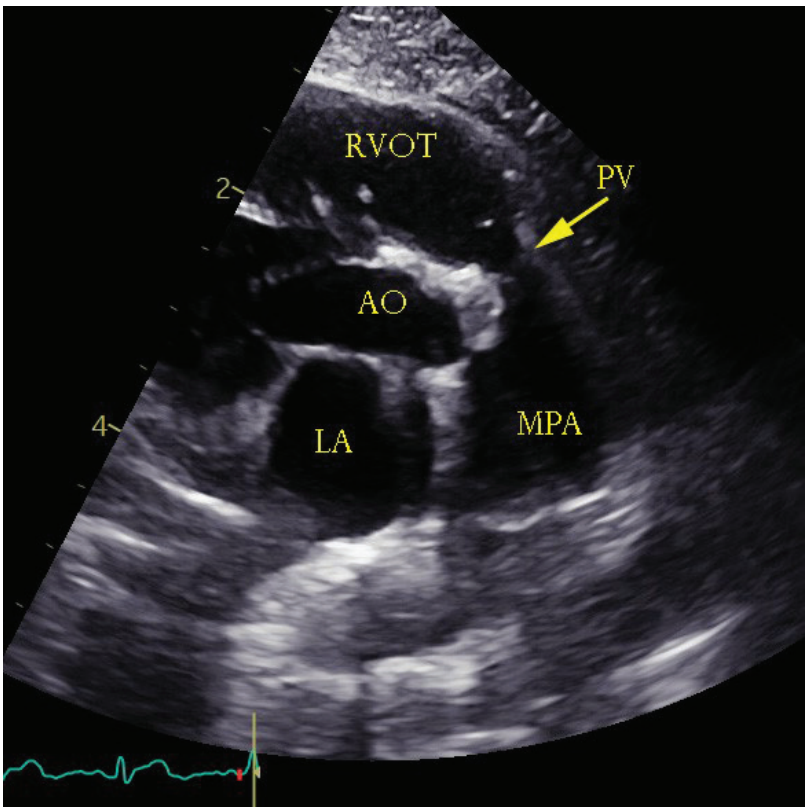


Figure 14.6 This is an echocardiogram image of a stenotic pulmonic valve. *Source:* H. Edward Durham Jr.

Diagnosis of congenital defects in kittens can be challenging. The gold standard is an echocardiogram performed and evaluated by a cardiologist. The role of the technician is multifocal. These defects have murmurs associated with them that are their characteristics. A stenotic vessel leaving the heart will have a loud murmur at the heart base. A patient with a PDA will have a continuous murmur. This means that instead of a "squish" sound followed by the sharper "dub" sound, the murmur covers both the systolic and diastolic cycles of the heartbeat.

Recognizing these murmurs makes the veterinary technician an asset to these small patients in expediting their diagnosis and care. It is also important for the veterinary technician to understand that these patients are fragile. Minimal handling is needed in a balanced dance to get the most ideal diagnostic images without doing further harm. This is especially important in the patients that present dyspneic. While advanced skills, such as venipuncture are often associated with the level of care these small patients need, it cannot be overstated how important the handling technique is with small dyspneic patients. Handling a dyspneic patient at any stage of their lives is a risk, and developing the technical skill to keep these patients stable is priceless. Handling techniques are described in the Technician Tidbits of this chapter as well as in Chapter 2: "Feline Friendly Interactions."

Due to the small size of the patient's heart, echocardiographic measurements are acquired within a few millimeters. An ECG may also show axis shifts and waveform abnormalities. Often, these patients are quite ill and in CHF, making them unstable and making the diagnostics even more challenging.

Therapies for a VSD or an ASD will vary. While closing these defects is not typically an option, the risk of heart failure is related to the size of the defect. Many times, these patients live a long life with a small defect. For severe cases, the therapy is often limited to keeping them out of heart failure with medications. Because of their larger heart sizes and vessel sizes, dogs have the option to plug these defects, but small cat hearts are not candidates for these plugs purely due to their size [6]. Each cat will respond to the disease a little differently. This is determined by the size of the defect as well as the specific location in the heart. For example, a VSD can occur anywhere on the intraventricular septum. A small VSD located in the middle of the septum will have a different effect on the heart function than a larger VSD located toward the top of the septum by the aorta. Regardless, the end result will be CHF, and the therapies are the commonly available heart failure medications. The difference in the prognosis of each of these patients is based on the severity of

the defect. The progression of the disease will be different for each patient and the point when, or IF, they progress into CHF and require more medications. The veterinary technician should be aware of the prognosis and the clinical signs of CHF and be able to communicate that to the clients so they can watch for clinical signs at home. Educating the client is so important.

Therapy for congenital heart disease in cats is often limited by their small heart size, but there are some options. A balloon valvuloplasty is sometimes appropriate in cats with a PS. This is done by feeding a catheter with a long balloon into the right heart and out to the PA. When the balloon is positioned over the valve, it is inflated. This will force the valve leaflets to separate. This may open the outflow from the heart to the lungs, improve perfusion, and reduce pressures in the right ventricle.

A PDA is treated by closing off the ductus arteriosus and it is curative. Most commonly in cats, the PDA is closed by performing a thoracotomy and tying off the vessel with a suture. Due to the thoracic cavity being opened, it requires a lengthy healing period as long as 2 weeks. There is also the added risk of hemorrhage during the surgical ligation of the ductus arteriosus [3].

The preferred approach in cardiology depending on the size of the cat is to use catheters to place a plug or a coil into the patent vessel to occlude the blood flow [6]. The size of the patient is a pivotal consideration when considering the options for closure. A small patient with small vessels will not be able to accommodate the size of catheters required for a successful procedure. The catheter method is much less invasive with only a small incision in the jugular vein. The PDA is measured during the echocardiogram and a device appropriate to close it is selected based on both the size of the patient and the PDA. While the defect is always a patent vessel in the same location for each patient, the size and shape of the vessel are different in each patient. This means each patient requires an individual approach, to closing, it must be said that feline patients being candidates for the catheter approach to PDA closure are rare. This is for two reasons: the first is that so often these patients are too small for the catheter approach, and the second reason is the facilities able to perform these procedures are only in referral hospitals and academia. For many patients, the distance and the cost may make them ineligible for a catheter closure. The patients who are candidates for a catheterization to close the PDA are back home in a few days, and their hearts should return to normal size. The PDA closure is the favorite catheter lab procedure of the author as it is the only "fix" in cardiology. With all other cardiovascular diseases, the goal is to slowly progress and keep the quality of life to a high standard. The patient presenting with a PDA offers the rare opportunity to cure them so they may live a normal life [5, 6] (Figures 14.7–14.9).

Finally, a rare congenital defect that could be seen in the clinic as an emergency in a kitten is the tetralogy of fallot (TOF). These patients present with exercise intolerance and cyanosis. As the name suggests, TOF includes four defects in the heart

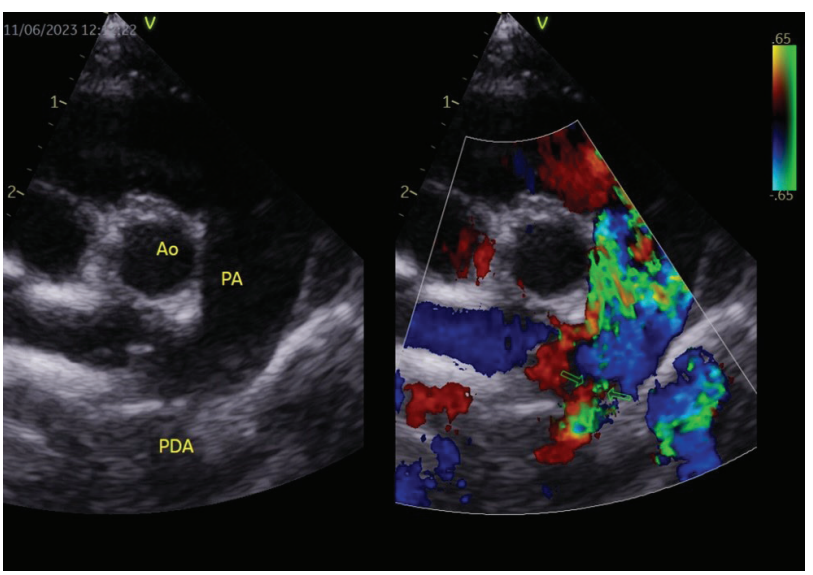


Figure 14.7 A side-by-side echo image of a PDA. The left side is the echo image showing the PDA. The right image has color flow showing blood flow through the PDA. *Source:* Andrew White, DVM, DACVIM (Cariology).

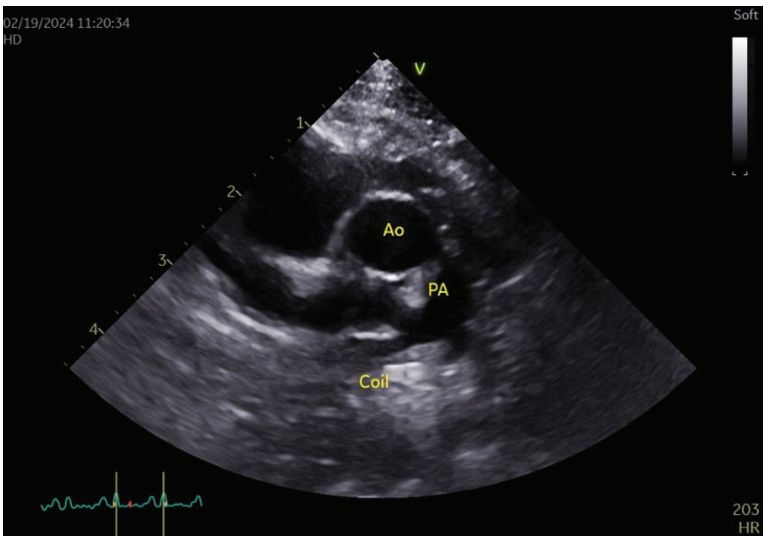


Figure 14.8 Echo image of a PDA closed with a coil via catheter technique. *Source:* Andrew White, DVM, DACVIM (Cardiology).

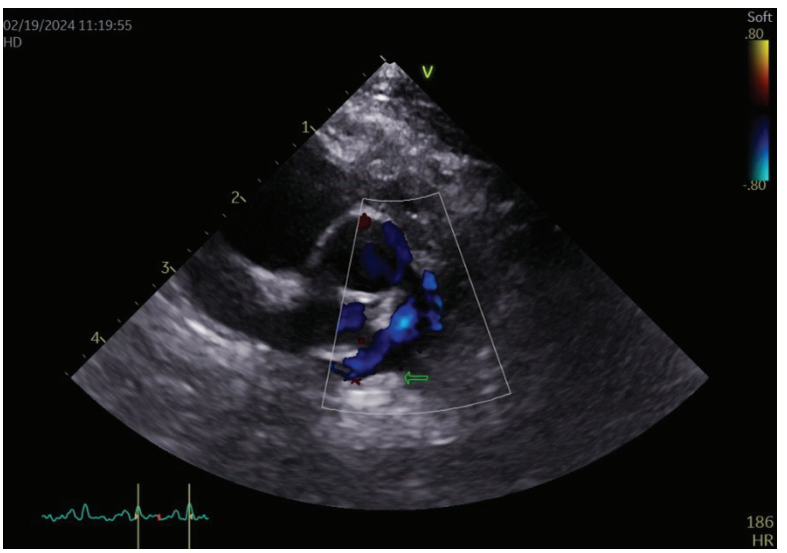


Figure 14.9 Echo image of a PDA closed with a coil. The color flow shows the newly occluded vessel. *Source:* Andrew White, DVM, DACVIM (Cardiology).

as it is forming. They are a VSD, a dextroposition of the aorta (this means the aorta opens to the right ventricle when it should only communicate with the left ventricle), PS, and right ventricular hypertrophy. The heart will be shunting blood from the right to the left. During normal heart anatomy, the right and left sides of the heart should not communicate. When blood is shunting right to left, the blood is not adequately oxygenated. When the blood is not oxygenated, the patient is in a constant state of hypoxia. A patient in a constant state of hypoxia will stimulate the release of erythropoietin. The body, specifically the kidneys, are convinced that poor perfusion is the cause of hypoxia and will produce more red blood cells to carry more oxygen. This will cause polycythemia (too many red blood cells), making the blood thicker, and the domino effect of consequences to the organs and tissues will compound. Therefore, one of the treatments for a TOF includes phlebotomy to thin out the blood. Sadly, patients with TOF do not often live long, and they should be kept as comfortable as possible (Figures 14.10 and 14.11).

14.5.2 Acquired Cardiomyopathies

The most common cardiomyopathy diagnosed in cats is HCM (Figure 14.12). This disease is characterized by the cat's predisposition to keep laying down layers of myocytes causing concentric hypertrophy, causing the heart walls to become thicker over time. The cause is unknown, but a genetic component is likely. There have been genetic mutations identified in two cat breeds with HCM, they are the Maine Coon and the Ragdoll. The result of the thickened walls creates a smaller lumen in the ventricles for blood to fill appropriately. As the heart pumps blood forward, the atria are unable to empty completely to the ventricles. As a result, the atria will be under greater pressure, and the walls will be stretched enlarging the left atrium. The precursor to CHF is an enlarged left atrium. In cats, there is the added risk of creating clots in the atrium that can result in arterial thromboembolism (ATE). There are currently no proven therapies to slow the progression of HCM [1, 4, 6].

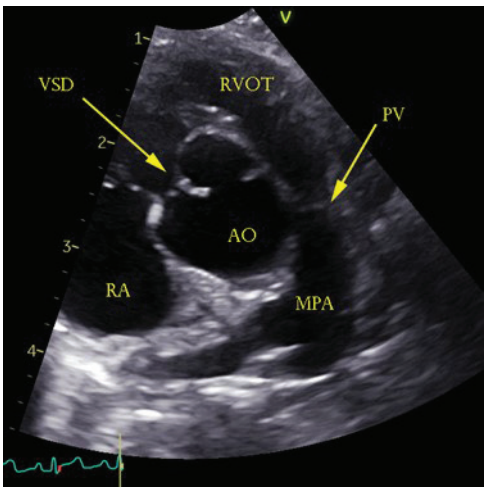


Figure 14.10 Echocardiogram image showing the heart base anatomy and a VSD as part of TOF. *Source:* H. Edward Durham Jr.

Other cardiomyopathies that make up the remainder of the cats affected include restrictive cardiomyopathy (RCM), unclassified cardiomyopathy (UCM), DCM, and arrhythmogenic right ventricular cardiomyopathy (ARVC). RCM is uncommon compared to HCM. These cats' hearts will have normal-looking wall thickness and the ability to squeeze is subjectively normal; however, the compliance of the walls is decreased. On physical examination, they may have a murmur and/or a gallop as well as arrhythmias. DCM used to be a common diagnosis made in cats that was found to be a direct result of taurine deficiency in the 1970s. Since this has been corrected with all the reputable commercially available diets, the occurrence of DCM in cats is now quite rare. DCM is characterized by the inability of the ventricles to efficiently squeeze and push blood forward. The ventricular walls appear thin and weak on echocardiogram [7].

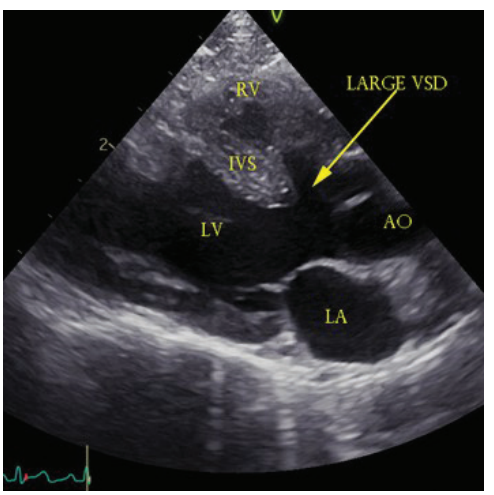


Figure 14.11 Echocardiogram image showing the overriding aorta and thick right ventricular walls as part of TOF. *Source:* H. Edward Durham Jr.

On physical examination, these patients may have a gallop and a soft murmur to no murmur. UCM is diagnosed when the criteria of the echocardiography findings are unclear. A UCM cat may be at the end stages of a HCM or RCM progression, and it becomes difficult to determine the prognosis. These patients will have enlarged atria, and their systolic function may be weaker. Physical exam findings may include a murmur or not. The end stages of these cardiomyopathies are myocardial failure and then CHF. The stages of heart disease as defined by the American College of Veterinary Internal Medicine (ACVIM) are A, B1, B2, C, and D. Stage A is a normal heart with no disease. Stage B1 is defined as a diagnosed disease with no significant heart changes. Stage B2 is a heart with diagnosed disease that warrants the addition of medications. The medications vary and are prescribed at the discretion of the cardiologist. Stage C is defined as the patient having been in CHF at least once. These patients now have a prescribed diuretic in addition to the previously prescribed medications. Lastly, there is stage D, which is when a patient is in refractory heart failure. Refractory heart failure is when the patient struggles to stay out of CHF with all the available maximum recommended doses of medications [7–12].

14.6 Cardiomyopathy Prognosis

The prognosis for cats with cardiomyopathies depends on the severity and the rate of progression. Some cats with cardiomyopathy live normal lives and succumb to another disease process, while other cats are at risk of CHF, thromboembolism, and sudden death [3–5].

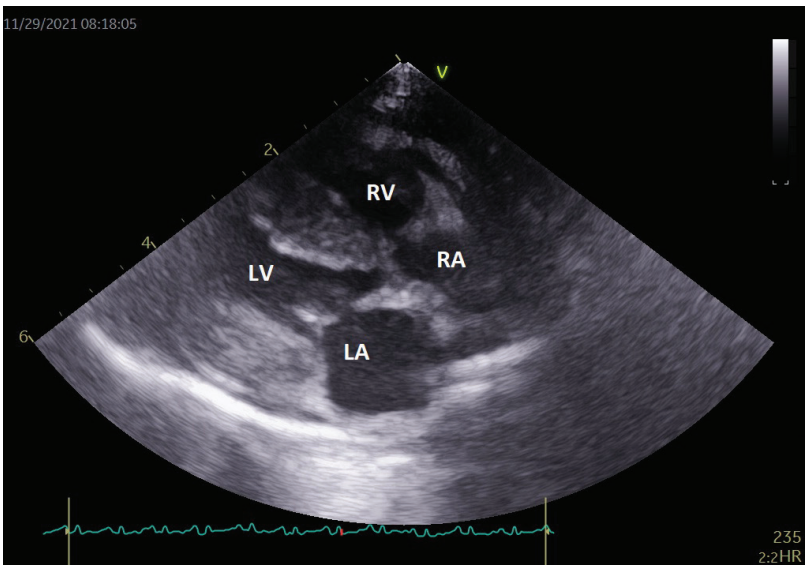


Figure 14.12 Echo image of the heart. The left atrium is enlarged, and the left ventricular wall is thick. *Source:* Andrew White, DVM, DACVIM (Cardiology).

14.7 Comorbidities to Consider

14.7.1 Hyperthyroidism

The effect of hyperthyroidism on the heart is stressful. The increased circulation of thyroid hormones increases the heart rate and demand for cardiac output. This will cause secondary changes to the heart muscle that resembles HCM. Untreated, this will progress to CHF. Less than 90% of patients with thyrotoxic heart disease respond well to I-131 and they remain euthyroid post-therapy. While there are a few available therapies for hyperthyroidism, the preferred treatment is I-131 radioactive iodine treatment. It is the least invasive and highly successful [4, 7].

The decrease in thyroid hormone overwhelming the heart will result in the myocardium returning to normal. Some patients will have both thyrotoxic heart disease as well as HCM. Treating hyperthyroidism will reverse the effects on the heart. However, any HCM will need to be monitored as it will continue to progress. See Chapter 18: "Endocrinology," for further information on thyroid disease in the cat.

Patients experiencing a thyroid storm can present with open-mouth breathing. The difference in urgency compared to a patient in CHF is the level of distress. A patient experiencing a thyroid storm will not be having difficulty in breathing. Their body language will show them to be alert and overstimulated. They are looking around and perhaps vocalizing. A patient in distress due to CHF, which is still sternal, will be more still with their elbows likely abducted, and they are not as alert to what is going on around them. Their focus and energy will be directed to their breathing [13] (Figures 14.4 and 14.13).

14.7.2 Renal Failure

Cats in renal failure present a higher level of difficulty when attempting to treat any heart disease. This is especially true once they progress into CHF. The drugs used to treat CHF consequently cause azotemia. The therapy for renal failure and CHF is diametrically opposed. Patients with kidney disease often require diuresis as part of their therapy. A patient with heart disease that is put on fluids to promote diuresis in the kidneys can be pushed into CHF. The goal of treating CHF is to decrease the circulating volume and workload on the heart. Therefore, CHF is treated with furosemide but as this is a loop diuretic, the kidney function may be compromised further. Patients with renal insufficiency or failure should be closely monitored for azotemia and electrolyte imbalances. Patients hospitalized with concurrent renal and heart disease present the veterinary technician with a challenge. The goals of the client and the veterinarian for these patients' care should be shared with the veterinary technician. The veterinary technician is the front line when noting any changes in these patients' stability and alerting the veterinarian immediately even of minor differences [2, 3].



Figure 14.13 This picture is of a cat during a thyroid storm. There is open-mouth breathing without the distress noted in patients with CHF. *Source:* Kristie Garcia, LVT, VTS (Cardiology).

14.8 Cardiovascular Emergencies

14.8.1 Congestive Heart Failure

Regardless of the underlying heart disease present, the end stage of heart disease can progress to CHF. Patients presenting with acute heart failure require minimal handling due to their fragility during that time. The clinical signs of heart failure are tachypnea, tachycardia, and often a murmur and/or gallop. Treatment should include supplemental oxygen therapy and a quiet cage. If the patient is too unstable for an IVC, furosemide intramuscular (IM) or SQ should be administered. If they need a thoracocentesis, the veterinary technician can set up for this procedure while the feline is in a quiet space after furosemide has been administered. At the clinician's discretion, these patients may be candidates for pimobendan. Pimobendan has been shown to benefit cats with heart failure, but it is currently being used off label, research is ongoing as of this writing [7–11] (Table 14.1).

Patients battling chronic CHF may benefit from a range of care. This can include thoracentesis, simply a change in diuretic medication or dose. As their disease progresses, they may reach a "plateau" in the efficacy of their furosemide and warrant a change to a stronger diuretic such as torsemide. Patients with CHF also need to have renal values and electrolytes monitored on a biochemistry panel. The goal for the feline patient and their family is to achieve a good quality of life with medication and diet changes. The quality of care for cats must include how easily they take their medications at home. The families of these cats have the toughest job medicating their pets, often multiple times each day. It is of the utmost importance for the patient and client to have a good quality of life and relationship during this time. As mentioned in the history-taking section of this chapter, talking to the client during a recheck appointment after medications have been started, must include questions on how easily they are able to give the medications. There are a lot of options available to help keep the quality of life balance good.

Options for medication formulations include compounding into liquids and compounding multiple meds into the same tablets or liquids. Multiple tablets can be put in empty gel caps and administered all at once. Medications can be hidden in pill pockets or other palliative foods. Each cat and their family are different, and therapy must be tailored when possible. It is never the veterinary team's place to judge, only to help with kind understanding.

A patient who has pleural effusion due to CHF may need a thoracocentesis to stabilize. The veterinary technician will prepare and, in some states/countries, can perform the thoracocentesis. It is important to know and adhere to the scope of practice for the veterinary technician in the state or province they are working in. A butterfly needle or peripheral IV

Table 14.1 Table clarifying commonly used medications for managing heart disease and CHF [14–16].

Drug classification	Name	Use	Contraindications
Antiarrhythmics	Atenolol Sotalol Diltiazem	Slows heart rate and decreases arrhythmias. Decreases frequency and rate of arrhythmias.	Can cause myocardial weakness.
Diuretics	Furosemide Torsemide Spironolactone	Treats pulmonary edema from congestive heart failure. Decreases myocardial fibrosis from long-term disease (spironolactone).	These are loop diuretics. Renal function must be monitored. Monitors electrolytes.
ACE-I	Benazepril Enalapril	Inhibits RAAS. Keeps blood pressure lowered decreasing the workload on the heart.	Enalapril is metabolized in the kidneys, and renal function must be monitored.
Anti clot	Clopidogrel Enoxaparin Xarelto® (rivaroxaban)	Prevents blood clots from forming in patients at risk for clot formation.	Increased risk of bleeding. Cost prohibitive.
Positive inotrope	Pimobendan	Increases the contractility of the heart; therefore, improving cardiac output.	Off-label in cats.

catheter, syringes, IV tubing, sample collection tubes, and container will need to be set up for the procedure. An ultrasound machine is beneficial during the procedure to visualize a "pocket" of fluid to be removed. If an ultrasound is not available, inserting the needle/catheter between the seventh and ninth intercostal space is the recommended standard. The area of the chest where the centesis is going to be performed must be clipped and prepped. In some cases, sedation may be warranted. The size of the needle or catheter is chosen at the discretion of the clinician. A needle may be easier to control and not kink while the fluid is being aspirated but has the added risk of lacerating the lungs. IV catheters are softer but bend/kink more easily, and more than one attempt may be needed to remove any remaining fluid. Samples of the fluid should be saved in EDTA and plain tubes in case a cytology and/or fluid analysis is ordered by the veterinarian.

14.8.2 Arterial Thromboembolism

A particularly sinister aspect of heart disease in cats is the risk of blood clots. As the left atrium is stretched from higher pressure, the circulating blood stagnating in the left atrium has time to form clots. In some cats, these clots become sizable and make their way out of the heart and into the arterial circulation where they can become an ATE. The severity of this depends on the location of the thromboembolism. A patient with a small thromboembolism to a front leg may have a better prognosis than a patient experiencing a saddle thrombus due to reperfusion injury. A saddle thrombus occludes blood flow to both hind limbs, pelvis, and tail of the cat at the bifurcation of the abdominal aorta to the back legs. This condition is very painful; therefore, analgesics should be administered immediately upon presentation. Once analgesics are administered, evaluation for CHF should occur. Not all patients with ATE concurrently are in CHF but should be ruled out. The deadly complication of the ATE in these cats is the reperfusion injury. This occurs as the clot breaks down and the bloodstream is flooded with the built-up potassium. This surge of potassium will cause the heart to slow and stop. The role of the technician for these patients is to recognize when the potassium may be increasing. Clinical signs of hyperkalemia are bradycardia, arrhythmias, lethargy, vomiting, diarrhea, and collapse. This only partially applies to cats with an ATE. Hyperkalemia will be acute in these patients, and to be proactive instead of reactive in treating these quickly occurring changes can be the difference between life and death. In the ATE cat at risk of reperfusion injury, an ECG should always be on these patients and a sampling line should be placed for frequent electrolyte checks. If the potassium begins to rise, the following ECG changes, in this order, will occur; the P waves will begin to disappear, the heart rate will slow and arrhythmias may be seen, the T wave will "tent" or enlarge, and the R wave will be small or wide. The ECG, quite literally, stretches into a flat line (Figure 14.14).



Figure 14.14 An electrocardiogram showing changes consistent with hyperkalemia. P waves gone, tiny R waves, tall T waves, and overall bradycardia. *Source:* Kristie Garcia, LVT, VTS (Cardiology).

14.8.3 Heartworm Disease

Both indoor and outdoor cats are at risk of heartworm disease. Heartworm prevention is recommended by the American Heartworm Society (AHS), and many commercially available options may be prescribed at the discretion of the veterinarian. Heartworm infections that progress to adult worms in cats are likely only a burden of a few worms, but the treatment used to kill them in dogs, melarsomine dihydrochloride (Immiticide®), is toxic to cats. Therefore, treatment in cats with heartworm disease is limited to managing the clinical signs. Clinical signs are most often respiratory in nature but can include coughing, (episodes mimicking asthma attacks) ascites, weight loss, and sometimes, neurological symptoms.

The damage from the heartworms is mostly in the lungs and can result in heartworm-associated respiratory disease (HARD). The best treatment for feline heartworm disease is prevention. Heartworm prevention in cats will have ivermectin. There are many products available on the market that cover multiple parasites. To ensure the best protection against heartworm infections, an FDA-approved prevention with ivermectin should be confirmed. The veterinary technician can be a valuable advocate for heartworm prevention in cats.

Testing for heartworm infection is a blood test. Both the antibody and antigen should be checked when ruling out feline disease. The most accurate test that is available now is the heated antigen test. The samples are heated to 104 °F for 10 minutes. This releases more of the antigen for the test to detect. Very rarely, a worm may be seen on an echocardiogram in the PA, so an echo is not the gold standard when looking for a heartworm infection. An echocardiogram is appropriate when the cat is heartworm positive and there is a question of how significant the infection may be. Managing a heartworm-positive cat can be a challenge as the adult worms will die and can make their way to any place in the cat mimicking a thrombus. A heartworm-positive cat can have blindness, paralysis, and seizures as the adult worms die. Thoracic radiographs can also be helpful in putting together a diagnostic picture of a heartworm-infected cat. As the most concerning result of heartworm disease is the patient developing HARD, changes in the PAs and bronchi, while not diagnostic for heartworm specifically, are important in assessing any need for steroids [14]. Once a patient progresses into HARD, it is difficult to control. A patient presenting in acute respiratory distress may need an aggressive response with high doses of medications to regain controlled breathing [14].

14.9 Diagnostic Techniques

The echocardiogram is an ultrasound of the heart. When diagnosing heart disease in cats, the echocardiogram performed and reviewed by a cardiologist is the gold standard. When the physical exam findings include a heart murmur and/or a gallop, the underlying heart disease cannot be determined without an echocardiogram. The heart valves and chamber walls are assessed for abnormalities. The blood flow direction and rates are also assessed and measured. Any abnormalities determined by the cardiologist will form their diagnosis and prognosis. Two patients diagnosed with HCM will have different prognoses based on the echocardiogram findings. The echocardiogram of the cat's heart can be challenging, especially for kittens or tachycardic patients. There is a very small margin of error that can result in a misdiagnosis in some cases. This is especially true for patients with congenital defects. Once the underlying heart disease is diagnosed and a treatment plan is put together, the veterinary technician can work with the veterinarian and the client to help ensure the best care is possible [3, 4] (Figure 14.15).

14.9.1 Pro-brain Natriuretic Peptide

The brain natriuretic peptide (BNP) is a protein that is responsible for natriuresis. Natriuresis is when sodium is released from muscle cells. A pro-BNP is a blood test that measures the protein responsible for natriuresis is released into the bloodstream by the stretched and stressed heart muscle. The value of checking a pro-BNP in cats is becoming more appreciated in veterinary medicine. In general, checking the pro-BNP for patients other than cats does not yield results sensitive

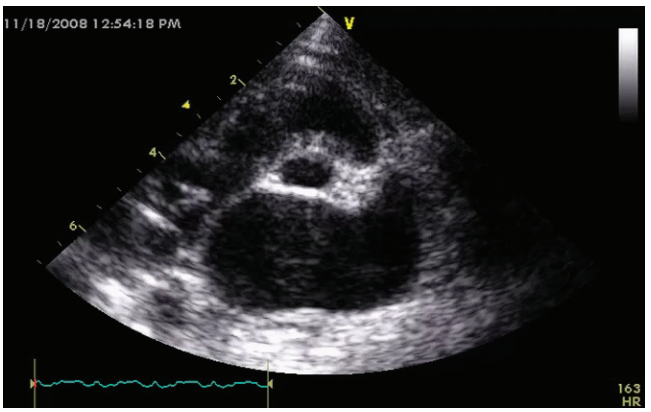


Figure 14.15 Echocardiogram image of HCM. *Source:* Andrew White, DVM, DACVIM (Cardiology).

specifically to heart muscle stretch. In cats, however, a high pro-BNP is now associated with the possibility of underlying heart disease; therefore, a cat with a high pro-BNP should have further diagnostics and/or a referral to a cardiologist. Including this test in the annual exams can help identify heart disease in some cats. There are commercially available SNAP tests to check pro-BNP. The veterinary technician needs only the SNAP test kit and a needle and syringe to run this test in-house [15].

14.9.2 Blood Pressure

Obtaining blood pressure in a cat does not have to be stressful for all involved. The veterinary technician will need a Doppler machine, an appropriately sized cuff, a sphygmomanometer, ultrasound gel, and tape. The ACVIM standard for obtaining blood pressure is to be in a quiet place, with the least amount of stress as possible. The added preference in cardiology is to have the patient in left lateral and use the front left limb, or with the patient sternal, using the tail. In following the guidelines suggested by the ACVIM consensus for obtaining blood pressure, the patient should be in lateral recumbency when using a limb or sternal recumbency when using the tail for best accuracy. The blood should not be traveling vertically from the cuff site to the heart. The cuff size selected should be 30–40% of the circumference of the limb or tail. The cuff can be secured with a piece of tape. The selected spot for the blood pressure can be shaved, although this often leads to stress. In place of shaving, a generous amount of ultrasound gel can be placed over the chosen artery. After the artery is palpated, the probe is placed over the artery, and then the pulse rate should be heard through the Doppler. The first reading should be discarded and then a minimum of five readings averaged. The limited studies available comparing oscillometric to Doppler techniques favor the Doppler for ease, repeatability, and accuracy in small animals [16–18].

14.9.3 Thoracic Radiographs

Thoracic radiographs in the cat with regard to heart disease yield more information during disease progression. While there may not be evidence of early HCM on a radiograph, as the left atrium enlarges, this will be seen on radiographs. To diagnose CHF, radiographs are the preferred diagnostic. In the absence of an echocardiogram, radiographs are the most valuable diagnostic. The veterinary technician is able to measure the heart and the left atrium using the vertebral heart scale (VHS) to expedite any therapy that the clinician may order as a result. The VHS requires the right lateral radiograph and a caliper. A line measuring from the corina to the heart apex is drawn. A perpendicular line is then drawn across the ventricles at the level of the vena cava. These two lines are then placed along the spine across the ribs starting at the beginning of the fourth rib. The rib spaces are counted to give the VHS of the patient [19]. The normal range is 6.7–8.1 in cats (Figure 14.16).

14.9.4 Electrocardiogram

Acquiring the ECG requires an ECG machine, alcohol, and/or ultrasound gel. The standard is to have the patient in right lateral recumbency. However, if the cat is in distress or uneasy in the right lateral, it can have the ECG recorded in the sternal position or another position that is less stressful to the patient. Any other position than the right lateral should be

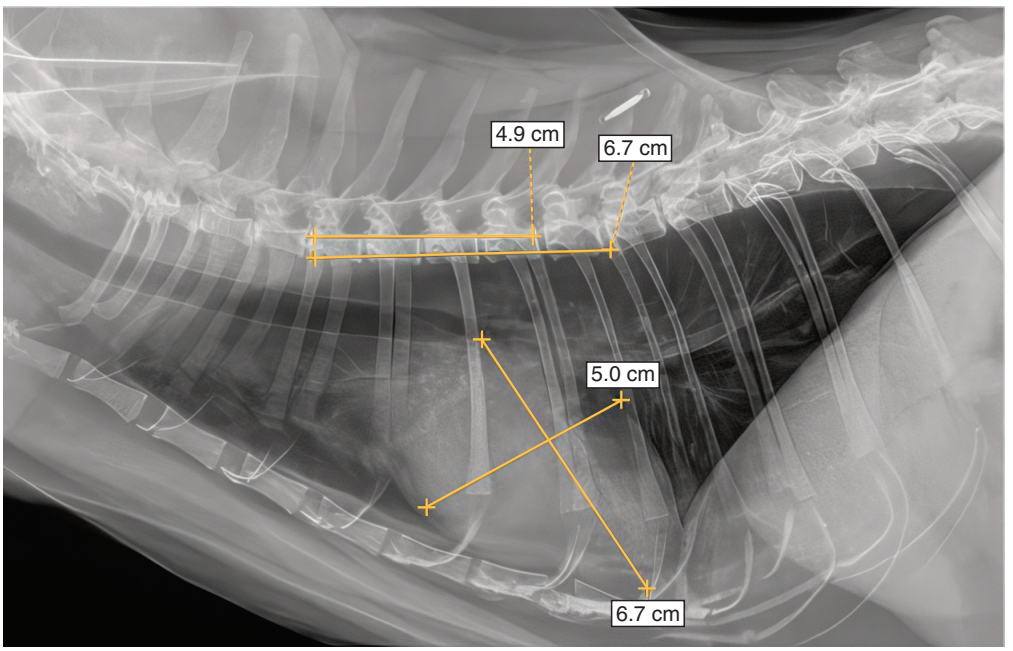


Figure 14.16 A lateral thoracic radiograph demonstrating the VHS. *Source:* Andrew White, DVM, DACVIM (Cardiology).

recorded in the patient's medical record. For a three-lead ECG, the leads are placed on each of the patient's limbs. Typically, they are labeled for the limb they are to be attached to.

Reading an ECG in any patient has challenges. The cat's ECG, however, has its own unique set of challenges because of tiny waveforms. As a review, the normal ECG waveform in small animals is to be acquired and printed or saved in lead II, 10 mV, and 50 mm/s. If this is not possible to assess the ECG adequately with these settings, any changes made must be recorded in the medical record.

The electrical system of the heart is driven by the sino atrial (SA) node. The SA node is a mass of tissue that resides in the right atrium and is where the heart rate is driven from. The SA node fires and causes the atrial myocytes to depolarize across the right and left atria. This will be seen on the surface ECG as the "P" wave. As the depolarization reaches across the atrial tissue, it is then funneled through the AV node. The AV node is a bundle of tissue with Purkinje fibers that reside between the right atrium and intraventricular septum. The AV funnels the signal through the ventricular septum to begin depolarization of the ventricular myocytes. The time it takes to get through the AV node is the pause on the surface ECG after the P wave. As the septum begins to depolarize, the impulse travels through the bundle of HIS to the left ventricle, and the Q wave is created. The R wave is the depolarization of the left ventricle and will appear as the tallest positive wave in lead II. As the depolarization travels up through the right ventricle, the S wave will be seen on the ECG. The right ventricle is smaller and set higher up on the heart. This means the impulse is traveling back "up" toward the atria. This results in the S wave appearing smaller and negative in lead II. As the myocytes repolarize before beginning the next phase, the T wave is seen on the ECG. When looking at an ECG and trying to recognize each complete waveform remember; that for each P wave, there must be a QRS following. Likewise, the QRS must be triggered by a P wave (Figures 14.17 and 14.18).

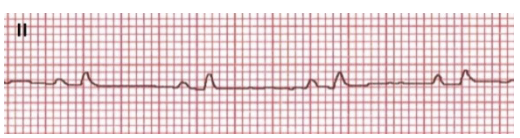


Figure 14.17 Normal ECG in lead II. *Source:* Kristie Garcia, LVT, VTS (Cardiology).



Figure 14.18 A normal ECG in lead II of a patient that may have a left anterior fascicular block (LAFB). More leads are needed to confirm. *Source:* Kristie Garcia, LVT, VTS (Cardiology).

A common change in the morphology of the feline ECG is a small R wave and deep S wave in lead II. This may be a normal morphology for the cat, but it could also be an LAFB. This can be confirmed by looking at multiple leads to determine the mean electrical axis (MEA). An LAFB only means that the normal electrical pathway through one of the left bundle branches may be damaged. In a cat, any clue given to support heart disease must be followed. The LAFB may be normal for the cat; however, it may point to underlying heart disease and should not be ignored. If a six-lead ECG is possible, the LAFB will have a positive waveform in lead I and negative in leads III and AVF. Notice, if the PQRS is normal, it is the wave sizes that are different. This can be confused with ventricular ectopy if the veterinary technician does not make sure the ECG settings are clear. If a six-lead ECG is not possible to obtain, the veterinary technician should bring attention to the ECG change to the veterinarian as well as document it in the medical record [20] (Figures 14.18 and 14.19).

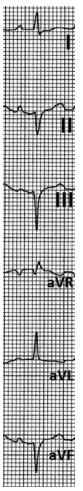


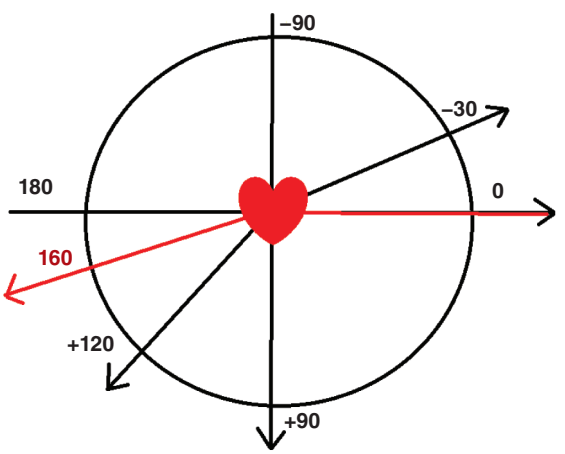
Figure 14.19 Typical six-lead ECG for a patient with an LAFB. *Source:* Kristie Garcia, LVT, VTS (Cardiology).

The normal heart rate of a cat is 150–240 bpm in the hospital. A heart rate less than 120 bpm warrants further investigation. The veterinary technician performing an ECG is ideal to expedite the diagnosis. Acquiring and reading an ECG is a valuable skill the veterinary technician can use to elevate patient care. There are emergent situations cats, specifically, present that result in bradycardia. The most urgent cause is hyperkalemia. As the potassium rises, the ability for electrolyte exchanges in the heart cells decreases. The result is a heart rate that slowly comes to a stop. The changes on the surface ECG that the veterinary technician should be aware of are first, the P waves disappear, the T waves become larger, and the overall heart rate slows [21, 22] (Figure 14.14).

14.9.5 Mean Electrical Axis

MEA is the assessment of the electrical activity through the heart muscle. In normal heart tissue, the electrical activity will travel in a 3D fashion with most of the energy traveling from the right atrium out toward the apex. The surface ECG in lead II may show some abnormal waveforms, but in order to measure the MEA, a six-lead ECG must be obtained. There are a few assessment techniques for determining the MEA, one is to determine the most isoelectric lead. This means the waves are the same size both positively and negatively in any lead. Then, using the MEA chart, determine the lead that is perpendicular to the isoelectric lead. The positive direction of the perpendicular lead will show the MEA for that patient. In the presence of heart disease with the resulting changes to the chamber sizes, the MEA will be affected as we see it on the surface ECG. For example, a cat with a disease resulting in right heart changes and a more dramatic electrical presence on the right side can show up as a right axis shift. As vet techs read the ECG, noticing a shift in the MEA warrants mentioning to the veterinarian. A shift in the MEA is not sensitive enough of a test to determine heart disease, but it does count as a piece of the puzzle. A patient with a murmur and/or gallop, tachycardia, and an MEA shift would be good reasons to refer for a cardiology workup. The limitation for many clinics when wanting to measure an MEA is the ability to acquire a six-lead ECG [21, 22] (Figure 14.20).

Figure 14.20 MEA normal range for cats is 0–160°. *Source:* Kristie Garcia, LVT, VTS (Cardiology).



Summary of tips for the feline ECG

- Troubleshooting an unclear ECG
  - **a.** Check the settings on the machine. Start with lead II, 10 mV, and 50 mm/s.
  - **b.** If the baseline is unclear because of shaking, purring, etc., move the leads away from the body wall.
  - **c.** If the patient will be monitored for a while (anesthesia), use ultrasound gel instead of alcohol to prolong good contact.
- Cats have tiny ECG complexes. Changing the mV settings to see the waveforms more easily is helpful. Starting with 10 mV and increasing to 20 or 40 mV can help identify all the waveforms. Remember to note changes in settings in the medical record.
- A common change in cat ECG is a deeper S wave in lead II. This change may suggest a right axis shift, but it also may indicate a left anterior fascicular block (LAFB). To rule out an LAFB, more leads are needed in addition to lead II. The veterinary technician would need to check a six-lead ECG. To record six leads, an ECG machine capable of more leads is needed. Monitors used to look at ECG routinely for quick assessments or monitoring anesthetized patients usually have the limitation of only looking at leads I, II, and III.
- Leads I, II, III, aVr, Avf, and avL are assessed with a six-lead ECG, and the MEA) is measured. An LAFB will show the S waveforms to be positive in lead I and negative in leads III and aVF. Clinically, this change could be secondary to underlying disease or could be a normal finding. Following up with more diagnostics is ideal.
- Waveforms do not "invert." If lead II is being assessed, the P and R wave are positive while the S wave is negative.

Veterinary technicians often wear many hats in the clinical setting. As the field of veterinary medicine continues to change, veterinary technicians find themselves redefining their roles over and over again. The unchanging constant is the devotion to the high standard of care for the patients entrusted to them. Often veterinary technicians are the first to see the patients when they present to the clinic or hospital. Whether triaging an emergent visit or acquiring a history for a good visit, they are the first caregivers they encounter. The stronger the veterinary technicians are in their abilities to understand disease processes as well as how to interpret physical exam findings, the higher the standard of care the patients receive. While their job includes making the veterinarian's job easier, the confidence and pride they have in their roles when they have the understanding to support them is the fulfilling feeling veterinary technicians all strive for in our day.

This is especially true of feline patients. They hide their disease and pain so well, that as veterinary technicians learn to interpret body language and physical exam findings, they become stronger patient advocates. Being able to care for a sick kitten or cat proactively instead of reactively is the high standard of care that gives us the feeling veterinary technicians strive toward. This is uniquely true of patients with varying degrees of heart disease. Having the ability and confidence to care for these patients as well as educate and support their families is hugely satisfying. This is the feeling of understanding and "speaking" to an animal in need.

See the companion website for further clinical references.

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15

Dentistry

Jan Yaroslav RVT, VTS (Dentistry), VTS (CP-Feline)

TECHNICIAN TIDBITS

- It is important to be able to recognize normal feline oral anatomy.
- Instrument choice, as well as care and maintenance, are key in feline dental suite design.
- Professional dental cleaning and the ability to produce full-mouth dental radiographs are essential skills for the technician.
- Client education on dental homecare for feline patients is very important.
- Dental homecare instruction starts with the first kitten visit and should be reinforced throughout all life stages.

Dental disease in cats is commonly overlooked and often undertreated. Cats are masters at hiding signs of illness. A cat that is not exhibiting clinical signs of pain can still have significant dental disease. It is thought that as many as 85% of cats aged three years and older have some sort of dental disease [1]. Identifying and preventing the progression of dental disease are important.

15.1 Feline Dental Anatomy

15.1.1 Oral Anatomy

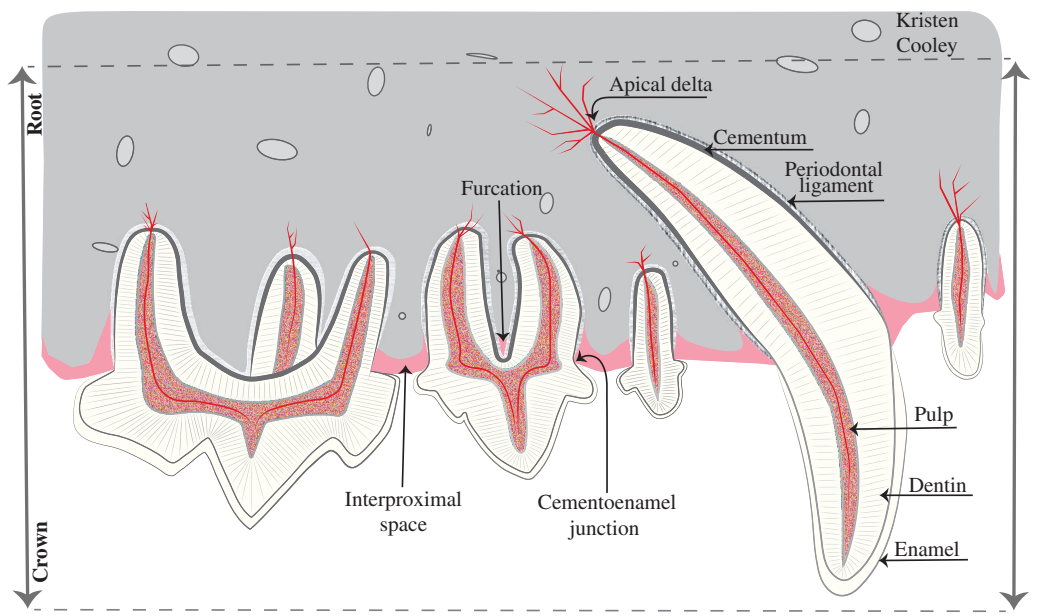
Cats are classified as having diphyodont dentition; they have two sets of teeth in their lifetime. The primary (or deciduous) teeth erupt at 2 weeks to 6 months of age. The permanent (or secondary teeth) should be fully erupted by 7 months of age. Cats have four specific types of teeth. The incisors are designed to cut, groom, and pick up. The canine teeth are used to grasp prey, tear, hold, and as defensive weapons in protection. The premolars and molars are used to grind food into a more digestible form (Table 15.1).

15.1.2 Tooth Anatomy

The structures of the tooth consist of the crown, root, enamel, cementum, dentin, pulp chamber, and periodontal ligament. The crown is the portion of the tooth that is supragingival and easily visualized during the oral exam. The crown is covered by enamel. Enamel is the hardest substance in the body. The root is the portion of the tooth that is subgingival. The periodontal ligament surrounds the root and is the supporting structure of the tooth. The root is covered by cementum. The cemental enamel junction (CEJ) is where the crown and neck meet and is sometimes referred to as the neck of the tooth. The dentin is directly underneath the enamel and the cementum. The pulp chamber is the part of the tooth that is underneath the dentin. The apical delta is an opening located at the end of the root through which the blood supply and nerves enter the pulp. The interproximal space is the area between two teeth. The furcation is the space between the roots of the same tooth (Figure 15.1).

Table 15.1 Feline dental formula and feline eruption table.

Primary deciduous – 2(I3/I3, C1/C1, P3/P2) = 26 teeth
Permanent – 2(I3/I3, C1/C1, P3/P2, M1/M1) = 30 teeth
Feline eruption timetable
Primary
Incisors – 2–3 weeks
Canines – 3–4 weeks
Premolars – 3–6 weeks
Permanent
Incisors – 3–4 months
Canines – 4–5 months
Premolars – 4–6 months
Molars – 4–5 months



Crown: the enamel covered portion of the tooth above the gingiva
Fucation: the space between the roots of the same tooth
Apical: toward the tip or apex of the root
Coronal: toward the tip of the crown

Figure 15.1 Tooth anatomy. *Source:* Kristen Cooley.

15.2 Patient History and "History Gathering Questions"

Patient history gathering is an essential tool for the feline veterinary technician. This information is important in the creation of the treatment plan for the feline patient. This topic is covered in detail in Section 15.6.

15.3 Dental Equipment

A well-equipped dental suite is essential for practicing high-quality veterinary dentistry. When purchasing dental equipment, the frequency of use, type of use, space available for equipment, and cost should be evaluated before making a decision. The purchase of dental equipment provides an excellent return on investment.

The 2019 American Animal Hospital Association (AAHA) Dental Care Guidelines for Dogs and Cats recommend having a dedicated dental space, separate from the sterile surgery suite. The dental space should be in a low-traffic area. Ideally, a separate dental suite is optimal. The dental suite should provide adequate ventilation, high-intensity lighting, and magnification equipment to facilitate visualization of the oral cavity [2]. The dental table should allow drainage and may be fixed or mobile. A fixed table is one that is attached to a wall and has a space at the working end where the operator can place their legs under while working on the patient. A mobile table has the advantage of being raised or lowered to a comfortable ergonomic height for the operator and can help prevent work-related injury to the back and neck. The feline-only practice can utilize a dental table design that is much smaller, therefore utilizing a smaller footprint when designing the dental suite. Most dental wet tables have a grate at the working end where debris and liquids can fall into the tub below. Tables should be constructed of impervious material that is easy to clean (Figure 15.2).

Dental units are a vital piece of equipment in the dental operatory. The most common type is an air- or gas-driven unit. Air-driven units include a compressor to deliver pressurized air to dental handpieces. Compressors take room air and compress it to drive the handpieces. Compressors are often mounted on a cart that has switches and handpiece holders. Dental units may also be mounted on walls, with the compressor in a remote location, connected by hoses. Air-driven units accommodate a variety of handpieces. Most units contain high- and low-speed handpieces, a three-way air–water syringe and may include an ultrasonic scaler and suction unit. The handpieces are operated using a foot pedal, which allows hands-free control. Air-driven units also have the ability for water to be delivered into the handpieces, which function as a



Figure 15.2 Example of an ideal feline dental suite designed with patient and operator safety and comfort in mind. *Source:* Jan Yaroslav.

coolant. Some air compressor systems use oil for lubrication. The oil level should be monitored frequently because insufficient oil can cause overheating and damage to the compressor.

Compressors also require the air storage tank be drained of any condensation on a regular basis. Failure to do so allows water to fill the tank, decreasing the effectiveness of the system and possibly ruining the compressor. Gas-driven dental units use compressed gas from a cylinder. Gas-driven units can be either nitrogen- or carbon dioxide-driven. Gas-driven units eliminate the maintenance needs of compressors. Electric motor-driven units are also available for use as a high- or low-speed alternative for handpieces. These units are not water-cooled and function at a much slower speed than air-driven units.

The high-speed handpiece is an important part of the dental unit. These handpieces are designed to be used at speeds of 200,000–400,000 revolutions per minute (rpm) and are water-cooled to help cool the burs, which due to friction could cause tissue or tooth damage. High-speed handpieces are available with a fiber-optic light source. They are used for cutting teeth for extractions and making access holes in teeth in root canal therapy. Low-speed handpieces function at speeds from 5,000 to 20,000 rpm. They are not water-cooled. Two common attachments for this handpiece are the prophy angle and the contra-angle. A prophy angle is an attachment that allows the use of a prophy cup for polishing teeth during cleaning. Attachments are available, such as special files for engine-driven root canals and slow-speed burs for smooth restorations, for use with the contra-angle. Both types of handpieces require daily lubrication for maintenance and should be sterilized between patients. Most dental units come equipped with three-way syringes. They are used for flushing and rinsing the oral cavity and air-drying tooth structures during restorations and other procedures.

Power scalers convert electrical or pneumatic energy into mechanical vibration and operate in the range of 8,000–45,000 cycles per second. When the power scaler is placed against the calculus, the vibration shatters it, freeing it from the tooth surface. Power scalers must utilize a water source to help irrigate and cool the working tip of the instrument. The most common type of power scaler is ultrasonic. Ultrasonic scalers work by converting sound waves into mechanical vibration. Magnetorestrictive and piezoelectric are two types of ultrasonic scalers. Magnetorestrictive units have either a ferromagnetic stack-type insert or a solid ferrite rod insert. These inserts, when activated, cause the tip to vibrate. The ferromagnetic stack insert produces an elliptical motion at speeds of 18,000–30,000 cycles per second. The ferrite rod insert produces a circular motion at a speed of 42,000 cycles per second. Piezoelectric scalers have crystals in the handpiece to pick up vibration. They produce a linear motion at speeds of 25,000–45,000 cycles per second.

Tips for ultrasonic scalers come in several sizes that are designed for specific uses. The beaver-tail tip is relatively wide and designed for supragingival cleaning. The universal tip is ideal for feline patients and can be used both supragingival and subgingival. Several types of periodontal tips are available and designed for subgingival cleaning.

Dental hand instruments are divided into four main types: explorers, probes, curettes, and scalers. Most dental instruments have four specific parts: handle, shank, terminal shank, and working end. Handles come in a variety of round, tapered, and hexagonal shapes. The shank joins the working end to the handle. The terminal shank is the part of the shank that is closest to the working end. The working end is the portion that comes in contact with the tooth. Explorers and probes are two different types of instruments but are often grouped together because they are usually manufactured as double-ended instruments. One end is the periodontal probe, and the other end is the explorer.

Periodontal probes are used to measure gingival recession and periodontal pocket depth. They are available in a variety of styles and lengths. They are either notched or color-coded, corresponding to millimeter readings. The probe for use in feline patient should be delicate enough to fit into small spaces. The Williams probe, with markings from 1 to 10 mm, is a good choice.

Explorers are used to detect plaque and calculus, explore enamel defects, and check for exposed pulp chambers. The two types of explorers are the Pigtail explorer and the Shepherd's hook explorer. The Pigtail explorer has a fine, delicate tip, allowing greater tactile sensitivity. The Shepherd's hook is shaped like a crook and is the most commonly found explorer. The explorer can be used to detect tooth resorption and defects in the enamel and to evaluate fractured teeth for an open pulp chamber.

Curettes have two sharp working edges, a flat face, and a rounded back. Looking end-on, they have a half-moon shape. The rounded tip and back are less traumatic to soft tissues. They are used to remove calculus and plaque above and below the gumline and for subgingival curettage and root planning. Curettes come in a variety of types; some being designed to be area-specific. Common types of curettes include Universal, Gracey, and Columbia. Universal curettes can be used throughout the mouth. Gracey curettes are area-specific and are numbered for specific areas of use. Columbia curettes have a short shank, a medium-to-thin blade, and a medium curve to the working end. The Columbia 13/14 curette is ideal for use in feline patients due to the size and shape, and curvature of the blade.

Table 15.2 Dental instruments for the feline patient.

Explorer/probe – Williams
Curette–Columbia 13/14
Scaler–Morse 0-00
Winged elevators EX-W1XS, EX-W2XS
Root elevator 1.3S 1.3 mm straight
Periosteal elevator EX-9
Root forceps – Peets
Needle holder – micro Olsen–Hegar 12 cm
Scissors – LeGrange 11.5 cm
Tissue forceps – Adson 1 × 2 teeth 12 cm

Hand scalers have a triangular blade that tapers to a pointed tip with two parallel cutting edges. Hand scalers are used only for supragingival scaling. Types of scalers include Jacquette, Sickle, and Morse. Jacquette scalers have a medium blade with no shaft, and the blade is slightly longer than that of the Morse. The Sickle scaler has a long, sickle-shaped blade of medium thickness. The Morse scaler has a very thin, short blade with an acute 90° angulation. The Morse 0-00 scaler can remove calculus in small spaces; therefore, it is a perfect choice for use with feline patients.

Instruments used for oral surgery and exodontics include elevators, luxators, extraction forceps, root tip forceps, needle holders, scissors, thumb forceps, and scalpel handles. Periosteal elevators are designed to loosen gingival tissue from the buccal bone. Dental elevators are designed to be used in the periodontal ligament space. They function to weaken the periodontal ligament and loosen the tooth. Surgical instruments are used to suture gingival tissue post-extraction. Instrument choices for the feline dental pack are much smaller and more refined than those used in larger species (Table 15.2).

The care and maintenance of hand instruments are very important. They should be cleaned and sterilized between each patient. To remain functional, scalers and curettes must be kept sharp. There are two ways to test instrument sharpness: visual inspection and the use of an acrylic rod. For visual inspection, the instrument is held and rotated toward a light source. If the instrument is dull, the edge will reflect the light. If the instrument is sharp, the edge does not reflect light. To test for sharpness using an acrylic rod, the edge of the instrument is drawn across the rod [3, 4]. A dull blade glides over the surface without catching it. A sharp blade easily catches as the instrument is drawn against the surface of the rod.

Ideally, hand instruments should be sharpened after each use. Sharpening can be done with a honing machine or sharpening stones and sharpening stone oil. Stones can be flat or conical in shape. Common types of flat stones include India (used for coarse sharpening) and Arkansas (used for final sharpening). A conical stone is a round Arkansas stone. It is used to provide final sharpening to the instrument by working on its face. Two methods of sharpening with a flat stone are common. One technique is the moving stone/stationary instrument, and the other is the moving instrument/stationary stone. Both are good techniques, but the moving instrument technique is easier to master. A few drops of oil are placed on the sharpening stone. In this technique, the stone is placed on the table or held steady in the hand while the instrument is moved. The instrument is rotated so that the face (the flat surface between the two cutting edges) is parallel to the ground. The instrument is rotated to an angle of approximately 100–110°. The instrument is drawn back and forth in short strokes. If the instrument has a universal shank the process is repeated on the other side. For a curette, then stone is rotated around the front of the instrument to maintain the blunt toe shape. The conical stone is then used to remove any spurs from the face of the instrument. Dental hand instruments must be replaced when they can no longer be sharpened or are broken. Dental equipment can represent quite an investment for veterinary practice. Good maintenance, care, and handling practices will ensure that equipment can be used for many years.

15.4 Ergonomics

Personal protective equipment and ergonomics play an important role in the dental suite. Gloves must always be worn to protect the skin from exposure to biological exposure through open wounds or chemical contact. Eye protection or a mask, with a face shield, is necessary due to the possibility of broken burs or flying bits of calculus. Masks and the use of antimicrobial oral rinses for our patients are essential to protect the operator from the aerosolization of bacteria during dental procedures. Wearing a gown, or smock, and hat can also protect the operator from bacterial contamination of the clothes.



Figure 15.3 Proper use of the dental probe using the modified pen grasp. *Source:* Jan Yaroslav.

The importance of ergonomics for the technician working in the dental suite should not be ignored due to the risk of injury. Operator fatigue, back and neck strain, and repetitive motion injury can be common risks for technicians working in the dental suite. The suite should include good lighting and magnification equipment. The use of lighted magnification loupes is essential. Well-maintained hand instrumentation and proper training of team members can reduce operator fatigue and repetitive motion injuries. Technicians should receive training on the proper use of hand instruments using the modified pen grasp (Figure 15.3). Providing comfortable seating and an adjustable height dental table is important to promote good posture of the operator. This can help alleviate back and neck strain [5, 6].

15.5 Dental Radiography

Dental radiography is a very important diagnostic tool in veterinary practice. Thirty years ago, it was only common to offer this service in specialty practices. It is now the standard practice to perform high-quality dental radiographs at most general practices. Technology is rapidly advancing the tools of dental radiography. In the past, dental radiograph positioning was a skill that was hard to master and could be frustrating at times. Many factors influenced the production of diagnostic quality dental radiographs including but not limited to darkroom technique, chemical processing, handling

of radiograph film, storage of images, and positioning of radiograph equipment. Frustrations were common because of the time it took to process an image as well. It took two minutes to process a film using a chair-side darkroom. A seemingly well-positioned patient, film, and tube head could still produce a film that was over or under-exposed. Darkroom processing had lots of factors that could influence film quality including room temperature, age of chemicals, light leaks, and inadequate rinsing of films. Storage and retrieval of films were problematic, and films could be lost or were no longer of diagnostic quality. Digital systems have shortened the learning curve of dental radiograph positioning and techniques.

Dental radiograph systems can be either conventional or digital. Conventional systems include the use of a dental radiograph generator in combination with dental film and chair-side darkroom or automatic processor. Dental radiograph generators can be wall-mounted, mounted on a wheeled cart, or handheld. The wall-mounted units have limitations because they are not portable while the cart-mounted, or handheld can be easily used in all treatment areas. The handheld units are much smaller in size and easily stored. The three main parts of a dental radiograph generator are the tube head, the adjustable arm, and the control panel. The tube head houses the anode and cathode that generate the X-rays, a lead-lined tube for collimation, and a scale that is used to determine X-ray tube head positioning for radiographs. The adjustable arm allows for positioning the tube head at many different angles and levels in relation to the patient. The control panel contains the settings for the unit. Most units are fixed Milliamperage and kilovoltage. Time is the main setting used to produce proper technique. Dental radiograph film is a non-screened direct exposure film. Dental X-ray film is available in assorted sizes, numbered 0 to 4, which makes it adaptable to any size patient. Each individual film is housed in a lightproof, waterproof package. The film packets are marked with a raised dot indicating the exposure side of the film. Once exposed, the film must be processed using a manual chairside darkroom or automatic processor.

Digital systems consist of a dental radiograph generator in combination with dental software and a digital sensor or phosphor plate. The digital sensors are available in limited sizes, and are hard-wired into a laptop or desktop computer, and are a direct radiology system. The sensor is exposed, and the image is immediately available for viewing on the computer. Phosphor plates come in a variety of sizes like conventional film. The plates are reusable. The phosphor plate is exposed and put through a scanner, which digitizes the image and sends it to the computer, which is a computed radiology system.

Sixty-six percent of clinically relevant dental anatomy is not visible to the naked eye, and so cannot be visualized without the use of dental radiographs [7, 8]. It is simply not possible to practice quality dentistry without dental radiographs. There are several reasons to take dental radiographs. Indications for dental radiographs include missing and supernumerary teeth. Radiographs can determine if the tooth is impacted, fractured, or genetically absent. In the case of supernumerary teeth, it can determine if the tooth is a Gemini tooth or a fused tooth. Other indications include fractured teeth, tooth resorption, oral masses, nasal discharge, endodontics, and periodontal disease. Periodontal pockets of over one millimeter in cats should be radiographed. Dental radiographs are important in patients to evaluate the progression of disease. Dental radiographs are also an important tool in exodontics. Radiographs should always be taken pre- and post-extraction to document root removal and ensure proper exodontic technique.

Full-mouth dental radiographs should be recommended with every professional dental cleaning [9, 10]. The amount of hidden pathology discovered with routine dental radiographs can be amazing. It has been the author's experience that hidden pathology such as impacted teeth, dilacerated roots, apical abscesses, fractures, and neoplasia can often be found on radiographs of patients with seemingly normal oral exams.

When first learning dental positioning technique, the use of a skull can be helpful. Anatomical structures are more easily visualized on a skull and will help in learning where to position the X-ray beam. For more information on positioning, see online content associated with this chapter. Access to a digital system will also help in mastering positioning techniques. Digital systems provide instant gratification (not having to wait two minutes to develop conventional dental radiographs). Other advantages of digital systems include ease of film storage, ability to transmit images electronically, ability to manipulate images on the screen, and ability to mark pathology with text and symbols. Documenting pathology and presenting a copy to the owner is a great client education tool along with validating the perception of the value of the services you provide (Figure 15.4).

Radiation safety is an important consideration when working in the dental suite. Team members should be as far away from the primary beam as possible. The technician should never hold the sensor in the patient's mouth. The use of lead aprons and thyroid shields is mandatory. Dosimetry badges should always be worn in the dental suite. X-ray equipment should be checked for radiation leaks at state-mandated intervals.



Figure 15.4 Radiograph on a feline skull using the bisecting angle technique. *Source:* Jan Yaroslav.

Complications in dental radiology occur because of improper exposure, positioning, and developing. Dental radiograph machines are fixed MA and KVP. To troubleshoot improper exposure: if the film is too dark, decrease the time, and if the film is too light, increase the time. If using a digital system, changes can be made to the image using the software. Complications involving positioning include root elongation, root foreshortening, cone cutting, and overlapping dental structures. In the case of root elongation, move the tube head toward the midline. In the case of root foreshortening, move the tube head lateral. The SLOB rule stands for "same lingual, opposite buccal." It is a useful trick when dealing with three rooted teeth (usually maxillary PM4). When you have an image where two roots are overlapping, move the tube head more rostral and retake the image. The root that moves in the direction of the tube (rostral) is the palatal root. The root that moved in the opposite direction of the tube (caudal) is the buccal root. This technique is especially helpful when evaluating a tooth for endodontic therapy.

Developing techniques can also affect image quality. Other complications in image quality include artifacts on films. Prophy paste containing zinc is radio-dense and will show up on films as granular particles. Mouth gags, endotracheal tubes, and even calculus can show up as artifacts. When using digital sensors, if the sensor is placed upside down you get an image of the hardware instead of the tooth.

Dental radiology is an essential tool for all veterinary practices. The information gained by producing high-quality dental radiographs is huge. The more images taken, the more pathology discovered. The investment in equipment and staff training is well worth it.

15.6 The Feline Oral Exam

Oral examination in feline patients is important at all life stages. Starting with the first kitten exam, which includes getting the kitten used to be handled around the head. Start by educating clients on how to work on this at home by gently stroking the kitten's face and working up to opening the mouth and touching the teeth. These kitten visits are also used to educate clients on the importance of oral home care. Oral hygiene kits including a feline-friendly toothbrush and toothpaste, written instructions, and plaque-inhibiting dental treats are sent home at this visit.

Young adult annual wellness exams include reinforcement of oral home care. The importance of preventive professional dental cleanings is discussed during these visits as well. Routine dental cleanings under anesthesia can improve dental health, reverse early periodontal changes like gingivitis, and prevent more serious periodontal disease.

Senior cat wellness exams should include an emphasis on oral health as well. The oral examination should include a thorough history including questions about diet, appetite, eating and drinking habits, and toys and treats given.

Subtle changes in behavior, grooming, or eating habits should not be ignored as they can be a sign of dental disease. Symptoms, including but not limited to head shaking, weight loss, halitosis, sneezing, or pawing at the face or facial swellings are indications of dental disease. It is important to remember that many cats who do not show signs of pain can have significant oral pathology. It can sometimes be a challenge to do a thorough oral exam on some feline patients. Feline-friendly handling techniques using a less-is-more approach can make the process easier. See Chapter 2: "Feline Friendly Interactions," for further information.

The key to recognizing oral pathology starts with a thorough oral examination. The initial examination is conducted in the exam room with the owner present. Presenting complaints and history are important factors in this process. We need to listen to what our clients are saying. It is also important to ask the right questions. What age and breed are the patients? Nutrition, activity level, and associated symptomology are also factors. The head is connected to the rest of the animal; therefore, look at the whole pet. Often systemic disease can create oral pathology as well.

Start by observing the patient and his demeanor in the exam room. Check out the head. How does the animal hold its head? (e.g., down, to the side, or slightly elevated) Watch for any signs of discomfort like facial rubbing or salivation. This can indicate painful conditions of the ear, vertebral disease, as well as the teeth or tongue. Check for facial symmetry or any facial swelling. Facial swelling can be a sign of trauma, abscessed teeth, lymph node enlargement, or even neoplasia. Check the jaw relationships. Does the patient have malocclusion and is it normal for the breed? Open the mouth and note any pain or resistance to opening. Observe the oral mucosa for color, inflammation, lesions, or any swelling. Observe the teeth, looking for missing teeth, supernumerary teeth, crown deformities, or fractured teeth. Evaluate the tongue and hard palate for swelling, ulcerations, symmetry, and the presence of foreign bodies. Performing an oral exam on an awake patient is important but can be difficult for some patients. Examination of anesthetized patients will often reveal pathology that went unnoticed in the exam room.

15.7 The Professional Dental Cleaning

The ability to provide professional dental cleaning is an essential skill for the feline technician. General anesthesia is mandatory to be able to perform the procedure correctly. More information can be found in Chapter 6: "Anesthesia Considerations for the Feline Patient." Anesthesia-free teeth cleaning is sometimes marketed to our clients as a safer, more cost-effective alternative. It is considered malpractice due to the risk of harm to the patient. The chance of tooth or jaw fracture, the inability to examine the oral cavity in the awake patient, adequately clean subgingivally, and patient comfort are major concerns. It is the veterinary technician's responsibility to educate the client about these issues [11]. Excellent client education materials on this subject can be found on the American Veterinary Dental College (AVDC) website [12]

Professional dental cleaning has been called many things such as "a prophy" (dental prophylaxis), "a dental," and SPF (scale, polish, fluoride). It is recommended to use terminology that clearly conveys the importance of the procedure to the client. The professional dental cleaning procedure is an essential part of the Comprehensive Oral Health Assessment and Treatment. The steps in a professional dental cleaning include an oral assessment (including pre-cleaning oral photographs) preliminary charting, irrigation of the oral cavity with an antimicrobial solution, cleaning the teeth subgingivally and supragingivally, full mouth dental radiographs, and polishing, followed by oral irrigation and post-procedure photographs. A treatment plan is created after performing radiographs and the dental chart is revised (Table 15.3).

Table 15.3 Steps of a professional dental cleaning.

Complete oral examination under general anesthesia.
Preliminary dental charting and photographs.
Irrigation of the oral cavity with an anti-microbial solution.
Supragingival and subgingival scaling of the teeth.
Full-mouth dental radiographs.
Complete dental charting based on a revised treatment plan.*
Polishing the teeth.
Final irrigation of the oral cavity.
Perform post-cleaning photographs.

*Periodontal and oral surgery as prescribed by veterinarian.

15.8 Dental Charts

Feline dental charts are used to document oral pathology and treatments performed, and they are an essential part of the medical record. Dental charts can be digital or hard copy and should be large enough to document findings. They should include signalment and use current abbreviations and nomenclature. Dental chart stickers or stamps are commercially available but are not ideal because they do not provide enough space for proper documentation. Charts may also be provided in some practice management software programs.

15.9 Tooth Numbering Systems

Tooth numbering systems can be anatomical or use tooth numbers. The anatomical system uses the description of tooth location, such as maxillary right canine. It also includes abbreviations using an alphanumeric system. The tooth type is listed first (canine = C), then the quadrant is listed next by a number, either superscript or subscript. The most common tooth numbering system is the Modified Triadan System. The modified Triadan system uses a three-digit numbering system. The first digit denotes the quadrant. The next two numbers denote the tooth identification. The maxillary right quadrant is the 100 quadrant, the maxillary left quadrant is 200, the mandibular left quadrant is 300, and the mandibular right quadrant 400. For primary dentition, the mandibular right quadrant is the 500 quadrant, the maxillary left quadrant is 600, the mandibular left quadrant is 700, and the mandibular right quadrant is 800. The tooth identification numbers start with the central incisors (01) and move caudally. The maxillary right canine tooth is tooth number 104. This system is adapted for feline dentition using the rule of 4 and 9. The canine teeth are always number 04 and the first molar is always 09. This rule is especially helpful when evaluating feline patients. Tooth numbers 105, 110, 205, 210, 304, 305, 310, 311, 404, 405, 410, and 411 are missing in cats [13, 14].

15.10 Nomenclature and Abbreviations

The standard dental nomenclature and abbreviations were developed and are updated by the AVDC. It is used by the veterinary profession to be able to document and communicate in a standard and concise manner [15].

15.11 Oral Pathology

15.11.1 Periodontal Disease

Periodontal disease is the most common oral disease that is seen in veterinary patients and far and away the most frequent cause of tooth loss in cats. It has been estimated that over 80% of our patients over 3 years old have some form of periodontal disease [16]. Periodontal disease is an inflammation or infection of the tissues surrounding the teeth. Initially, the gingiva becomes inflamed when exposed to microorganisms in dental plaque. Gingivitis can progress to periodontitis

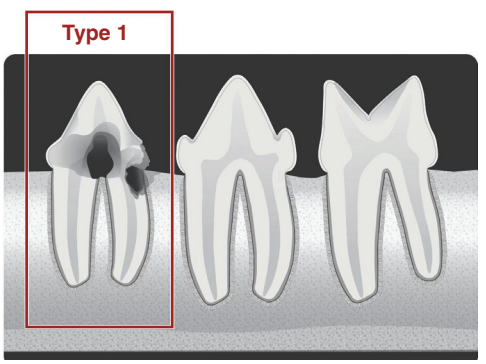
and affects the deeper supporting structure of the tooth. It causes destruction of the periodontal tissue, attachment loss progressing to tooth loss.

The classification of periodontal disease can be broken down into five stages. Normal (PD0): no inflammation of gingiva present. Stage 1 (PD1) is early gingivitis where redness of the gingiva and a mild amount of plaque is present. Stage 2 (PD2) is early periodontitis with increased inflammation, including edema and development of subgingival plaque and less than 25% attachment loss. The amount of supragingival plaque and calculus has also increased. Both stage 1 and 2, periodontal diseases can be reversed with professional cleaning and home care [17]. Stage 3 (PD3) is moderate periodontitis and includes a moderate amount of pocket formation with a 25–50% loss of bone support. Furcation exposure, tooth mobility, gingival bleeding, and recession may also be present. Stage 4 (PD4) is advanced periodontitis. Furcation exposure is measured with a periodontal probe and has 3 stages. Stage 1 (F1) is when the probe can be inserted less than halfway through the furcation, Stage 2 (F2) is when the probe can be inserted halfway, and Stage 3 (F3) is when the probe can be inserted completely through the furcation. Severe pocket formation, more than 50% attachment loss, gingival recession and excessive bleeding, bone loss, and tooth mobility will be present. Stages 3 and 4 are not reversible. We can only hope to stop the progression of the disease with periodontal therapy [18].

15.11.2 Tooth Resorption

Three conditions of the oral cavity more common in cats than in other species are stomatitis, eosinophilic granuloma complex, and tooth resorption. Tooth resorption has also been called cervical line lesions, neck lesions, feline odontoclastic resorptive lesions, and feline resorption in the past. The correct term is tooth resorption according to the American Veterinary Dental College because the condition has been found not only in felines but in other species such as canines and primates.

Tooth resorption is defined as the resorption of dental hard tissue by odontoclasts resulting in the erosion of cementum. Tooth resorption is classified into five stages based on the severity and into three types based on the location of the resorption [19] (Figures 15.5–15.8).



Figures 15.5 Tooth resorption type 1. *Source:* AVDC.

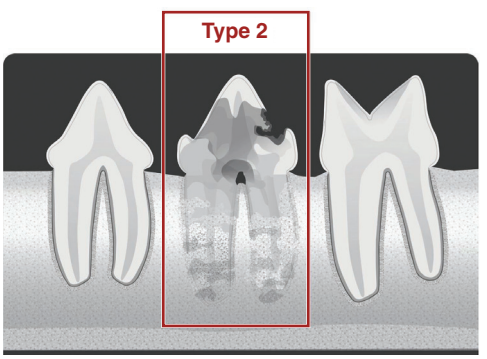


Figure 15.6 Tooth resorption type 2. *Source:* AVDC.

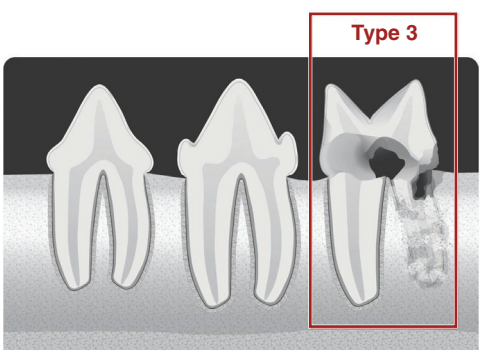


Figure 15.7 Tooth resorption type 3. *Source:* AVDC.

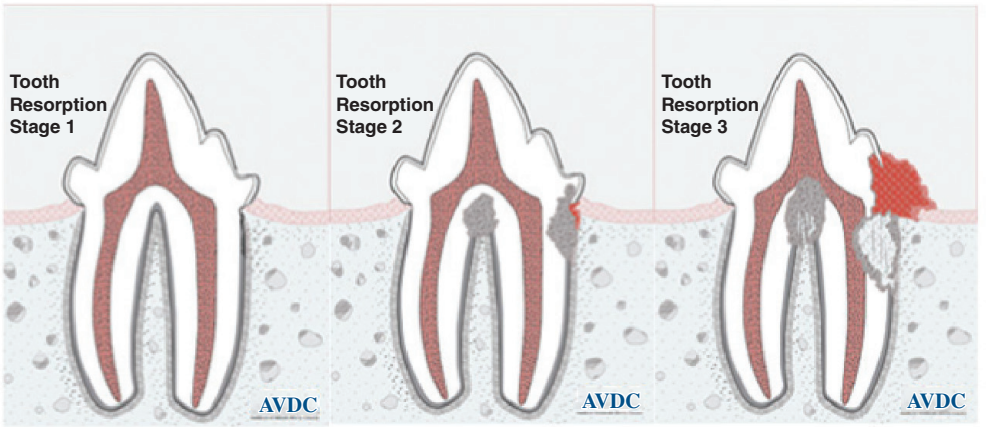


Figure 15.8 AVDC classification of clinical stages. *Source:* AVDC.

1. Stage 1 (TR1): Mild dental hard tissue loss (cementum or cementum and enamel): this stage is not observed clinically because the lesion is small and confined below the gingival.
2. Stage 2 (TR2): Moderate dental hard tissue loss (cementum or cementum and enamel with loss of dentin that does not extend into the pulp cavity.
3. Stage 3 (TR3): Deep dental hard tissue loss (extends into the pulp cavity); most of the tooth retains its integrity.
4. Stage 4 (TR4): Extensive dental hard tissue loss; most of the tooth has lost its integrity.
   i. Stage 4a: Crown and roots are equally affected.
   ii. Stage 4b: Crown is more severely affected than the root.
   iii. Stage 4c: Root is more severely affected than the crown.
5. Stage 5 (TR5): Remnants of dental hard tissue are visible only as irregular radiopacities and the gingival covering is complete.

Tooth resorption types (based on radiographic appearance):

1. Type 1 (T1): There will be a focal or multifocal radiolucency with a normal radiopacity and a normal periodontal ligament space.
2. Type 2 (T2): There is a narrowing or disappearance of the periodontal ligament space in at least some areas and decreased radiopacity.
3. Type 3 (T3): The tooth will have areas of normal to narrow or lost periodontal space. There will be focal to multifocal areas of decreased radiolucency and generalized decreased opacity in other areas of the tooth.

There is no gender, breed, or age predisposition. It has been reported that up to 75% of cats may be clinically affected [20]. Diagnosis and treatment of tooth resorption are determined by oral examination and intraoral radiographs. Extraction is the treatment of choice due to the progressive nature of the disease. Complete extraction is important for those teeth with

Table 15.4 A summary of the stages of tooth resorption.

AVDC Stages of tooth resorption
Stage 1 (TR 1): Mild dental hard tissue loss (cementum or cementum and enamel).
Stage 2 (TR 2): Moderate dental hard tissue loss (cementum or cementum and enamel with loss of dentin that does not extend to the pulp cavity).
Stage 3 (TR 3): Deep dental hard tissue loss (cementum or cementum and enamel with loss of dentin.
Stage 4 (TR 4): Extensive dental hard tissue loss (cementum or cementum and enamel with loss of dentin that extends to the pulp cavity); most of the tooth has lost its integrity.
TR4a Crown and root are equally affected.
TR4b: Crown is more severely affected than the root.
TR4c: Root is more severely affected than the crown.
Stage 5 (TR 5): Remnants of dental hard tissue are visible only as irregular radiopacities, and the gingival covering is complete.
AVDC types of tooth resorption based on radiograph appearance
Type 1: On a radiograph of a tooth with type 1 (T1) appearance, a focal or multifocal radiolucency is present in the tooth with otherwise normal radiopacity and normal periodontal ligament space.
Type 2: On a radiograph of a tooth with type 2 (T2) appearance, there is narrowing or disappearance of the periodontal ligament space in at least some areas and decreased radiopacity of part of the tooth.
Type 3: On a radiograph of a tooth with type 3 (T3) appearance, features of both types 1 and 2 are present in the same tooth. A tooth with this appearance has areas of normal and narrow or lost periodontal ligament space, and there is focal or multifocal radiolucency in the tooth and decreased radiopacity in other areas of the tooth.

an intact periodontal ligament space. Coronal amputation is an option for those teeth with severe root resorption. It was once thought that treatment of stage 1 lesions could be achieved with restoratives but was found to have a poor success rate. The treatment of choice is extraction. Much research has been done on feline tooth resorption, but they are still considered to be idiopathic in nature (Table 15.4).

15.11.3 Eosinophilic Granuloma Complex

The eosinophilic granuloma complex can involve lesions in the oral cavity, lips, and skin. Lesions can appear on the mucosa of the hard and soft palate, dorsal tongue surface, and sublingual area. Eosinophilic ulcers (also called "rodent ulcers") are seen in the rostral portion of the upper lip. Lesions have raised edges with a yellow-pink ulcerated surface. Most lesions are thought to be associated with underlying sensitivity such as allergies to food or insect bites in conjunction with bacterial or viral infections. Diagnostics recommended include cytology and/or histology to rule out neoplasia. Treatment options consist of glucocorticoids, antibiotics, and immunomodulators. The use of flea prevention products and a food trial is also recommended due to the possible association with allergies [21] (Figure 15.9).

15.11.4 Stomatitis

Stomatitis in cats is described as persistent inflammation of the oral mucosa. Symptoms of stomatitis include weight loss, halitosis, inappetence, pawing at the face, drooling, and difficulty swallowing due to pain and discomfort in the oral cavity. The inflamed tissues become ulcerated and bleed easily. Stomatitis can affect the gingival, alveolar mucosa, labial and buccal mucosa, and extend to the palatoglossal folds. Diagnostics include a chemistry panel and complete blood count. Retroviral testing is also recommended, as stomatitis has been associated with both feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV)-infected cats. The disease appears to be immune-mediated in nature and may be associated with chronic viral infections. A professional dental cleaning and full mouth dental radiographs are indicated to assess the extent of the disease. A biopsy of the gingival can be done to rule out evidence of neoplasia. Medical treatments include impeccable home care for plaque control and pain management in the early stages to anti-inflammatory and immunosuppressive drugs as the disease progresses. Surgical treatment consists of the extraction of teeth in the areas of inflammation. Surgical and medical treatment options are often used together. Surgical treatment can have up to an 80% cure rate. Recent studies using mesenchymal stem therapy as an alternative treatment for stomatitis have been promising [22, 23] (Figure 15.10).



Figure 15.9 Eosinophilic granuloma complex. *Source:* Jan Yaroslav.



Figure 15.10 Stomatitis. *Source:* Courtesy of AVDC.

15.11.5 Oral Neoplasia

Oral tumors occur in cats can be either benign or malignant. Senior cats are generally predisposed to oral tumors, but they can be seen in younger cats as well. Cats can often be asymptomatic, and owners may be unaware that the cat has an oral mass. The diagnosis of oral tumors often occurs when the tumor becomes invasive, causing pain.

Oral examination during each patient visit is imperative in early tumor detection. Symptoms rarely appear with benign tumors. Benign oral tumors are less common in cats, but epulis, lipoma, and plasmacytoma are occasionally seen. A biopsy and subsequent staging of the disease are always indicated with any oral mass.

Drooling, weight loss, bloody oral discharge, halitosis, and dysphagia can be symptoms of malignant oral neoplasia. Malignant oral tumors in cats include squamous cell carcinoma, fibrosarcoma, osteosarcoma, lymphosarcoma, and malignant melanoma. The most common malignant oral tumor in cats is squamous cell carcinoma (SCC) [24, 25]. When found in the lower jaw, it often presents as a mandibular swelling. Radiographs of mandibular SCC tumors show massive bone destruction with a sunburst formation. SCC can also be present in other areas of the oral cavity such as the lingual, sublingual, and maxillary. Metastasis to regional lymph nodes is common in about 30% of cats and distant metastasis occurs late in the disease process. Maxillary SCC may present as a non-healing tooth extraction site. Diagnostics includes comprehensive lab work, radiographs of the thorax, and biopsy of the lesion. Treatment options include radiotherapy, chemotherapy, and surgical excision, including mandibulectomy.

15.11.6 Client Education and Home Care

The goal is early detection and prevention to improve dental health in our feline patients. Client education on the importance of oral home care and regular wellness examinations can make the goal successful. Client education bonds clients to the practice. Most clients are very interested in learning about how to better care for their pet. Our goal is to improve the quality of life for our patients by recommending home care that can be easily done by the client. This includes giving multiple options for realistic home care. The information should be delivered in a consistent manner by all team members. The technician's role is to reienforce the veterinarian's treatment plan recommendations. The technician plays a vital role in both helping the client understand the importance of recommended treatments, removing barriers to being able to provide treatment, and the ability of the client to perform recommended home care. Home care can be either active or passive. Tooth brushing is considered active and is the gold standard for oral home care because of its effectiveness in plaque control. It is important to start with early training at the first kitten visit. The process takes patience and is most successful with slow progress. It often takes several weeks to reach the point where a cat will allow tooth brushing.

The first step is to teach the client to spend time each day stroking the kitten's head and lips. Once the kitten accepts and enjoys being touched the next step is to have the client lift the upper lip, so the teeth are visible. Using a gauze square with a small amount of chicken broth or tuna juice the client then can attempt to brush the exposed teeth using a circular motion on the tooth surface. Once the client is successful with this, the next step would be to use a toothbrush combined with a feline-approved toothpaste.

Feline toothbrushes are available in several different styles. The finger toothbrush is a good choice for use in cats. Tooth brushing is not going to be realistic for all patients. Recommendations for passive ways to inhibit plaque formation include dental diets, treats, gels, and water additives. Commercial dental diets work by using a kibble matrix with or without a chemical anti-plaque agent [26]. Only those products that are Veterinary Oral Health Council (VOHC-approved should be recommended. The VOHC was established in 1997 to evaluate and endorse veterinary oral home care products. Approved products that have proven anti-plaque properties can be found at VOHC.org [27].

It is the goal for the feline veterinary technician to provide high level standard of practice veterinary dentistry for our patients. Mastery of feline dental skills can be achieved through dedication, patience, continuing education, and practice.

See the companion website for further clinical references.

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16

Dermatology and Auricular Conditions

Amanda Friedeck, BS, LVT, VTS (Dermatology)

TECHNICIAN TIDBITS

- Skin infections in cats are not as common as in dogs.
- A mixed population of white blood cells (neutrophils, eosinophils, macrophages, plasma cells, and mast cells) indicates inflammation; the presence of fungal hyphae or bacteria indicates infection; and a monomorphous cell population with few inflammatory cells indicates neoplasia on cytology.
- The patterns seen in hypersensitivity reactions are self-induced alopecia, miliary dermatitis, cervical-facial dermatitis, and eosinophilic granuloma complex.
- Allergic pruritus can be overdiagnosed as psychogenic alopecia, but a true diagnosis of behavior is rare.
- Feline allergy does not correlate with the human or canine models.
- Environmental allergens are aero-pollinators and are designed to travel long distances, so avoidance is not possible.
- Immunotherapy is not a cure-all; it can take up to 1 year for full effectiveness and expectations are 80% resolution, 80% of the time.
- All patients on immunotherapy will flare; this does not mean the immunotherapy is not working.
- Otitis externa, with either bacteria or *Malassezia*, is not as common in felines as it is in canines.

The subject of feline dermatology covers a wide array of topics that could fill an entire book. This chapter will cover the most common disease processes seen in practice as well as a few that are strictly feline diseases. Topics that will be covered are basic feline dermatology, feline reaction patterns, hypersensitivities, facial dermatosis, and auricular disease.

16.1 Patient History and "History Gathering Questions"

Obtaining a history of any allergic patient will include the same basic question, no matter what disease process is at play. Talking to an owner about pruritus can be tricky as owners do not always realize the manifestations of pruritus. When speaking about pruritus, it is best to break it down into the individual actions such as licking, chewing, biting, and rubbing and discuss specific locations the owner has noticed. Once pruritus is classified other questions should include age of onset of clinical signs, seasonality, if present, and parasite control measures. Other questions should be asked about the pet's environment, primarily indoor versus outdoor, other pets in the household, travel history, and dietary history of the patient since clinical onset.

16.2 Clinical Signs

Clinical signs in felines vary depending on the presenting disease. Felines can have serious self-induced trauma typically over the head and neck. Pruritus may or may not be noticed due to either the patient is not pruritic, or felines like to hide when they are pruritic, and the owners never see them. Signs of pruritus may be the only way to know for sure. These signs include self-induced alopecia (SIA) or self-trauma from scratching. Other clinical signs to look for are alopecia, crusting, erythema, and scale. More specific clinical signs will be discussed throughout the chapter depending on the dermatologic condition.

16.3 Physical Examination Findings

Physical examination of felines can be harder since many have limited time for examinations. A quick thorough exam is beneficial to all involved. The physical exam should be done the same way every time, so nothing is missed. It can be either systematic or nose to tail. Always check mucus membranes and the roof of the mouth for ulcers. Both the pinna and the canals should be checked in every dermatologic case. Be sure to get a good exam between the toes and in the claw folds. The inguinal and axilla should be examined when checking the ventrum, and anal glands should be palpated as well. More in-depth physical exam findings will be discussed with each individual disease process throughout the chapter.

16.4 Specific Nursing Care Considerations

Handling a dermatology cat is no different than examining any other. Be sure the feline is in a contained location prior to examination and handled in such a way that the entire animal can be examined easily.

16.5 Basic Feline Dermatology

16.5.1 Pyoderma

Folliculitis, or inflammation of the hair follicle, is caused by bacterial pyoderma or parasites. Skin infections are rare in cats [1–5], but they should always be ruled out by cytology. Clinical signs of pyoderma include crusted papules, alopecia, and scaling on the head and neck. The cytology of the crusted papules will reveal neutrophils and bacteria. *Malassezia* is not a common finding in cats and is seen with feline allergic syndrome, but it has been reported to be an identifier for internal malignancies [3]. *Malassezia*, if seen, is usually on the face and in the ears, and can cause erythema, SIA and lichenification, although this is less noted in felines than in canines [1]. When dealing with a suspected pyoderma, always rule out dermatophytes, as they are more common in felines. See Chapter 23: "Infectious Diseases," for further reading on dermatophytes. Treatment of bacterial pyoderma or *Malassezia* in felines does not differ from treating canines except that it may be harder to use topical therapy. Antibiotics and antifungals should be used at an appropriate dose for 2 weeks after clinical remission, which is usually in 2–3 weeks.

16.5.2 Parasites

The most common mites in feline are *Otodectes cynotis* (ear mites). It is highly contagious to other animals and can rapidly spread throughout a multi-cat household [6]. *Otodectes* causes a large amount of dry, dark brown debris within the ear and will have a variable amount of erythema and pruritus [6, 7]. The degree of clinical signs tends to increase with the severity of the disease [6]. Animals can develop hypersensitivity to mites which causes a higher degree of pruritus with a limited number of mites. Some cats have been known to be asymptomatic carriers of ear mites as well [6]. Many times, diagnosis is achieved through otic examination, and the mites can be seen walking around the inside of the ear. Cytology can be obtained by collecting the debris and mixing it with a drop of mineral oil, and microscopically visualizing at 4× or 10× objectives.

There are many other mites that can cause problems in felines. *Cheyletiella blakei* or walking dandruff is seen on the dorsum and flanks. It causes intense pruritus which in turn causes self-trauma and alopecia [7]. *Demodex gatoi* is contagious to other cats and causes scaling, excoriations, and crusting on the head, neck, and dorsum with variable pruritus [1, 7]. Other clinical signs include erythema and hyperpigmentation with minimal inflammation. This mite lives in the stratum corneum, so deep skin scrapes are necessary for diagnosis [1]. Outdoor cats may be exposed to *lynxacarus*, the cat fur mite, or chiggers. Both mites cause pruritus with the former causing SIA and the latter being seen on the face and pinna [7]. Depending on geographical location, there are other parasites to be concerned about: *notoedres*, scabies, lice, cuterebra, and the sand fly that carries leishmania [1]. Treatment for mites is easy, as they are sensitive to most flea medications; just be sure to treat all animals that may have been exposed [6].

16.5.3 Plaques

By definition, a plaque is a 1 cm or larger, elevated lesion with a flat top that is wider than it is tall. A nodule is also larger than 1 cm and is a solid circumscribed lesion that can drain depending on the cause of the nodule. Using size, shape, color, and fixed vs. movable properties can be used to further describe these lesions [8]. Plaques are commonly seen with either allergic skin disease or neoplasia, while nodules can be cystic, fungal, bacterial, sterile (eosinophilic granuloma complex [EGC] or sterile nodular panniculitis), or neoplastic. Cytology is the best way to distinguish between the causes of a plaque or nodule. The aspirate can show you what cell types are present. A mixed population of white blood cells (neutrophils, eosinophils, macrophages, plasma cells, and mast cells) indicates inflammation; the presence of fungal hyphae or bacteria indicates infection; a monomorphous cell population with few inflammatory cells indicates neoplasia. You can also see a predominant eosinophil population which would point towards EGC. Inflammation can be further distinguished by cell type: mostly neutrophils and macrophages are pyogranulomatous where few neutrophils, but the higher number of eosinophils and plasma cells indicate a granulomatous inflammation [8]. When dealing with plaques a biopsy is the best method for diagnosis; it can definitively distinguish between neoplastic, fungal, bacterial, and sterile etiologies [8].

16.6 Allergic Reaction Patterns

Before we delve too far into feline hypersensitivity reactions, we must first understand the reaction pattern in cats. Cats like to do things differently and do not have the same distribution patterns as canines [9]. For felines, reactions usually involve the face, head, neck, pinna, ventral abdomen, and legs. Less likely areas are the lateral thorax, flank, perineum, axillae, and lumbosacral. Canines have a higher percentage of paw involvement than felines. Otitis, with or without infection, is only seen in about 20% of the cases of feline hypersensitivity, which is much lower than what is seen in canines [10]. For felines, the patterns seen in hypersensitivity reactions are SIA (Figure 16.1), MD (Figure 16.2), CFD (Figure 16.3), and EGC (Figure 16.4) [3]. None of the reaction patterns are diagnostic for any specific hypersensitivity but are clues as to what may be the inciting cause of the pruritus.



Figure 16.1 Self-induced alopecia. *Source:* A. Friedeck.



Figure 16.2 Miliary dermatitis. *Source:* A. Friedeck.

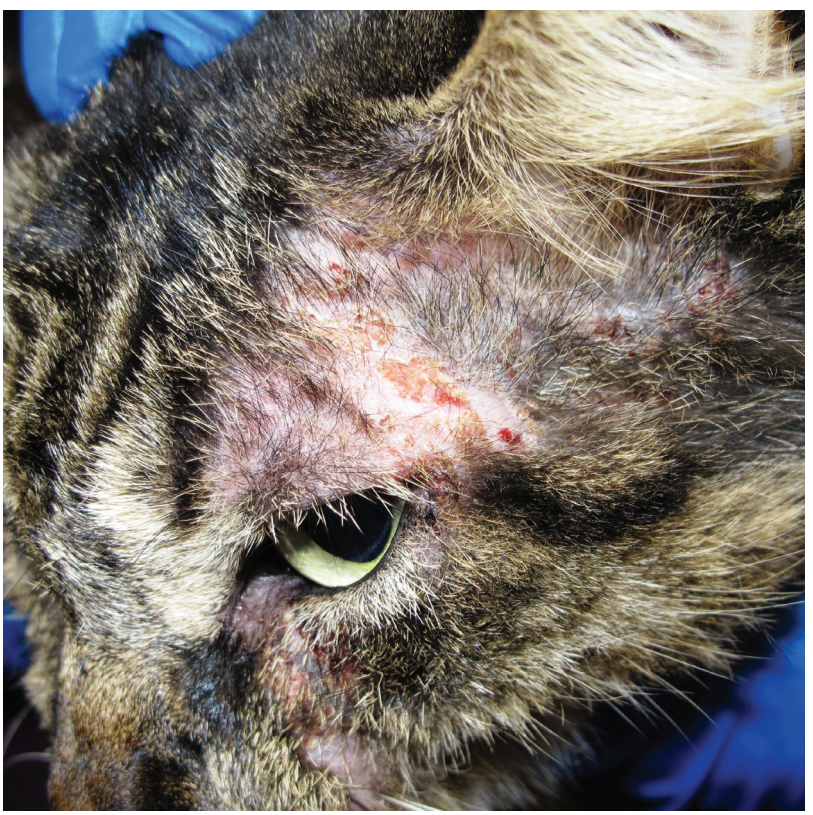


Figure 16.3 Cervical-facial dermatitis. *Source:* A. Friedeck.

16.6.1 Self-induced Alopecia

SIA is also known as barbering, fur mowing or symmetrical alopecia. It is caused by the cat licking, chewing, or pulling out its own fur as well as scratching at the locations. It will cause partial to complete alopecia usually on the ventrum with variable erythema and excoriations [2]. It can be overdiagnosed as psychogenic alopecia, but a true diagnosis for behavior

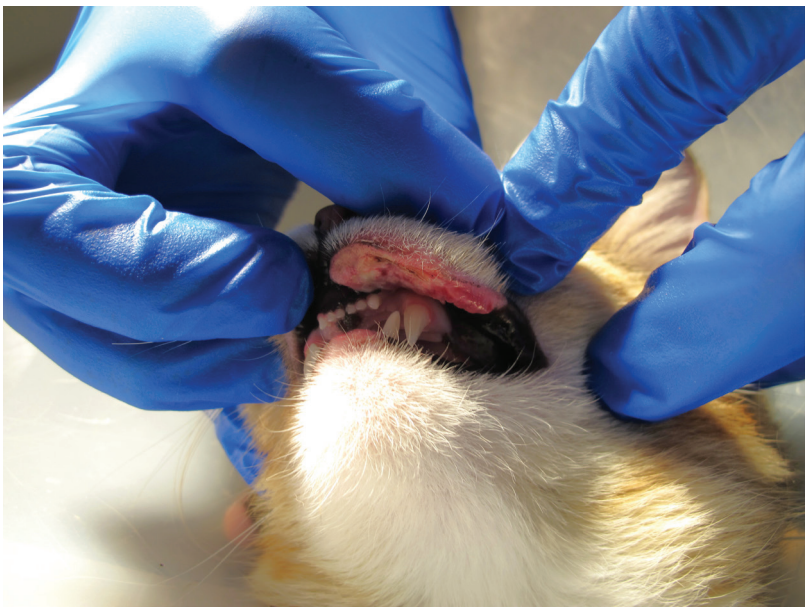


Figure 16.4 Eosinophilic granuloma complex—rodent ulcer. *Source:* A. Friedeck.

is rare [2]. Most owners do not see the cat over-grooming as many cats like to do it in secret, but owners may notice an increase in hair balls, or hair in the stool [10].

16.6.2 Miliary Dermatitis

MD is usually better palpated than visualized as it causes pinpoint erythematous crusted papules located on the head, neck, and dorsum [2, 10]. They feel like miliary grain in the skin. MD is usually pruritic and can cause excoriations and alopecia as the disease worsens [10]. MD can be caused by a reaction to fleas, food, or the environment but also from mites such as *cheyletiella* or ear mites, and a decreased amount of essential fatty acids in the diet. Pemphigus and mast cell tumors can create lesions similar to MD, but the papules are usually slightly larger. Diagnosis of MD is based on feel, but it is recommended to do skin scrape and cytology to rule out folliculitis and initiate ectoparasite control if that is not being done. A biopsy can be collected to distinguish between autoimmune disease, neoplasia, and allergy, just not what type of allergy is present. Treatment for allergic-based MD is an elimination diet trial first, then environmental allergy treatment if that fails [3].

16.6.3 Cervical-facial Dermatitis

CFD or head and neck pruritus is self-explanatory. This pattern affects the head and neck only and there are usually excoriations, crust, alopecia, and erythema noted [2, 10]. The pruritus can be so extreme that there are erosions and ulceration of the skin [10]. If the pruritus is this severe, intervention is necessary with either an e-collar or bandages to reduce the chance of further trauma to the skin [10]. Antipruritic medications are necessary while trying to figure out which hypersensitivity is the primary cause.

16.6.4 Eosinophilic Granuloma Complex

EGC is usually caused by flea hypersensitivity, with or without environmental allergy and cutaneous adverse food reactions (CAFRs) [11]. This complex is seen in three forms: eosinophilic ulcer, eosinophilic plaque, and eosinophilic granuloma [2, 3, 10–12]. It has been reported that 37.7% of felines with EGC have more than one [10].

Eosinophilic ulcers are also known as indolent ulcers or rodent ulcers. It is commonly seen with flea allergy dermatitis (FAD), but any allergy can cause one [11]. The lesion is an asymmetrical craterous ulcer that can be unilateral or bilateral on the philtrum of the upper lip or adjacent to the canine tooth. This ulcer has a well-circumscribed, raised rim that

surrounds the pink to yellow surface of the ulcer [2, 3, 10–12]. It will only affect the mucocutaneous junction with little to no pruritus or pain [12]. Progression of the ulcer can be varied with chronic lesions having granulation tissue and necrotic yellow to white tissue within the ulcer. The primary treatment for rodent ulcer is ectoparasite control for all in contact with the patient. If that does not work, then a diet trial and possible allergy workup are recommended. Anti-inflammatory medications can help with swelling and any discomfort.

Eosinophilic plaques are intensely pruritic, eroded to ulcerated, oozing papules to plaques created by self-trauma [10, 11]. They are usually located on the ventral abdomen and medial thigh but can be located anywhere [10]. These lesions are usually seen in conjunction with MD and eosinophilic granulomas of the chin and can be exacerbated by a secondary pyoderma. On average these cats present with lesions between 2 and 6 years of age [11]. The most common cause of eosinophilic plaques is flea allergy dermatitis or CAFR. Anti-pruritic medications are necessary to help control these lesions.

Eosinophilic granulomas or linear granulomas are most frequently seen on the caudal thigh but can be seen on the medial aspect of the forelimbs, the chin, and the oral cavity [2, 3, 10, 11]. These granulomas create a linear thickening in the dermis that is semi-firm and well-circumscribed. The surface will be erythematous, alopecic, with pale gritty collagen degeneration and cavitation [8, 11]. There is variable pruritus seen with this form of the complex. Granulomas on the chin are also called pouty chin as they give the patient the appearance of jutting the lower lip and chin forward [2, 10, 11]. Granulomas within the oral cavity are located on the tongue or hard palate and cause excessive drooling, halitosis, anorexia, and difficulties swallowing [2, 10, 11]. Dyspnea is possible depending on the size of the granuloma [2]. These are seen at any age, and those under two years of age may regress spontaneously [11]. These lesions are typically associated with any hypersensitivity reaction.

Treatment of the primary cause of EGC is paramount for the regression of these lesions. Adequate flea control should be instigated in all cases, which may be difficult if owners are unwilling to admit their pet could be exposed to fleas. Diet trials can be difficult to do in cats; this will be discussed in-depth later in the chapter. The use of glucocorticoids in the treatment of EGC is the cheapest option but does come with its own set of risks. Topical, injectable, or oral forms are available. Using oral steroids is typically safest because the dose the patient is receiving is more easily controlled [l].

16.7 Hypersensitivity Reactions

The subject of feline atopy has gained a lot of attention over the past few years. Since felines with allergic dermatitis do not have the traditional Th2 response or a Th1 response, and IL-31 does not seem to play an influential role in the disease, the terminology has been adjusted to Feline Atopic Syndrome (FAS) [13]. FAS covers environmental reactions, CAFR and asthma due to the possibility of an IgE response [9, 10]. Feline atopic skin syndrome (FASS) is the new nomenclature for the inflammatory and pruritic skin disease manifested by feline reaction patterns and may also be associated with IgE reaction to the environment, fleas, and CAFR [2, 9, 14]. We will be focusing on FASS in place of feline atopic dermatitis. Pruritus associated with allergic skin disease is additive. Each stimulus (fleas, pollens, food sensitivities) increases the level of pruritus until the threshold is crossed. Once this threshold is crossed, clinical signs of pruritus are noted. Each animal has a personal threshold to which clinical signs are seen. If this threshold is not surpassed, there are no clinical signs. Individual stimuli are additive and can fluctuate in intensity depending on the time of year. This is known as the "Summation of Effect" [7]. Pruritus is seen as licking, scratching, and barbering of the hair. Intense pruritus can have a significant impact on the patient's quality of life, therefore initiation of an anti-pruritic should be started immediately to decrease the patient's discomfort [15]. Felines are notorious for hiding their over-grooming, though most owners will notice an increase in hairballs or episodes of vomiting [7]. Many times, felines can have more than one type of allergy [7].

Allergic skin diseases in canines and humans are remarkably similar, with a lot of research conducted on canines. Felines have been grouped in with canines for a long time, but as new research comes out on the feline allergy model it has been noticed that it does not correlate with canines and humans [9]. The influence of IgE is much less defined in feline allergy, which causes a decreased correlation of serum IgE levels to clinical signs with feline asthma being the only disease process associated with it [2]. Felines tend to have an altered number of dendritic cells, eosinophils, and mast cells when affected by feline allergy. Clinical signs seen in feline hypersensitivity are the four reaction patterns as stated previously in this chapter. Other noncutaneous signs can include otitis, conjunctivitis, sinusitis, and asthma. Felines can have pinnal pruritus without bacterial otitis, which is commonly mistaken for an ear mite infestation. Ceruminous otitis externa can be identified once cytology is completed if no parasites or infection are seen [2]. Clinical signs for feline pruritus are caused by either parasite (flea or mosquito), CAFR, or environmental factors. When speaking with owners

about a cat, always find out what parasite prevention they are using, type of food, and fecal consistency. There is a possible genetic basis for feline hypersensitivity; Persian, Maine coon, Himalayan, and Siamese are overrepresented, with Abyssinian and Devon Rex being predisposed to developing at least one form of the disease. Seasonality of clinical signs will depend on the offending allergy; environmental typically starts out seasonal but can be nonseasonal depending on the offending allergens. CAFR is non seasonal, flea allergy dermatitis is more seasonal in colder climates but can be nonseasonal in warmer and endemic areas [14].

16.7.1 Flea Allergic Dermatitis

The most common hypersensitivity in felines is flea allergic dermatitis or FAD. This diagnosis is more common in epidemic areas and exhibits at least one of the reaction patterns. It can be seen as the only hypersensitivity, or it can exacerbate others. FAD is a type I and type IV hypersensitivity reaction, which means it can have an immediate response or a delayed (48 hours) [14, 16]. FAD can present like canine FAD, with pruritus on the caudal third of the body, but will also have MD, SID, and eosinophilic plaques. Many owners refuse to believe their animal can have fleas as evidence of fleas is often hard to find. This is due to patient grooming [14, 16]. Allergy testing can be done for fleas but has a high likelihood of false negatives and false positives. Mosquito bite hypersensitivity (MBH) is a type I or immediate reaction and shares many features with FAD. Lesions seen with MBH are wheals, crust, and papules on the pinna, bridge of nose, as well as MD and CFD (Figure 16.5). With chronicity there will be nodules, excoriations, and a pigment change. On rare occasions, there can be lesions located in sparsely haired areas: paw pads, eyelids, chin, and lip [16, 17]. There are no age, breed, or sex predilections, but clinical signs are typically seen in patients around three years of age. These animals have exposure to the outside in tropical climates, but they can be seen seasonally in cooler climates. The lesions will self-resolve within 24 hours if no new bites occur. On cytology of the papules, a high number of eosinophils will be seen with bacteria only if it is secondarily infected. The best course of treatment is to limit or avoid being outside from dusk to dawn when mosquitoes are out [17].

Treatment trials for parasites are generally the best treatment option. Year-round prevention using an insect growth regulator (IGR) and adulticide are recommended. Topical products containing isooxazoline work very well, but all animals in contact with the patient must also be treated year-round [14, 16, 18]. If the environment is infested, the use of a professional exterminator may be necessary [14, 16]. Partial resolution noticed in the cat can be caused by additional forms of hypersensitivities or secondary infections. If the trial is a complete failure, the cat is most likely not flea allergic or there was inadequate control of the fleas. A few examples of failures for flea control are as follows: not all animals were treated



Figure 16.5 Mosquito bite hypersensitivity. *Source:* A. Friedeck.

continually, the cat (or its housemate) was allowed to roam outside, the patient was bathed too soon before or after topical treatment was applied, or the environment was not adequately treated [10]. Isooxazolines may provide some repellant activity for mosquitos but restriction to indoor only is the best treatment for MBH. There are no repellents that are safe for cats, most have DEET or permethrin [16, 17].

16.7.2 Feline Atopic Skin Syndrome

FASS is not pathognomonic for any single disease, it is caused by three specific dermatoses: FAD, CAFR, and environmental. All felines with FASS will express at least one of the four reaction patterns, any many will have two or more [14, 16]. While the genetic component of FASS is established in canines and humans, it has only been loosely documented in felines. However, it is seen more often in pure breed cats than in mixed breeds [2, 7]. Abyssinian and Siamese are the most common breed seen with FASS typically between 6 months and 4.5 years with females being more prone to males at 58% versus 41%. Noncutaneous signs of FASS include allergic otitis, allergic asthma, gastrointestinal (GI) disease and conjunctivitis. Pinnal pruritus is commonly seen without otitis externa [10, 14, 16]. FASS does not have a diagnostic test; it is a diagnosis based on exclusion [14]. Secondary pyodermas (bacteria and *Malassezia*) are not common in felines, only seen in about 20% of the cases, but can complicate the diagnosis process and should be treated when present [7, 9]. Other rule outs are FAD, ectoparasites, dermatophytosis, endocrine disease, and psychogenic alopecia [3]. Psychogenic alopecia is more common when there has been a large environmental change such as moving across the country, moving from country life to city life, a new baby or pet added to the family, or a drastic change in owners' work hours. Psychogenic alopecia should only be suspected if a strict food trial and flea control do not work; at that point, a veterinary behaviorist would be recommended [3].

Treatment for FASS needs to be flexible when dealing with cats. Topical therapies will be more difficult to do daily than with dogs [7]. The length of time it takes to diagnose a cat with FASS depends on the owner's investment of time and money and the patient's willingness to participate in the diagnostic testing. Some owners will want everything done at one time, if possible, and others are more willing to do a step-by-step version [3, 7]. Only after all other differentials are ruled out can FASS be confirmed [3].

Owners must be reminded that allergy testing, by either skin injection or by serum, does not diagnose allergic dermatitis in any species [2, 7, 10, 16]. Normal animals can and do have positive reactions; the reason they are not showing clinical signs is because their personal threshold has not been met. Allergy avoidance is a common misconception for environmental allergy; it is impossible to fully avoid them. Environmental allergens are aero pollinators. These outdoor allergens are designed to travel in the air and can be carried for vast distances (300–400 miles), so avoidance as the only strategy will not work [19]. Some indoor allergen exposure (dust mites, dander, and storage mites) can be minimized through environmental hygiene practices [7, 17].

If the patient has mostly indoor allergen reactions, certain steps can be taken to limit the exposure. If able, spend more time outside and keep the pet out of the bedrooms where a buildup of dander is possible. Frequent vacuuming will also reduce the allergen load. Using HEPA filters that are changed frequently and employing a professional exterminator can also help reduce the allergen burden inside the home [15].

Allergy testing can be done in two ways: intradermal allergy testing (IDAT) or by allergen-specific IgE serum (serum testing). IDAT uses the circulating IgE in the skin to bind to mast cells and create a wheal that is measurable in the skin where serum testing measures the amount of IgE to specific allergens circulating in the blood [10]. IDAT is considered the gold standard with immediate results, but there are limitations to being able to perform an IDAT. IDAT's in cats are notoriously difficult to read since cats do not have the same vigorous mast cell response that canines and humans have, thus creating exceedingly small reactions that do not last long. They also have higher level of circulating steroid from stress and lower levels of reactive IgE [7, 10, 15]. The reaction to the allergen in cats tends to happen much faster than in canines, so care must be taken while injecting. Most canines are ready for interpretation around 15 min after the injections are done, whereas the cats reaction will typically be gone by 15 min. Pros for IDAT include immediate results, and the test is based on the skin's response to the allergen. Cons for IDAT: all patients should be sedated for the IDAT, as an average of over 50–70 injections are performed; an area must be clipped on the side of the chest; there are many drugs that will interfere with testing, whether that be for sedation of the patient or treatments they have been on in the recent past [10, 15] (Table 16.1). Also, the time of year plays a huge factor in when an IDAT should be performed. It is usually recommended to test within 60 days of the peak season. Otherwise, the body may have "forgotten" that it should react to that allergen until it is heavily exposed again later in the year [10]. Serum allergy testing uses ELISA to evaluate the amount of circulating IgE in the

Table 16.1 Drugs that will interfere with skin testing and medications that will not interfere.

Drugs that will interfere with skin testing		
Steroids	Topical	2 weeks
	Otic	2 weeks
	Oral	3–4 weeks
	Injectable	8 weeks
Antihistamines	Oral	2 weeks
Drugs that will NOT interfere with skin testing		
Cyclosporine		
Apoquel		
Cytopoint		

blood. Pros for serum testing are that it usually does not require sedation but that is cat dependent, there is no clipping involved, and past drug administration does not affect the test much. Cons for serum testing are that it does not test the actual skins response, just circulating numbers of IgE, so false positives are possible. A large volume, around 6–7 ml of whole blood, is needed and serum testing is not standardized across companies. The choice of where to send the serum testing is just as important as when to do the test. The only company that has been standardized is Heska [15]. Once testing is completed, the results must be compared to the history, clinical signs, and seasonality [7, 10]. There is no point in putting a spring allergen in the immunotherapy of a patient with summer and fall seasonality [7]. Immunotherapy has two treatment forms: injectable and sublingual (oral). Immunotherapy is not a cure-all and takes time to become effective. Owners should be told multiple times that it will take 6 months before the owner starts to see a response, and up to a year for full response to therapy [7]. We expect 80% resolution 80% of the time, some patients can be maintained on just immunotherapy, but more commonly; the patients will need more than just immunotherapy to make them comfortable [7, 15]. If the severity and number of flares a year can be reduced, that is success. All patients on immunotherapy will flare; this does not mean the immunotherapy is not working. Owners need to be reminded about this frequently. Expectations about results and responses to therapy should be set prior to even discussing skin testing. Medical management of FAS and FASS can be used independently or in conjunction with immunotherapy. As stated previously, the goal of therapy is to decrease the frequency and severity of the flares as safely as possible for the cat. Remember, the treatment regimen for the disease should not be worse than the disease itself. Many times, cats will need a higher dose initially to get them under control before decreasing them to the lowest dose possible [20]. Medical management from most conservative to least is as follows: antihistamines, cyclosporine, steroids, and oclacitinib (Apoquel). Antihistamines competitively block histamine receptors. They vary in response between patients and will take up to 15 days to see the full response. The best option for felines is cetirizine (Zyrtec) or chlorpheniramine as they are absorbed well. The downside of antihistamines is that they only been shown to reduce pruritus by 10–14% [15, 20].

Cyclosporine inhibits calcineurin and has the same efficacy as steroids when used at anti-inflammatory doses. It has been shown to decrease clinical signs in 40–85% of cases but does take 6–8 weeks to be fully effective. For felines, there is no bioequivalence in human generics so the veterinary product should be used. Cyclosporine does have a synergistic effect when used with antifungals, some antibiotics, and a few cardiac meds. What this means is when given concurrently, less cyclosporine will be needed to get the same effect. Cyclosporine is started at 7–10 mg/kg daily for a minimum of 1–2 months until clinical signs resolve, then it can be decreased slowly every 2 weeks to the lowest dose possible to keep clinical signs at bay. Always be sure felines are Feline Leukemia Virus/Feline Immunodeficiency Virus (FeLV/FIV) negative prior to starting treatment, and these patients cannot be allowed outdoor access, as they are at higher risk of acquiring fatal toxoplasmosis. Side effects of cyclosporine are GI signs (vomiting, diarrhea, nausea, and hypersalivation), which usually resolve after a few days with continued treatment, as well as lethargy. It sometimes helps to give cyclosporine with a small amount of food to help prevent gastrointestinal side effects. Gingival hyperplasia can be seen but is typically more common in dogs than cats. Hypertrichosis (excessive hair growth) has been seen in dogs but is less severe in cats [7, 11, 15, 20].

Steroids are highly effective in the treatment of FASS, but higher doses are typically needed [15]. Steroids decrease the number of circulating IgE and eosinophils, which in turn decreases the environmental hyperresponsiveness of the patient [20]. It is recommended to use oral steroids over injectable whenever possible since the dose of orals can be altered much more rapidly if the need arises than if injectables are used, especially in cases where side effects are noted [7]. The two most common steroids used orally in felines are prednisolone and methylprednisolone. They are usually started at 1–2 mg/kg per day for a week, then decreased to the lowest possible dose that maintains the cat at a reasonable level. If the cat does not respond to that dose, it can be increased to 3–5 mg/kg per day [7, 11, 15]. If steroids are the only therapy, the likelihood of being able to wean the patient off them is greatly reduced. Topical steroids can be especially useful in cats if they tolerate the application. It is possible to overtreat with topical steroids and can have systemic absorption, suppressing the hypothalamic-pituitary-adrenal axis. Topical steroids can cause cutaneous atrophy (thin skin) and skin fragility. Side effects of long-term steroid use are many: polyuria, polydipsia, weight gain, iatrogenic Cushing's, diabetes mellitus, increased bacterial infections, dermatophytes, demodex, gastric ulcerations, and congestive heart failure [7, 11, 15, 20]. Oclacitinib (Apoquel) is a JAK-STAT inhibitor that blocks the intracellular pathway leading to inflammation and decreases the sensation of pruritus in the neural fibers. The product is off-label for cats but has a very rapid relief from pruritus. It seems well-tolerated by cats but can cause increased liver values. There are no long-term safety studies so caution should be used, and the owners are fully informed about the risks. Very few side effects have been noted with the most common being vomiting and loose stool [15, 20].

16.7.3 Cutaneous Adverse Food Reactions

CAFRs in felines occurs in 1–6% of feline dermatoses; this could be due to the disease being underreported or underdiagnosed in most pruritic feline patients [14, 16, 21]. It is a type I hypersensitivity reaction to meat proteins that are frequently misdiagnosed as psychogenic alopecia [21]. The disease presents with nonseasonal generalized pruritus with at least one reaction pattern seen, and typically in middle-aged animals, with only 27% showing signs under a year of age [10]. There does not seem to be a strong sex predilection, with the ratio of females to males being 1.4:4; however, Siamese seem to be predisposed to developing the disease [10, 21]. The pruritus can be disproportionately severe on the head and neck [16, 21].

Clinical presentation of CAFR in felines can vary. Forty-two percent will have cervical facial pruritus, 52% with SIA, 31% MD, and 18% EGC [10]. Other cutaneous signs include urticaria, nodules, and otitis externa [10]. Up to 33% of the cats with CAFR will have noncutaneous signs such as vomiting or diarrhea, but can also have respiratory issues, conjunctivitis, and plasma cell pododermatitis [10, 14, 16, 21]. Secondary infections are not as common in cats as they are in dogs. Not all patients with CAFR will respond favorably to antipruritic medications; only 85% [10]. Skin testing or serum allergy testing should not be used since they are inaccurate and insensitive [16].

The only way to diagnose CAFR is through diet trial. This is easier to do in canines than in felines for many reasons. All cats must be restricted to indoors only for the duration of the trial to decrease the likelihood of hunting. They have an increased risk of hepatic lipidosis if they do not eat the trial diet in a few days and are typically fed a wider variety of protein sources [3, 7, 16]. The most common ingredients for cats to be allergic to are beef, chicken, and fish [3, 7, 16]. It is recommended to use a high-quality, highly regulated diet to decrease the risk of cross-contamination when being made in the factory. It is essential to choose a single protein source that the cat has never been exposed to or a hydrolyzed diet [3, 7, 16]. Many smaller companies and boutique diets are not strict about cleaning between protein sources, and even a small amount of cross-contamination can negate a trial [3]. A home-cooked diet can be made for these patients, but it should be balanced by a veterinary nutritionist, as cats are obligate carnivores [16]. All other food items should be avoided during the 8-week trial. If the cat responds to the diet, over 60% will show favorable signs in the first 6 weeks, with up to 90% by 8 weeks. If at 8 weeks no decrease in pruritus is noted, then CAFR can be eliminated from the differential list. If pruritus is only decreased and not eliminated, then CAFR is not the only type of allergy affecting the patient [16]. If the pruritus is eliminated, then the cat should be challenged with the old diet to see if clinical signs return within a week or two. If clinical signs return, then CAFR can be diagnosed. From here, the owner has the choice of feeding the trial diet indefinitely or an individual ingredient challenge can be started. This is achieved by feeding a single ingredient on top of the trial diet for up to a week for each ingredient. If no pruritus is noted within a week, then that ingredient can be deemed safe, and the next ingredient can be added for 1 week. If pruritus is noted, the ingredient is not safe, and the trail diet is fed until clinical signs regress, then the next ingredient can be added. The individual ingredient challenge can take a long time to complete but will give the owners a better understanding of which ingredients to avoid [7, 16, 21].

16.7.4 Feline Allergic Asthma

Feline allergic asthma is defined as an eosinophilic inflammatory disease affecting the bronchioles, which can lead to reversible bronchoconstriction and remodeling. It is similar to human asthma and is thought to be a type I hypersensitivity to aeroallergens [9, 10]. It can manifest as acute respiratory distress with occasional mortality, chronic cough, exercise intolerance, and wheezing. Also seen are open-mouth breathing, tachypnea, cyanosis, and collapse. Diagnosing asthma is by history, clinical signs, thoracic images, bronchial-alveolar lavage (increased eosinophils vs. increased neutrophils seen in bronchial inflammation), and cytology. Thoracic images can be either thoracic radiographs or computed tomography (CT). Chest rads show a bronchial pattern with thickening of the walls in a pattern of doughnuts or rails. CT will help distinguish airway disease vs. healthy cats [10]. Treatment for allergy-induced asthma is steroids and bronchodilators to try to decrease the body's reaction to the allergens but will not restore normal airway physiology [13]. Immunotherapy has an efficacy of 45–75%, with 67% having complete remission, of those a third still needed rescue therapy during flares [20].

16.8 Facial Dermatosis

There are many causes of facial dermatitis in felines (Table 16.2). Fungal infections are one of the top causes of facial dermatitis. Dermatophytosis is the main cause of irregular to annular alopecia, erythema, and crust with variable pruritus. The main species in felines is *Microsporum canis*. This spore is spread by direct contact, is zoonotic, and the spores can survive in the environment for years. It is diagnosed by DTM culture, Wood's lamp, biopsy, or Dermatophyte PCR. Wood's lamps should not be used for definitive diagnosis, as false positives are common and should be followed up with a DTM. Topical or systemic antifungals are used for treatment. *Malassezia* is usually seen on the face and ears with variable pruritus. It causes erythema, alopecia, and lichenification. It is treated with topical or systemic antifungals and may play a part in feline chin acne [1]. A more in-depth look into dermatophytes is located in Chapter 23: "Infectious Diseases."

Allergic diseases, such as CAFR, can cause a nonseasonal pruritus, erythema, and alopecia on the head, neck, and ears, with variable responses to steroids. FASS is usually seasonally exacerbated pruritus on the face, chin, and head, with indolent ulcers. EGC is commonly seen on the face. Mucocutaneous and oral lesions are associated with EGC. Mosquito bite hypersensitivity is seen in the sparsely haired areas of the face and causes erythema, papules, nodules, and plaques with erosive to ulcerated crusts. There can be pigment change, alopecia, and scaling. Avoidance is the best course for treatment [1].

Autoimmune diseases, such as pemphigus foliaceus, cause lesions on the bridge of the nose, the pinna, and periocular. Lesions include pustules, papules, crust, and erosions with variable pruritus. The lesions are bilaterally symmetric. Pemphigus erythematosus is uncommon and causes scale, erosions, alopecia with pruritus, and pain in varying degrees. Typically, it is noted on the face and nose in areas where photoaggravation can occur. Discoid lupus erythematosus is rare and causes erythema, erosions, crust, and alopecia on the pinna, face, and bridge of the nose. Any lesion thought to be an autoimmune disease should be biopsied once any secondary infections are resolved [1].

Bacterial infections are rare on the face and head, and the lesions are typical for MD. Mycobacteriosis is more commonly seen in outdoor cats. It causes alopecia and nodules with thickened subcutaneous tissues on the head, neck, and ventral abdomen. This bacterium prefers fat pad areas and has variable pruritus. When faced with nodules, biopsy is always the best route for diagnosing the underlying problem. If mycobacteria are suspected, additional biopsy for culture and gene sequencing is necessary for a definitive diagnosis [1].

Parasites such as *Notoedres, Sarcoptes*, and *Otodectes* can cause a varying array of lesions on the face. *Demodex gatoi* is a stumpy, contagious mite that lives in the stratum corneum of the head and neck. It has variable pruritus with alopecia, scale, excoriations, and crust. Also seen are erythema and hyperpigmentation, with minimal inflammation [1].

16.8.1 Solar Keratosis

Solar keratosis is seen in orange or white cats in the sparsely haired areas of the face and trunk. Lesions include scale, hyperkeratosis, and alopecia. These lesions can progress to squamous cell carcinoma (SCC). SCC is seen more in sunbathing dogs and cats with white animals having 13 times the elevated risk. Most animals with SCC are older and can develop into ulcers and destruction of the tissues surrounding the lesion. Other cancers affecting the face are lymphoma, lymphocytosis, sarcoid, and xanthomas [1].

Table 16.2 Causes of facial dermatitis in felines [1].

Allergy	Environmental
	Food
	Mosquito bite
Autoimmune	Discoid lupus erythematosus
	Pemphigus erythematosus
	Pemphigus foleaceus
	Systemic lupus erythematosus
Bacterial	Actinomycosis
	Cat bite abscess
	Leprosy
	Mycobacteriosis
	Staphylococcus pseudintermedius
	Tuberculosis
Fungal	Cryptococcus
	Dermatophytosis
	Malassezia
	Histoplasmosis
Parasitic	Chiggers
	Cuterebra
	Demodex
	Leishmaniasis
	Lice
	Notoedres
	Otodecties
	Scabies
Viral	Calicivirus
	FeLV
	Herpes
	Papilloma
	Poxvirus
Other	Chin acne
	Idiopathic facial dermatosis
	Intertrigo
	Lentigo
	Lymphoma
	Solar keratosis
	Squamous cell

16.8.2 Chin Acne

Chin acne does not have a single culprit and is always secondary to other diseases (Figure 16.6). It is an uncommon idiopathic disease. It can happen in any breed, at any age, with no sex predilection. Altering the patient does not change the likelihood of developing acne. The first lesion noted is comedones on the chin, lower lip, and sometimes the upper lip. If the disease has only comedones without any other clinical sign, leave it alone; squeezing the lesions or scrubbing can lead to more serious infections. Deeper infections cause draining tracts, exudative furuncles, and cellulitis. Pruritus typically increases with the severity of the disease. Secondary infections need to be treated appropriately, usually for 4 weeks, if furuncles or draining tracts are present then 4–6 weeks may be needed. The hairs on the chin can gently be clipped and warm water or Epsom salt compresses can be used to soften the material. Human acne treatment wipes can be used to help flush the follicles, but it must be alcohol-free. Benzoyl peroxide, ethyl lactate, or sulfur salicylic shampoos can also be used. Care must be taken not to scrub aggressively as this will cause more ingrown hairs. If the inflammation is severe, the use of glucocorticoids can be useful for 10–14 days. Once the infection is cleared, then maintenance wiping is usually sufficient to prevent relapse [22, 23].

16.8.3 Idiopathic Facial Dermatitis

Dirty face disease or idiopathic facial dermatitis is rarely seen in young Persian and Himalayan cats (Figure 16.7). This disease is characterized by a dark, adherent, waxy to greasy debris along the nasal folds, facial folds, and perioral. Ceruminous otitis externa can also be seen. There are variable pruritus depending on the amount of inflammation. Self-trauma is common as pruritus increases. The facial and nasal folds are erythematous, and secondary bacterial infections and *Malassezia* are often seen. The disease is assumed to be hereditary and will affect either sex. The severity tends to increase as the animal ages. Cytology of the exudate usually contains neutrophils, eosinophils, and mast cells. A biopsy can be performed but is usually nondiagnostic. Any secondary infection should be treated, and topical anti-seborrheic can be started on the face if tolerated. For more severe cases, systemic anti-inflammatories may be needed. Topical tacrolimus can also be applied. Maintenance for these patients involves lifelong anti-seborrheic wipes, and relapses are common [22, 24, 25].

16.8.4 Lentigo

Lentigo is an asymptomatic cosmetic disease affecting orange cats (Figure 16.8). It causes well-defined hyperpigmented macules on the lip margin, nasal planum, eyelid, and gingiva. They usually start at an early age and progress over time [24].

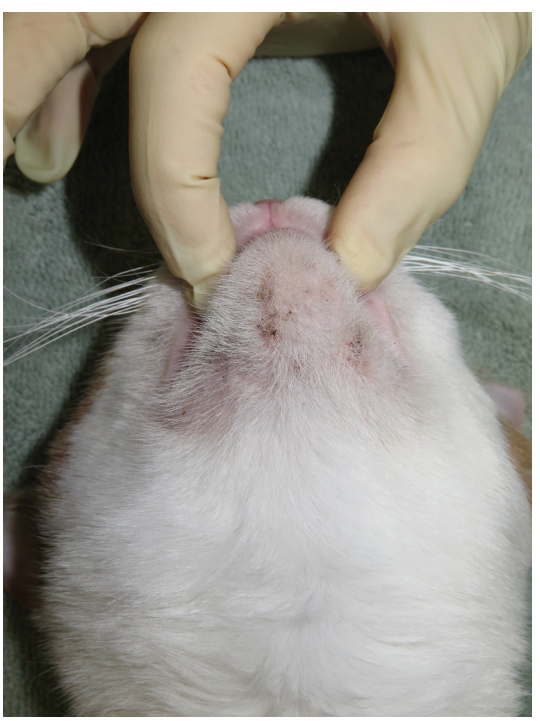


Figure 16.6 Chin acne. *Source:* A. Friedeck.

16.9 Feline Auricular Anatomy and Conditions

16.9.1 Feline Auricular Anatomy

The structure of feline ears is not much different than canine ears. On the pinna, the hairs arise from the rostral margin and fold back across the canal opening to decrease the amount of material gaining access to the canal. These hairs are very sensitive and will elicit a twitch if touched. The vertical canal is hairless, reasonably pliable, and moveable. The shape is the same between cats and dogs with the vertical and horizontal canals creating an "L" shape. The horizontal



Figure 16.7 Dirty face of Persians. *Source:* A. Friedeck.

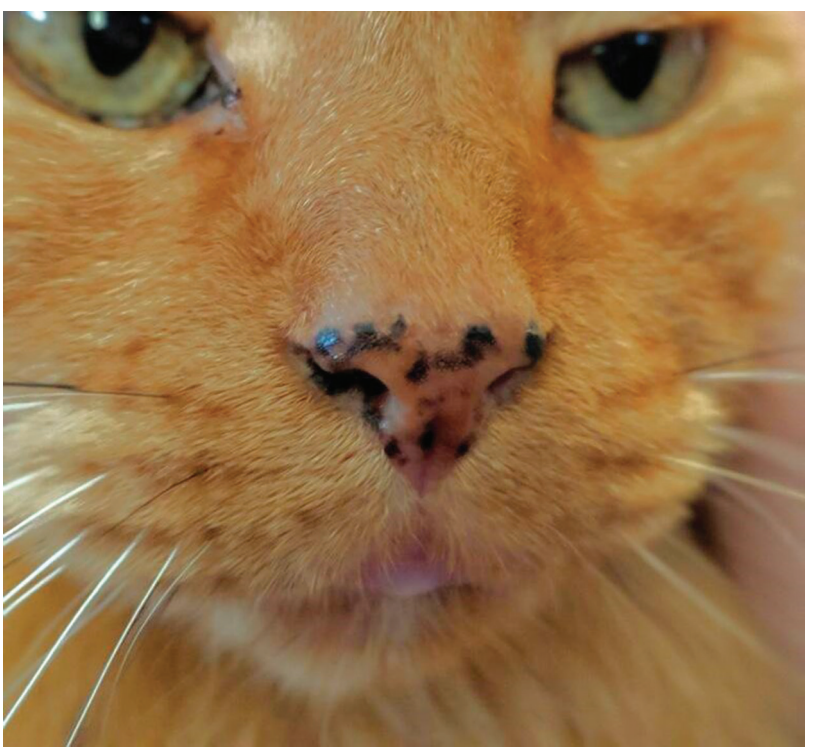


Figure 16.8 Lentigo. *Source:* A. Friedeck.

canal is much less pliable and movable. The entire canal should be between 6 and 9 mm in diameter. Cerumen (ear wax) should be sparse in healthy cats, and a film will be created over the canals. Lateral migration of the stratum corneum helps move the cerumen, dead skin cells, and debris out of the ear. The tympanic membrane (TM) separates the external ear canal from the middle ear. The TM has two parts: the pars flaccida carries the blood supply and is much narrower than what is seen in canines. The pars tensa is the hearing aspect of the TM. It is very thin, slightly transparent, and slightly

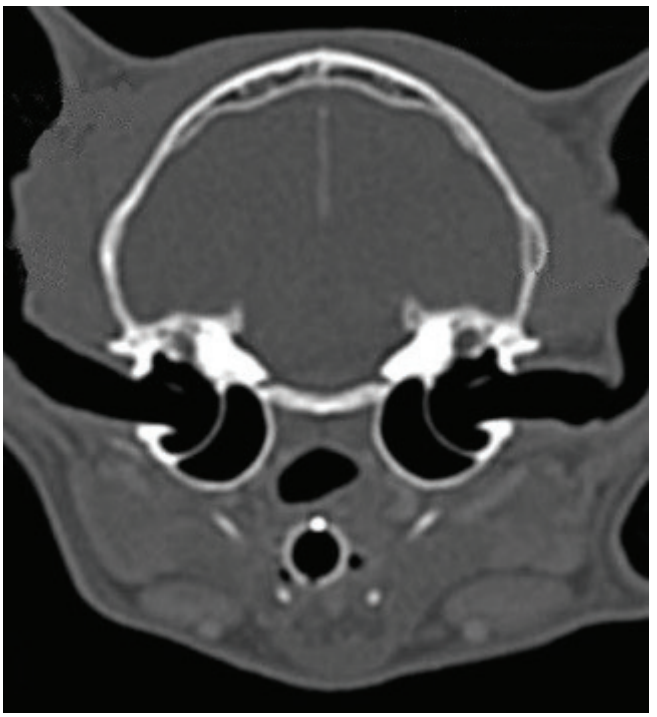


Figure 16.9 Normal CT of a feline with a shelf in the bulla. *Source:* A. Friedeck.

opaque with prominent striations. The manubrium is the head of the malleus, is slightly curved rostrally, and is where the pars tensa grows from when ruptured [6].

The middle ear structure is different than most canines. In canines, they have a large hollow tympanic bulla; cats have a bony shelf that divides the bullae into the ventromedial and dorsolateral compartments (Figure 16.9). The Eustachian tubes attach to the medial wall near the bony shelf and connect the middle ear to the pharynx; they are used to equalize the air pressure in the bullae and drain mucus into the pharynx. Located above the bullae are the auditory ossicles and the opening to the cochlear and vestibular systems. The sympathetic nerve in cats is close to the Eustachian tubes and is very superficial and vulnerable when removing polyps, flushing the middle ear, or during the treatment of ear infections. Stimulating this nerve will cause Horner's syndrome [6].

16.9.2 Otitis Externa and Otitis Media

Otitis externa is not as common in cats as it is in dogs. Head shaking and exudate are typically the only signs seen by owners. Diagnosis based on the look or smell of the ears should be avoided; cytology should be done for every case. Depending on whether both ears are affected; it can help alter the differentials. Unilateral disease is usually due to a foreign body, neoplasia, or inflammatory polyp. Bilateral disease can be either a parasitic infection, an underlying allergy, or, rarely, inflammatory polyps. Otitis externa in felines is almost always secondary to another underlying disease. Predisposing causes in cats are not as easily managed as in canines. If there are perpetuating causes that are not treated, they will cause relapsing chronic otitis and can lead to irreversible changes in the ears that require surgical intervention. Otitis externa is commonly caused by *Staphylococcus pseudintermedius* and *Staphylococcus felis*, but other pathogens can be seen, and a mixed population is common. *Pseudomonas* will create a biofilm in the ear leading to highly resistant infections that must be actively scraped out of the ear. This film will prevent the penetration of topical therapy and provide a protective layer over the bacteria. Topical treatment of otitis externa should be the mainstay. For a cat, smaller amounts are needed than in canines; usually, 0.5 ml is adequate. Care should be taken if using a product licensed only for canines as cats have a higher risk of ototoxicity. If there is a lot of debris in the ear, it should be cleaned daily during treatment; if not, then do not clean. Any cleaner that is cerumenolytic or cerumino-solvent will help soften and remove any of the dry debris that is in the canal. If the debris is more seborrheic or purulent, then a surfactant-type cleaner would be better. An astringent will help decrease the maceration of the canal lining and an antimicrobial will help with treatment [6].

Prior to treatment, the identification of any bacteria, *Malassezia*, inflammatory cells, or mites is paramount. Ear mites can be seen using mineral oil and 10× objectives, while bacteria, *Malassezia*, and inflammation should be stained and viewed under 100×. Biofilms are possible in both cats' and dog' ears. It is a thick, dark exudate that clings to the canal walls and inhibits antimicrobial penetration. When dealing with a biofilm, higher concentrations of medications are necessary. Culturing of the canal is not necessary when topical treatment will be used. Culture and sensitivity results are for systemic medications; the use of topical medications places a much higher concentration directly on the infection. Most systemic medications do not concentrate well in the ear canals and should only be used for otitis media [6].

Prior to diagnosing otitis media, diagnostic imaging should be obtained. Flat radiographs are the most available but least sensitive. If these radiographs are attempted, a dorsoventral, right and left lateral, right and left obliques, and a retrocaudal open mouth should be obtained. CT is another option but is less available to most owners. It is fast and reliable and will give the most accurate view of the middle ear. Contrast enhancement will allow for evaluation of the bone and soft tissue in and around the middle ear. It can also highlight the extent and severity of the disease (Figure 16.10). MRI is the most expensive option; it is best used for soft tissue and nerves. It will not provide great images of the bone so it is usually not used for strictly middle ear disease [6].

Otitis media can be a primary or secondary problem. An inflammatory polyp is the most common primary disease process. Chronic upper respiratory infections can lead to increased inflammation ascending the eustachian tube into the middle ear. Rarely can an infection spread to the bullae from an abscess or severe systemic infections. Clinical signs of middle ear disease can be mild until neurological deficits are observed. These include Horner's, ataxia, nystagmus, facial paralysis, and vestibular signs. Otitis media can be suspected with visualization of the TM, material can be bulging against the TM, and it may change colors depending on the color of the material behind it. The treatment of otitis media involves performing a myringotomy, collecting material in the middle ear for culture, and retro-pulsing copious amounts of sterile saline through the bulla. Flushing cannot access the inner compartment of the feline ear. If material is located behind the shelf, surgery is the only option. When systemic antibiotics are needed for OM, it is necessary to use one that can penetrate bone. Topical medication will only be efficacious if it is instilled into the middle ear directly and is not feasible for long-term treatment, as regular ear drops will not make it all the way to the middle ear in a high enough concentration to treat the infection. It will only take 2–3 weeks for the TM to heal after a myringotomy. If the ears are refractory to treatment or if there are no antibiotics available to use based on culture, then surgical intervention will be needed [6].

Resistant infections are becoming more common. They should be suspected if 2–3 weeks of appropriate treatment are not enough to treat the infection. Other reasons for treatment failure are polyps, neoplasia, foreign body, biofilm, stenosis, otitis media, perpetuating factors are not treated, and poor compliance on the owner's side. *Pseudomonas* is typically very



Figure 16.10 Abnormal CT of a feline with otitis media. *Source:* A. Friedeck.

resistant to many antibiotics due to its ability to create biofilms. Biofilms usually require the physical breakdown of the film by scraping it off the canal walls while under general anesthesia [6].

Foreign bodies can be seen in cats' ears, even in those who do not roam outside. The common culprits are grass awns, but hair, cotton, and organic debris can also occlude the canals. Foreign bodies tend to be pruritic and can be painful. It is usually unilateral disease, but it can be seen bilaterally depending on the offending cause. Foreign bodies can penetrate the TM and cause OM. Most foreign bodies can be visualized under general anesthesia and should be removed completely, or chronic secondary infections can occur. If no foreign body can be seen within the canal, then a CT is warranted. Even if the foreign body is removed, secondary infections and inflammation must be treated for full resolution [6].

16.9.3 Inflammatory Polyps

Inflammatory polyps are seen mostly in young cats but can be seen in older cats too. These are usually unilateral, but they can be bilateral. These polyps can arise from the Eustachian tube and grow into the ear or pharynx. They can cause otitis externa and/or media, Horner's syndrome, and unilateral purulent discharge. When under general anesthesia, if the polyp can be visualized, traction can be applied to see if it can be removed. Depending on where the growth originates from will depend on how easily it can be removed. CT can help identify the location; if deeper than the ear canal, surgery is the only option for removal. Remember that the nerves are very superficial and can be aggravated while removing a polyp so neurologic signs can worsen or become permanent. Secondary infections and inflammation will still need to be treated after the polyp is removed [6].

Cystadenomatosis or cystomatosis is grape-like clusters of cysts that grow in and around the ear canal (Figure 16.11). These are pigmented ceruminous papules or nodules that can occur singly or in large groups. They are usually not pruritic or painful unless they are secondarily infected. There is a possible genetic component and inflammatory triggers with Persians being predisposed. These clusters start out small but will increase in size and number over time and can eventually occlude the ear canal resulting in chronic secondary infections. The secondary infections must be treated to maintain the patient's comfort. Steroids can be used to decrease the size of the cysts. For smaller nodules, CO_2 laser can be used to ablate the lesions and partially open the canals. The biggest problem is that the lesions will return, so laser treatments will need to be repeated every 6 months to a year. Debulking more extensive lesions is a very bloody surgery and is not recommended. If surgery is needed, a total ear canal ablation (TECA) is done, where the entire canal is removed [6].



Figure 16.11 Cystomatosis. *Source:* A. Friedeck.

16.9.4 Auricular Neoplasia

Neoplasia is more commonly seen in older cats with unilateral disease. These are normally ceruminous adenomas but can also be adenocarcinomas. Other types of cancer are rare in the ears. Malignant ear tumors can cause extensive destruction of the surrounding tissue and potentially spread to the lymph nodes and other organs. Sometimes, these tumors can be visualized in the ear canal, but a CT is necessary to see the extent of the damage caused by the tumor. Biopsy within the ear canal is possible but the sample size is usually too small to be of much help. Neoplasia has the potential to be completely excised if a TECA is performed. The cartilage of the ear is firm enough to contain most of the tumors within the ear canal. Only overly aggressive tumors can spread into the surrounding tissues [6].

16.10 Diagnostic Techniques

Diagnostic techniques depend on the lesion that is being sampled. Direct impressions are better for crusted lesions or epidermal collarettes. Direct impressions are simple to collect. A slide is used to remove the crust or to push back the epidermal collarette's edge, and a sample is taken from the newly exposed areas and stained. Ear cytology is performed by using a cotton-tipped applicator and gently inserting it into the canal as close to the vertical and horizontal junction as possible, and rolling along the long axis. This material is then rolled onto a slide and stained. Skin scrapes are used to look for mites in the skin. A medical spatula or surgical blade is used to gently scrape the top surface of the skin and the material is then transferred to the slide using mineral oil.

When dealing with feline dermatology, the process of identifying the actual disease is no different than in canines. This chapter covered some of the more common diseases seen in felines and a few that are strictly seen in felines. Management of any disease in felines can be tricky and care must be taken to ensure the health and safety of both the feline and the owners.

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17

Emergency and Critical Care

Kelly M. Foltz, BA, AAT, CVT, LVT, RVT, VTS (ECC)

TECHNICIAN TIDBITS

- Direct arterial blood pressure is considered the most accurate method although noninvasive methods are more accessible and pose less risk.
- Due to the risk of occult heart disease and fluid overload, fluid resuscitation of the cat in shock should be undertaken cautiously after a normal body temperature is achieved.
- Feline urethral obstruction has a good prognosis provided that appropriate care is rendered quickly, particularly in cases where hyperkalemia is severe.
- Blood typing and crossmatching are required for feline patients due to the risk of potentially fatal transfusion reaction(s) if incompatible products are administered.

Approximately 70 million pet cats live in the United States and Canada [1]. Veterinary technicians share goals with veterinarians to facilitate the identification of the source of pain or pathology through physical examination and diagnostic processes while simultaneously alleviating pain and fear, enhancing the quality of life (QOL) and the human-animal bond. In the emergency room (ER) setting, information gathered must be accurate and verifiable, interventions must be timely, and the needs of the patient must be respected during treatment. When considering the behavioral needs of the domestic cat, veterinary technicians should be aware that the ER clinical environment is consistently stressful for feline patients due to noise, odors, strange people and objects, and disrupted routines [2–5]. Very little of what cats find reassuring is provided in the veterinary ER/intensive care unit (ICU; quiet, warmth, consistent routines, familiar faces, foods, and smells), but attention to their behavioral needs will enhance the comfort and security of cats in this setting [2–9]. Veterinary technicians are uniquely positioned to advocate for feline patients through their empathy, compassion, and creativity. Refer to Chapter 1: "Feline Behavior," for more information on the ethologic needs of feline patients.

Before a feline patient arrives in the ER, it has already run a gauntlet of stressors and been exposed to a variety of odors, sounds, and stimuli. In many cases, the cat has already been hiding within the home before it is transported to the ER. There are a variety of actions veterinary technicians can take at each step of the ER visit to mitigate stress for these patients and improve outcomes. In the ER, an accelerated pace is usually prioritized but with cats, it is best to "think slow to go fast," conducting all aspects of the initial examination in a steady and controlled manner. Readers are directed to Chapter 2: "Feline-friendly Interactions" and Chapter 3: "Preparing the Veterinary Hospital for the Feline Patient," for more information on optimal techniques and modifications for the veterinary ER in regard to the feline patient.

17.1 Patient History and "History Gathering Questions"

In the ER, technicians do not have the luxury of a prior relationship with the patient and clients or access to the cat's prior medical records. It is imperative that a quality patient history be collected efficiently to streamline care; in addition, technicians must maximize the time they spend with clients to establish their trust and confidence. In emergent situations, history collection is limited to a few key questions (what? when? for how long? etc.), and focused, in-depth history collection is delayed until it has been ascertained that the patient is stable enough to wait or initial life-saving interventions have been administered. Core general history questions are centered around clinical signs the client has noticed, duration of signs, history of prior health problems, current medications, and vaccine status. These are followed by detailed questions specific to the presenting complaint and

Table 17.1 Using the "Wish, Worry, Wonder" communication model to guide crucial history-taking and client conversations in the ER.

Using the "Wish, Worry, Wonder" communication model
Scenario: A patient presents with a suspected urinary obstruction, and the client will not consent to treatment.
Solution: Use the "wish, worry, wonder" model of layered statements to gently coach the client toward action while acknowledging that they are overwhelmed.
WISH:
"I *wish* this wasn't happening to (patient's name) today. I can see that you feel that way, too.
WORRY:
"We are *worried* that he is experiencing cardiac complications due to elevated potassium in his blood because of the urinary obstruction. This would be life-threatening for him."
WONDER:
"I *wonder* if you would give your consent for us to check an ECG and serum potassium as soon as possible. That will cost approximately (x) dollars, and we can do both tests here very rapidly. This may save (pet's) life."

impacted body systems. Technicians should also inquire about the patient's level of pain, behavior changes, change in appetite, toilet habits, and alterations in general routine. In cases of suspected toxicity, it is helpful for the client to either bring packaging with them to the ER or call someone at home who can send a picture of the package or read information off the label. It is equally important for technicians to understand that clients may be emotional and disorganized in the ER, as emergencies are by nature disruptive. Reflective listening, emphasis on nonverbal communication to validate verbal communication, and use of the "wish, worry, wonder" communication model will help technicians guide emotional conversations (Table 17.1).

17.2 Feline Interactions in the ER

Feline interactions are a point of contention within most hospitals. While a variety of tools exist for feline handling very few are cat friendly [7–9]. It is imperative that respect for the cat is incorporated into handling methods to ensure that both the patient and personnel remain safe. While urgency is associated with ER care, safety, and positive interactions should never be sacrificed in the service of speed. Respectful, safe, and effective handling in the ER can be accomplished with chemical restraint, cooperative care, and strategic planning regardless of the busy and time-sensitive nature of the ER. Prior planning is essential, and all necessary supplies should be gathered well before interacting with the patient or before the administration of sedation or anesthesia. A creative, empathetic, prepared, and knowledgeable technician is the most effective feline handling tool available. The advantages of chemical restraint in appropriately selected patients cannot be overlooked since most "bad" feline behavior in the clinical setting can be attributed to pain, fear, or misinterpretation of the cat's communication by handlers [1, 6–10]. Escalated interaction results in an escalation of fight/flight behavior by the cat, resulting in an increased number of bite and scratch injuries and worker's compensation claims [10]. A better understanding of feline ethology and body language minimizes undesirable miscommunications (see Chapters 1: "Behavior" and 2: "Feline-Friendly Interactions"). For more information on the role of pain in feline behavior, refer to Chapter 7: "Analgesic Considerations for the Feline Patient."

17.3 Clinical Signs

Clinical signs vary widely based on the disease process and affected body system(s); consequently, clinical signs associated with each disease process will be included in their respective sections of this chapter.

17.4 Physical Examination Findings

Physical examination is the cornerstone of diagnosis in the ER and ICU. Exam findings associated with each disease process are included in their respective sections of this chapter.

17.5 Triage

Triage of the emergent feline patient begins over the telephone, taking care to provide information to clients that is clear, concise, and correct. Any staff member interacting with clients via the telephone should be mindful of the requirements for a valid veterinarian–client–patient relationship so that no inappropriate diagnosis or treatment recommendations are made. When performing telephone screening, staff must rely on the client's knowledge base, experience, and description(s) to make decisions. Required information for all calls includes the pet's signalment (age, breed, and sex) along with the client's name, telephone number, and location [11–13]. The current complaint should be noted along with a brief overview of the problem (onset, duration, severity) and any care rendered by the client, breeder, or regular veterinarian [11–13].

Once this information has been gathered, the location of the clinic along with directions and any pertinent information about exam fees should be relayed to the caller. No diagnosis is ever given over the telephone and staff should reassure clients while remaining calm. After the call is complete, the team should be notified that an emergency is en route, and an estimated time of arrival shared. Supplies are prepared based on the type of emergency. Once the patient arrives, it should be evaluated immediately. Ideally, a trained technician is the first staff member to examine the patient, but customer service personnel can also be trained in basic triage. "Triager" is a French verb that means "to sort." Patients are sorted based on urgency and overall risk to life. There is no standardized triage system in veterinary medicine, although several have been proposed [11–13]. In general, triage systems are specific to a facility and reflect the patient population, staffing, and needs of the hospital. Some conditions require immediate intervention, including cardiopulmonary arrest (CPA), active seizures, collapse, hemorrhage, trauma, suspected shock, respiratory distress, head trauma, ocular injury, and stuporous/obtunded mentation [11–13]. These patients should be moved to a ready area as soon as possible while another staff member takes a brief history, establishes consent to treat, and asks the client for a code status while giving a broad estimate of the cost of care. Staff should be empathetic but firm and reassure clients that treatment will begin immediately; in addition, they should clarify that a doctor will speak with the client as soon as the patient has been stabilized. Rapid consent for emergency care streamlines treatment and prevents the veterinarian or staff from getting "bogged down" in an exam room explaining procedures. Once consent is established, it is imperative that a doctor or credentialed technician speaks to the client at the first available opportunity to update them about their pet's condition since minutes feel like hours when a client is in emotional distress. Empathy and reflective listening are required for conversations about consent for care, cost of care, spectrum of care, and possible outcomes.

17.5.1 The Primary Survey

Following triage, cats that are acutely injured or severely ill are promptly moved to the ready area of the treatment room, while patients that are stable wait to be seen in an exam room or in the lobby. If there is any doubt, the patient should be moved to the treatment area immediately for further evaluation. As trained observers, veterinary technicians can gather a significant amount of information about a patient during the time it takes to interact with the client in the lobby. Without touching the patient, the technician can assess respiratory rate and effort, posture, and level of consciousness (LOC), cursory extent of wounds, active or resolved bleeding, obvious ocular abnormalities, determine a preliminary pain score, and detect readily apparent fractures.

If the patient is severely injured or ill, once the cat has been moved to the treatment area, the primary survey is prioritized to evaluate the cardiovascular, neurologic, and respiratory systems. This can be accomplished with quick femoral pulse palpation, thoracic auscultation in all quadrants, and assessment of cranial nerve function and LOC [11–13]. Assessment of these systems yields rapid information about perfusion, shock, and oxygenation. The technician should further evaluate heart rate, pulse rate, pulse quality, and synchronicity of the pulses to detect deficits. A respiratory rate should be calculated, respiratory effort assessed along with auscultation of all lung fields, examination of the oral mucus membranes, and assessment of capillary refill time (CRT) performed [11–13]. As already noted, the patient's neurologic function can be rapidly evaluated by noting LOC, pupil size, facial symmetry, and ambulation/gait. Some clinicians recommend the inclusion of bladder palpation or ultrasound in the primary survey with or without FAST ultrasound of the thorax and abdomen in their primary survey (Focused Assessment with Sonography for Trauma) to check for cavitary effusion or pneumothorax [11–14]. The primary survey should be completed in less than 2–3 minutes.

Following the primary survey, action is taken to correct abnormalities noted in these systems. This may include the provision of oxygen via flow-by, mask, or cage; establishing vascular access via intravenous (IV) or intraosseous (IO) catheter; administration of fluids or drugs, decontamination of intoxicated patients, abdominocentesis or thoracocentesis,

pericardiocentesis, or CPR [15, 16]. Once early treatment is rendered, a secondary survey can occur. This is a nose-to-tail, thorough examination of the patient including all other body systems (eyes/ears/oral cavity, gastrointestinal, genitourinary, neurologic, integumentary, lymphatic, and musculoskeletal systems) plus a re-evaluation of the cardiovascular, neurologic, and respiratory systems. The cycle of primary survey, treatment intervention, and re-evaluation of critical vital signs is repeated until the patient is consistently stable.

17.5.2 Vascular Access

One of the first interventions made in the feline ER patient is the establishment of reliable vascular access through peripheral IV catheterization [16]. Anesthesia techniques like subcutaneous infiltration of the site with lidocaine or the use of topical lidocaine-prilocaine cream improve patient's comfort. The largest catheter that the vessel can support should be placed in cases where the shock is suspected; however, in patients with peripheral vasoconstriction, vascular collapse, or anemia, it is more prudent to establish access with a smaller catheter to facilitate treatment as soon as possible [16]. As a rule of thumb, most adult cats can tolerate a 22–20 g unit. If the patient may damage the catheter and an E-collar is undesirable, commercially produced catheter guards are available or one can be made cheaply from spare cardboard, old X-ray film, or old E-collars.

If peripheral venous access is not achieved rapidly, it may be necessary to place a peripheral catheter in the jugular vein. Additional alternatives for emergency vascular access include the venous cutdown and intraosseous catheter. If the patient will be hospitalized for an extended period, a central venous catheter, peripherally inserted central catheter (PICC), or other sampling line should be considered. Multilumen central and PICC lines offer distinct advantages: they allow the administration of incompatible or high osmolarity infusions, permit the administration of multiple fluid types and potentially incompatible drugs simultaneously, facilitate on-demand sample collection, are vessel-sparing, and can also be used to administer total or partial parenteral nutrition or to monitor central venous pressure. However, placement and use of these units require skill and are not without risk of insertion site infection, blood-borne infection, thrombus formation, malposition, extravasation, and iatrogenic anemia due to oversampling. Catheterization of central vessels is not a procedure to be undertaken in an unstable patient due to the need for sedation and/or general anesthesia.

17.6 The Feline Inpatient

Following triage and after the feline patient has been evaluated, many will be admitted to the hospital. Cats have special considerations when staying in the hospital and should be housed in a ward separate from dogs in cage banks that do not permit them to see each other (Chapter 3: "Preparing the Veterinary Hospital," for the Feline Patient). Because olfaction is a major component of feline communication, pheromone analogs such as Feliway© or ComfortZone© can be used in bedding or housing areas to reduce stress [2–4, 6–9]. If it is impossible to house cats and dogs separately, part of the cage door can be covered with a pheromone-sprayed towel for privacy. Regardless of their proximity to dogs and other cats, each cage should be large enough to accommodate the patient, a hiding box, a litter pan 1.5 times the length of the patient, and food/water dishes [3, 6, 8]. Food and water should be placed as far from the litter pan as possible. Arthritic, very young, or debilitated cats with distal extremity bandages benefit from a low-sided litter pan such as a baking sheet or plastic fast-food tray.

Hiding places do not have to be fancy but they are essential to reduce stress and improve coping [2–4, 6, 17–22]. The cat's own carrier can be used in the cage; if possible, bedding from home should be retained if it is not soiled, since it holds familiar odors that help the cat feel safe (Figure 17.1). Plastic storage boxes, milk crates, and produce crates from the farmer's market that can be disinfected and re-used are a sustainable alternative to cardboard boxes (Figure 17.2). Soft "cave" style beds can also be used if they are washed in between patients, although rigid hiding places allow the cat to perch on top. If additional privacy is desired, a towel or blanket can be draped over the top and front of the box. Research in shelters, laboratories, and veterinary clinics has validated that providing a hiding place to cats can enhance coping, resilience, and normative behavior expression [2–4, 6, 17–22] while aiding acclimation to the new environment.

The average acclimation time is 48 hours; nursing staff should expect feline behavior to improve after 1–2 days in the hospital [17–22]. The more effort made to reduce the patient's stress levels, the easier it will be to interact with the cat and perform treatments and procedures. The cat stress score (CSS) is an easy-to-use rubric that can be incorporated into daily



Figure 17.1 Cage set-up showing an appropriately sized litter pan (far left), water bowl some distance from the litter box (foreground), and the cat's own carrier with the door removed as a hiding place. *Source:* Kelly M. Foltz, CVT, LVT, RVT, VTS (ECC).

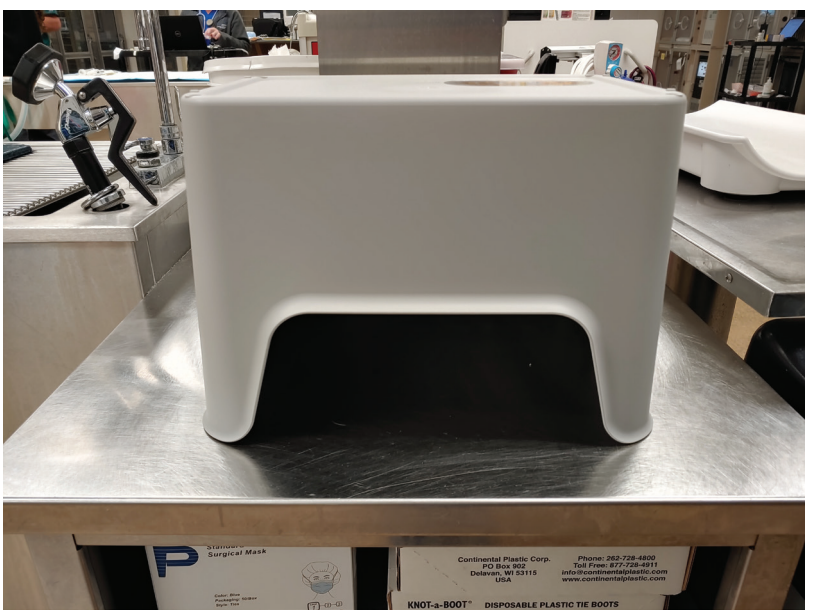


Figure 17.2 A variety of containers from discount stores can be re-purposed as hiding boxes for feline inpatients. This one is meant to be stacked on top of others of the same style, but turned upside-down, it gives cats both a place to hide and to perch. *Source:* Kelly M. Foltz, CVT, LVT, RVT, VTS (ECC).

patient exams or used in conjunction with pain scoring [21, 22]. Treatments should be scheduled so there is continuity and consistency of the technician(s) assigned to care for the cat, the patient has time to rest between treatments, and the cat can develop a routine while it is in the hospital [21, 22].

17.7 Specific Nursing Care Considerations

Arterial blood pressure measurement is commonly performed in the veterinary ER and ICU and is classified as invasive (or direct arterial pressure, DAP) or noninvasive (or indirect, NIBP). When arterial blood pressure is assessed, there are three components: systolic, diastolic, and mean. Systolic pressure is the peak arterial wall pressure of each heartbeat, diastolic pressure is the trough arterial wall pressure during relaxation before the next heartbeat, and mean arterial pressure is the average arterial pressure for that cardiac cycle [23–28]. This section will focus on Doppler and oscillometric techniques, each of which offers pros and cons when used in feline patients. DAP is assessed via arterial catheter and blood pressure transducer. This method requires a patent arterial catheter and provides waveform tracing, continuous minute-to-minute assessments, and systolic/diastolic/mean measurements, and is considered the gold standard for blood pressure monitoring in veterinary patients [23–25]. In contrast, there are four noninvasive methods currently available in veterinary medicine: oscillometry, high-definition oscillometry, optical plethysmography, and Doppler ultrasonography [23–26].

Oscillometric methods rely on estimates of systolic/diastolic/mean pressure generated via an algorithm. Optical plethysmography utilizes the light-emitting probe of a pulse oximeter, inflatable cuff, and sphygmomanometer to detect pulsatile changes in blood volume and generate a waveform. Tables 17.2 and 17.3 below enumerate additional details about arterial blood pressure in cats.

Noninvasive methods are simple to use, relatively inexpensive, and pose little risk to the patient but are generally believed to be less accurate than DAP. Some methods do not provide diastolic or mean values. Assessing NIBP may be difficult in patients who are hypothermic, in shock, anemic, and/or who have peripheral vasoconstriction. Invasive methods require specialized equipment and technical skill in the placement of a peripheral arterial catheter, maintenance and troubleshooting of transducer(s), and maintenance of the arterial catheter; in addition, they pose risks to the patient of severe hemorrhage if the arterial catheter becomes damaged or dislodged. If drugs are accidentally administered via arterial catheter, an adverse reaction or death may result. Thrombus formation in or around the catheter threatens perfusion to tissue distal to the clot, and when the catheter is removed, care must be taken that pressure is applied to prevent hemorrhage.

Doppler blood pressure monitoring is popular because it is inexpensive, not invasive, easy to perform, and provides reasonable accuracy in certain patient populations. However, Doppler BP has limitations and may not be the best choice for patients who are hypotensive or hypertensive; in addition, if the cuff cannot be sized accurately (as in pediatric patients), the pressure values must be interpreted with caution [28–33]. The American College of Veterinary Internal Medicine issued comprehensive guidelines for the screening, diagnosis, and management of systemic hypertension in dogs and cats in 2007 which are an excellent resource [28]. Systolic measurements obtained on cats may be closer to mean arterial pressure and Doppler may be preferable to oscillometric methods [29–34]. Skelding and Valverde, upon review of the available literature, recommended Doppler as a reasonable estimation of direct arterial *mean* BP in cats [25, 26], while a 2017 prospective randomized trial conducted at the University of Tennessee assessed age, body condition score, and muscle condition scores in conjunction with systolic BP collected from the radial (forelimb) and coccygeal sites on 66 cats. That study recommended the use of the coccygeal site in elderly cats or those with significant sarcopenia [32] (Figure 17.3). A 2020 study by Cerna et al. published in the Journal of Feline Medicine and Surgery compared oscillometric and Doppler blood pressure measurements in 23 conscious cats, finding that oscillometric and Doppler methods could not be used interchangeably [34]. In cats, consistency of site used, cuff size, and operator may be more significant than in dogs due to variance between coccygeal and radial sites.

Table 17.2 Calculation for mean arterial blood pressure (MAP) using systolic and diastolic measurements [24–27].

Arterial blood pressure calculation
MAP is the product of cardiac output (CO) and systemic vascular resistance (SVR):
$MAP = CO \times SV$
To calculate MAP, use the following equation:
$MAP = [(DAP \times 2) + SAP] \div 3$
DAP, diastolic arterial pressure and SAP, systolic arterial pressure

Table 17.3 Normal arterial blood pressure ranges in the cat [24–27].

Normal blood pressure ranges
Systolic: 80–140 mm Hg
Diastolic: 55–75 mm Hg
MAP: 60–100 mm Hg

Nursing care considerations vary widely based on the disease process and affected body system(s); consequently, nursing care associated with each disease process will be included in their respective sections of this chapter.

17.8 Common Emergencies by Body System

17.8.1 Cardiovascular

17.8.1.1 Cardiovascular Shock

Shock is defined as poor perfusion resulting in inadequate energy production at the cellular level due to the lack of oxygen and other nutrients resulting in cellular death and organ dysfunction [2]. The etiologies of shock are multivariate. Shock is classified as circulatory, metabolic, or hypoxic; within circulatory shock, sub-types include hypovolemic, distributive, cardiogenic, and obstructive and patients may experience multiple types of shock simultaneously [35]. All feline ER patients should be evaluated for shock with the caveat that shock presents differently in feline and canine patients. Compensatory mechanisms (tachycardia, bounding pulses, injected mucous membranes) are not typically seen in this species. Cats in shock may demonstrate either a normal heart rate or bradycardia (HR <160); in addition, hypothermia and hypotension (systolic BP <90 mm Hg) with bradycardia or alone are strongly supportive of shock. [36, 37] Other clinical signs of shock in cats include poor pulse quality (weak, thready), pallor, depressed or dull mentation, prolonged CRT, and cool extremities [35–37]. The goal of treatment for shock is to restore perfusion through fluid therapy, oxygen supplementation, blood transfusion, drug therapy, and active warming [35–37].



Figure 17.3 The coccygeal artery is used to assess Doppler blood pressure in this feline patient. This technique has been validated for accuracy. *Source:* Kelly M. Foltz, CVT, LVT, RVT, VTS (ECC).

Hypothermia induces vasoplegia; cats in shock may be unable to respond to intervention if they are hypothermic so gradual warming is prioritized via incubator, forced air blower, or other safe warming device [37]. Feline patients should be carefully warmed prior to the administration of aggressive fluid therapy or fluid overload may result due to the prevalence of occult cardiac disease in this species [37, 38]. Each cat should be auscultated carefully before, during, and after fluid resuscitation to monitor for a gallop rhythm, heart murmur, or altered lung sounds that may indicate fluid intolerance. Technicians may be familiar with the phrase that "the gut is the shock organ in dogs" but the lungs are the organ(s) most affected by shock in the cat. Pleural effusion, pulmonary edema, ARDS, and ALI have been documented secondary to shock and fluid resuscitation in feline patients.

The approach to fluid therapy in feline shock patients should be based on the individual case. Debate exists as to the optimal approach toward fluid resuscitation of the feline shock patient; at this time, large volume/total blood volume resuscitation is no longer recommended, but conservative or limited volume fluid resuscitation has been recommended [38, 39]. When administering isotonic crystalloids for shock, a dose of 40–60 ml/kg is divided into quarter boluses and administered over 10–20 minutes before the patient is reassessed for response to therapy [35, 37]. Up to four of these aliquots can be administered before considering alternatives, such as pressor agents or colloids. Perfusion parameters to reassess following a bolus include mentation, pulse quality, heart rate, extremity temperature, CRT, and blood pressure (blood pressure does not always correlate to oxygen delivery). If crystalloid boluses are ineffective, colloid solutions can be administered at 3–5 ml/kg [35, 37]. Debate exists about the safety and utility of colloid solutions. Hypertonic saline is also used for volume expansion at 2–4 ml/kg IV and is considered a fluid of choice in head trauma. If the patient is hypothermic, warmed fluids will assist in attaining normothermia [37].

17.8.1.2 Feline Aortic Thromboembolism

Feline aortic thromboembolism (FATE) is a devastating illness of domestic cats first reported in 1930. Cats with hypertrophic and restrictive cardiomyopathy (HCM, RCM) are more prone to FATE, although cats with hyperthyroidism, endocarditis, neoplasia of the lungs, and supravalvular mitral valve stenosis may also develop FATE [40–42]. Mortality may be as high as 90% although some sources indicate a survival rate of 27–45% [43–46]. It is difficult to assess outcomes in FATE; most research is conducted in academic institutions but many more cats with FATE may be euthanized in general practices [46].

FATE occurs when a thrombus formed in the left atrium or ventricle embolizes, ultimately lodging in an artery [39–42]. The most common site is the so-called "saddle" or aortic trifurcation of the pelvic limbs and tail. Less commonly, a thrombus may lodge in a brachial, cerebral, renal, mesenteric, or other artery. Initial triage and intervention are focused on providing analgesia and oxygen so that diagnostic tests and imaging can be completed. During triage, flow-by or mask oxygen can be supplied if the patient tolerates it. An IV catheter should be placed ASAP in an unaffected limb and blood collected for CBC/chem/coagulation testing if desired. *Analgesia should never be delayed, even if clinical staff believe that the client will elect euthanasia.* Once vascular access is established, an opioid analgesic is administered. Buprenorphine is widely available and can be dosed at 0.02 mg/kg IV Q6H; it may also be administered IM if vascular access is delayed but may be insufficient to manage severe pain [1, 42, 45]. Pure mu agonists such as methadone or fentanyl are potent and can be titrated to effect; methadone is dosed at 0.6 mg/kg IV Q4–6 hours and fentanyl is dosed at 3–5 mcg/kg IV administered as a slow bolus and followed by a CRI at 2–5 mcg/kg/h [1, 42, 45]. If imaging establishes a diagnosis of CHF or crackles are noted, diuretic therapy with furosemide 1–2 mg/kg IV Q1-8H is initiated [45]. It is ideal to have baseline renal values prior to starting diuretic therapy, and furosemide may impact serum potassium levels since it is not a potassium-sparing diuretic. Pimobendan is dosed at 0.625–1.25 mg per cat Q12H PO for the treatment of heart failure [42–45].

If respiratory distress persists, the patient should be housed in an oxygen cage or incubator with supplemental oxygen at a target of 35–45% and ambient heat support if hypothermic. Eye lubrication is applied every 4–6 hours when patients are housed in an oxygen cage. When administering IV medications to cats with heart failure, small volumes of flush should be used to avoid worsening CHF. Free choice water should always be available to patients receiving diuretic therapy. A microbore extension set attached to the patient's IV catheter permits the administration of medications from outside the oxygen cage without decreasing the O_2 concentration or causing patient stress. Once analgesia is administered and CHF ruled out or treatment initiated, therapy is focused on thrombolysis and anticoagulation. For more information on diagnosis and treatment, the reader is directed Chapter 14: "Cardiology and Cardiovascular Diseases."

17.8.2 Environmental Emergencies

17.8.2.1 Smoke Inhalation

Environmental emergencies in the veterinary ER include but are not limited to heatstroke, hypothermia, altitude sickness, envenomation, toxicity, and smoke inhalation. Veterinary technicians should anticipate some of the unique circumstances and challenges that come with structural fires and smoke inhalation. In many cases, multiple pets from a single household may present simultaneously; in addition, clients may be profoundly distressed having just lost their home, and may not have access to credit cards, identification documents, pet insurance information, or ready cash to leave deposits for care. They may only have their pets and the clothing they were wearing at the time of the fire. In many instances, some pets survive a fire while others do not. Veterinary technicians should be prepared to support these clients with empathy and compassion.

Smoke inhalation results in airway injury via a variety of etiologies. The inhalation of carbon dioxide, a byproduct of combustion, results in preferential binding of carbon monoxide to hemoglobin at an affinity 200× that of oxygen molecules, leading to reduced oxygen delivery to tissues, including the brain [47]. This RBC/carbon monoxide complex is referred to as carboxyhemoglobin [47–49]. Carbon monoxide further impacts mitochondrial use of oxygen for energy synthesis while thermal injury occurs due to high-temperature air scorching soft tissue, damaging the mucociliary elevator of the trachea causing edema, serum leakage, and epithelial sloughing throughout the upper and lower airways with accompanying bronchoconstriction [48]. Aerosolized contaminants from burning plastics, synthetic fabrics, and treated lumber cause additional irritation and impact surfactant function. The result is a combination of thermal, metabolic, and ischemic injuries to the delicate airway tissues.

On presentation, cats may be unconscious due to a low inhaled oxygen percentage. If conscious, the cat(s) may be distressed, vocal, or dyspneic with tachypnea, panting, stridor, expiratory wheezes, or harsh lung sounds with or without

crackles noted on auscultation [47–49]. Dermal burns may be present. It is important to note that pulse oximetry is inaccurate when performed in these patients due to carboxyhemoglobinemia or methemoglobinemia, and readings may be artifactually high when the patient is actually hypoxemic. If available in practice, co-oximetry can be used to identify carboxyhemoglobinemia or methemoglobinemia [47–49].

Treatment is focused on supporting appropriate oxygenation via cage O_2, nasal cannula delivery, or high-flow nasal oxygen (HFNO) if the cat is large enough [47–49]. Supplementing oxygen at a high inspired O_2 percentage aids in the clearance of carboxyhemoglobin and allows O_2 binding to hemoglobin, restoring O_2 delivery to tissues. These patients are fragile and may require sedation to reduce the stress associated with handling and diagnostic testing. In addition, if bronchoconstriction or bronchospasm is suspected, bronchodilators are administered. On rare occasions, emergency tracheotomy or intubation and mechanical ventilation are required. Analgesia is always recommended, as are IV fluids. If available, HBOT can be beneficial in accelerating the clearance of carbon monoxide even more rapidly than conventional oxygen therapy [47]. Current guidance does not include the administration of prophylactic antimicrobials or corticosteroids [47]. For the care of dermal burns, see Chapter 13: "Wounds and Bandaging."

17.8.2.2 Envenomation

The United States is home to multiple species of venomous snakes in the crotalid and elapid species. A discussion of both phyla (crotalids and elapids) is beyond the scope of this text. Envenomation is more likely to occur in the spring, summer, and early fall months when days are warmer and snakes are more active. Cats are commonly bitten on the forelimb but can also be bitten on the face or trunk (Figure 17.4). Factors that affect the severity of envenomation are variable for each patient and include signalment, bite location, comorbidity, snake-dependent factors, and pre-hospital care [50–55].

Pit viper venom is a complex biological substance designed to cause hemorrhagic shock, slow death, and pre-digestion of prey [50–55]. Potency varies from snake to snake based on species, age, size, gender, time of year, and bite intention. Clinical signs include but are not limited to puncture wounds with oozing blood or serum, bruising and ecchymoses, pain, lethargy, ptyalism, edema, necrosis, lameness, and general malaise [50–55]. Once edema, swelling, and bruising occur, it may no longer be possible to identify punctures. In severe cases, collapse, respiratory distress, obtundation, hypotension, incontinence, and cardiac arrhythmia may also be seen [50–55].

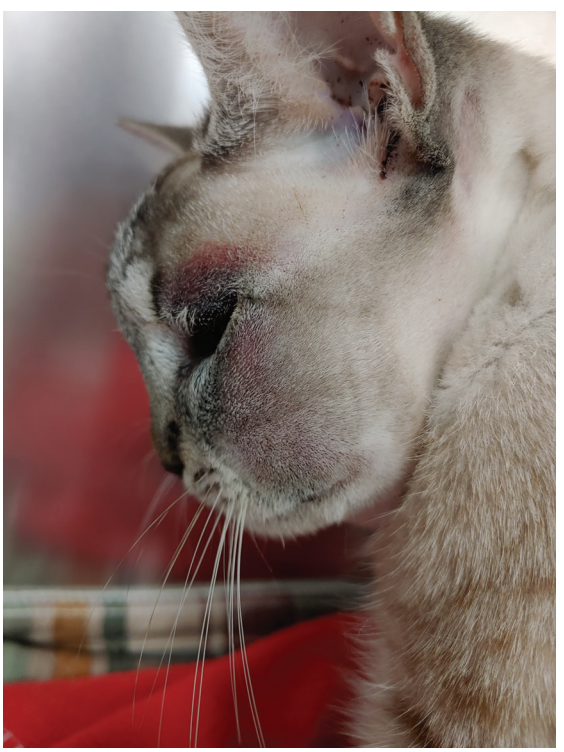


Figure 17.4 Profile view of a young female domestic shorthair cat bitten on the face by a pit viper; note the edema and bruising consistent with the hemolytic and coagulopathic effects of this venom. *Source:* Kelly M. Foltz, CVT, LVT, RVT, VTS (ECC).

Envenomation in cats can be mistaken for other pathologies like abscesses, spider bites, and other causes of lameness. Bruising/ecchymoses may go unobserved in long-coated animals depending on the location of the wound, although facial strikes are generally unmistakable. Technicians should never handle snakes, even if they appear deceased, due to the risk of peri-mortem envenomation. Suspicion for envenomation should be high in any cat with corresponding signs that have been exploring areas of brush, tall grass, on the banks of lakes or creeks, wood piles, barns, or thick vegetation.

Basic triage, primary and secondary surveys, and assessment of perfusion parameters should be conducted in all patients suspected of pit viper envenomation [50–54]. While patients may have pain, bleeding, bruising, and edema at the site of envenomation, many are hemodynamically stable with a small cohort that does not require antivenom and only requires analgesia and observation, important since the patient's condition can change rapidly. Unstable patients have evidence of poor perfusion and/or hypovolemia. Cats that have been bitten on their face may experience ocular trauma, neurologic abnormalities, or facial swelling and oral/airway edema that puts them at risk of complete airway obstruction. Rapid establishment of peripheral vascular access is essential, and CBC, chemistry panel, and coagulation samples should be collected at the time of

catheterization. A blood smear should be evaluated for evidence of echinocytes, although the absence of echinocytosis does not rule out envenomation. If possible, an ECG should be performed to screen for cardiac arrhythmias.

Patients may require intubation, tracheotomy, or mechanical ventilation [50–54]. A pure mu opioid analgesic should be administered promptly (fentanyl, methadone, hydromorphone); nonsteroidal anti-inflammatory drugs (NSAIDs) and steroids are contraindicated in patients with coagulopathy and shock. Shock should be treated with targeted IV boluses of a balanced, isotonic crystalloid fluid and refractory hypotension may require pressor therapy. Maintenance IV fluid therapy will assist in maintaining circulating blood volume, correcting electrolyte disturbances, aiding in acid–base balance, and supporting renal function. Technicians should be aware that clipping and cleaning the site may release additional venom. At a minimum, envenomated cats should be hospitalized for several hours of monitoring since complications such as kidney injury, wound necrosis, and airway compromise may develop later. Systematic documentation of clinical signs using a snakebite severity score is crucial to track response to therapy and guide decisions about antivenom administration [51].

The administration of antivenom is the only definitive treatment for envenomation. The current products of choice are equine-derived, fragment antigen binding (Fab) cleaved products. These products are less antigenic than whole molecule products and have a wider distribution within the body; however, repeated dosing may be required due to increased clearance through the kidneys due to molecule size. These products are lyophilized for easy storage or are available in suspension and do not require refrigeration during storage. There is a reduced risk of immediate hypersensitivity reaction when using these products in comparison to older products, although isolated cases of suspected serum sickness have been documented when large volumes have been administered. Typically, the product is diluted in 100–250 ml normal saline according to the manufacturer's instructions and administered over 1 hour as needed. In an emergency (circulatory collapse, obtundation, peri-arrest), 10 ml of antivenom can be diluted in 50 ml of normal saline and administered as a bolus.

Sequelae to crotalid envenomation includes anemia, thrombocytopenia, wound necrosis, kidney injury, and hemoperitoneum (rare). Broad-spectrum antimicrobial use is no longer recommended as a standard of care [55]. Veterinary literature on pit viper envenomation in cats is scarce and available studies indicate mortality rates of 16–22% with a preponderance of bites occurring on the forelimb (51–61% of cases in two studies) [50–54]. Felines can receive Fab antivenom and should be re-treated with the product if clinical signs persist [50–54]. Due to their small size, if the envenomation is severe, blood transfusion with a type-compatible and crossmatched product may be required.

Re-envenomation is a rare phenomenon where venom is released from the tissue bed of entry after treatment with antivenom. It has been documented in both canines and felines [56] and is treated with antivenom. Switching from a Fab product to a whole molecule antivenom may mitigate the phenomenon, as the larger unfragmented molecule will remain in circulation longer [56, 57]. Controversies in the treatment of pit viper envenomation have been addressed in recent research. Diphenhydramine pre-medication and glucocorticoid administration were once cornerstones of therapy but are no longer supported and steroids may complicate recovery [57]. The prognosis for recovery is generally excellent.

17.8.2.3 Pyrethrin and Permethrin Exposure

Pyrethrins are natural insecticides derived from the Chrysanthemum plant; in companion animal medicine, these products, and their synthetic analogs (called "pyrethroids") are used in the treatment of topical parasitism [58–60]. Permethrins are a sub-class of pyrethrins used in flea and tick prevention products for dogs, although a few products are available for cats that contain <0.1% permethrin [60]. This class of insecticides alters the closure rate of sodium channels in neurons via reversible binding to membrane lipids and antagonism of GABA and glutamic acid, leading to persistent and over-excited firing of the cells [60, 61]. Cats are more sensitive to these chemicals than dogs and are exposed to them when topical flea and tick products are applied by well-intentioned clients; the product is absorbed across the skin, or the cat ingests it through grooming itself or a dog that has been treated [61]. Cats commonly experience toxicity from OTC products labeled specifically for cats or when a canine product is applied, with more severe signs noted following exposure to permethrin. Clinical signs may appear up to 24 hours following exposure and can persist for up to 3 days; in cases of permethrin toxicity, death may result if the patient is not treated [60]. No minimum lethal dose has been determined for pyrethrins and the severity of signs is not correlated to the dose received [61].

Clinical signs are associated with the neurologic effects of the insecticide and include ptyalism, generalized muscle tremors, hyperesthesia, hyperexcitability, hyperthermia, and gait changes. Ataxia, blindness, mydriasis, vocalization, and respiratory distress may also be noted. Central nervous system depression, seizures, vomiting, and diarrhea are rare in pyrethrin toxicosis but have also been documented [59, 60]. Tremors may be severe and can be misinterpreted by clients as generalized seizures. Diagnosis is made based on physical examination, clinical signs, and history of exposure.

Once a diagnosis is made, the patient is bathed in tepid or warm water with a gentle all-purpose dish soap prior to placement of a peripheral IV catheter [59, 60]. Bathing may be repeated, with care taken to prevent iatrogenic hypothermia and protect the catheter. Due to the lipophilic nature of the insecticide, intravenous lipid emulsion 20% (ILE) is recommended at a dose of 1.5 ml/kg as an IV bolus, then as a CRI at 0.25 ml/kg/min for 30–60 minutes [60–62]. Dosing is repeated in 4 hours as needed [60]. Throughout ILE therapy, blood samples should be examined for lipemia to target therapy. While generally low-risk, persistent lipemia, and corneal lipidosis following ILE have been noted [62]. Methocarbamol can be administered at 55–220 mg/kg (not to exceed 330 mg/kg) IV or PO for tremors although dexmedetomidine may be more cost-effective [59, 60]. Administration of anticonvulsants can be considered if necessary. IV fluids are recommended for renal support, especially in hyperthermic patients since myoglobinuria may result from persistent muscle fasciculations [60]. Most patients respond well to decontamination and supportive care with no significant long-term complications.

17.8.3 Genitourinary

17.8.3.1 Feline Urethral Obstruction

Feline urethral obstruction (UO) is a common and potentially life-threatening condition linked with the larger syndromes of feline lower urinary tract disease (FLUTD) and feline idiopathic cystitis (FIC) [63]. In FLUTD, cats present with dysuria, stranguria, hematuria, pollakiuria, and/or periuria [64–67]. As many as 13% of cats presenting to their general practice veterinarian have clinical signs consistent with FLUTD or FIC but in many cases, no causative agent is identified [64–67]. FIC is poorly defined and is best understood as a syndrome resulting in a sterile inflammatory process due to complex changes in, and interactions between, the cat's urinary tract, adrenal glands, sympathetic nervous system, environment, emotional well-being, and environmental stressors [63]. FLUTD and FIC do not always result in urinary tract obstruction but may predispose the patient to obstruction.

Feline UO is readily treatable with 90% of patients surviving to discharge [64–67]. However, in severe cases, UO is fatal due to shock, acid–base imbalance, and hyperkalemia. Urethral obstructions result due to physical (mucus plug, crystals, uroliths) or functional etiologies (urethral spasms). Recent research has identified risk factors for UO: neutered male, overweight, sedentary lifestyle, and a stressful home environment [64–67]. In comparison to the female urethra, the distal penile urethra of male cats is longer and narrower, predisposing them to obstruction.

Technicians should always have UO in mind when presented with a neutered male cat with hiding, vomiting, increased time in the litter box, vocalization, increased grooming, lethargy, or collapse. When taking a history on these cats, it may be advantageous to inquire about recent stressful events in the home such as a move, introduction of a new dog or cat, arrival of a human infant, or home remodeling. It is also essential to understand the dynamics and routines of the cat's home so the technician can act as a coach and counselor if changes are necessary following treatment. Table 17.4 includes sample history questions for the UO cat.

The "classic" PE finding in urethral obstruction is a large, inexpressible urinary bladder although this is not always consistent and patients with normal neurologic function resist bladder expression. The external genitalia should also be examined closely for evidence of discoloration, abrasion, edema, paraphimosis, and a mucus or crystal plug [64–67]. Some patients are alert, euvolemic, and hemodynamically stable on presentation while others are clinically ill. Approximately 40% of patients present with hypothermia and there is a correlation between hypothermia <96.6 ºF, bradycardia of <120 beats/minute, and hyperkalemia >8 mEq/L [64–67]. Bradycardia is considered moderate at 100–140 bpm and severe at <100 beats/minute (the heart rate of a painful cat should be >150 bpm) [64–67]. Bradycardia is observed in 5–6% of UO cases and warrants prompt intervention as it may indicate life-threatening hyperkalemia [64–67]. Varying degrees of dehydration are seen, and perfusion parameters should be assessed as part of the primary survey. Systolic BP may be normal but severely ill patients may be hypotensive due to shock.

Initial intervention is focused on assessing cardiac function, reversing hyperkalemia, providing fluid therapy and analgesia, and promptly relieving the obstruction [64]. A peripheral IV catheter should be placed as soon as possible, and blood collected for packed cell volume (PCV)/total solids (TS), chemistry or renal panel, electrolyte assays, and venous blood gas. In one study, ~30% of UO cats had an elevated creatinine and 33% had elevated BUN while hyperphosphatemia was noted in 25% of cats [64–67]. Acidosis, hypocalcemia, and electrolyte derangements are also common. Hyperkalemia is considered mild at <6 mEq/L, moderate at 6–8 mEq/L, and severe at >8 mEq/L. [64–67] Fluid therapy at 10–20 ml/kg/hr is usually sufficient to resolve mild hyperkalemia following de-obstruction. If hyperkalemia is moderate to severe, in addition to fluid therapy, 50% dextrose dosed at 1 ml/kg and diluted to a concentration of 10–20% is administered in conjunction with regular insulin (1U/cat) [64–67]. The administration of dextrose stimulates endogenous insulin release, causing the movement of

Table 17.4 Sample history questions for the obstructed cat that may identify contributing factors and opportunities for clients to improve the cat's QOL and stress level.

Sample detailed history questions for the feline urinary obstruction patient	Rationale
When was your cat last normal?	Has the client observed any changes that may indicate the duration of the obstruction?
When was your cat's last witnessed urination?	Speaks to acuity of the issue.
How many cats are in the household?	This will rule in or out a variety of scenarios; for example, are there stressors for the patient?
Are your cats indoor, outdoor, or some combination of both?	If the cat is an indoor cat, stressors are likely different than if the cat goes outdoors. In addition, toilet habits are more likely to be observed in an indoor cat.
How many litter pans/boxes are there in the house? Where are they located, and what type of litter do you use?	This will speak to stressors and give a clue of how the client may react when told they potentially need to add litter boxes.
What type and how many water sources are available?	Access to fresh, clean water has been documented as an important factor in preventing recurrence of urinary obstruction.
What type of food does your cat eat, and where in the home is he/she fed?	This will alert the technician if a diet change from dry to canned or onto a prescription diet might be needed at the time of discharge.
Have you noted any changes in your cat's toilet behavior?	Speaks to pollakiuria, periuria, stranguria, accidents, and inappropriate urination that may indicate FIC or other issues.
If you have more than one cat, have you witnessed any issues between the cats (fights, bully behavior, resource guarding, etc.)?	Speaks to stressors that may contribute to UO.
What are your goals for treatment today?	This question is essential to align care teams and clients around expectations and priorities.
Please tell me what concerns you the most today.	This question gives clients the opportunity to share concerns about finances, patient QOL, survival odds, or worries about long-term care.

potassium from the extracellular space to the intracellular compartment. Administration of exogenous insulin facilitates this process but in a normoglycemic patient, dextrose must be supplemented via CRI to prevent hypoglycemia. In cats with marked bradycardia, 10% calcium gluconate is administered at 0.5–10 ml/kg IV over 3–10 minutes while the patient is on continuous telemetry monitoring [64]. Calcium gluconate reduces the membrane threshold potential of cardiac muscle cells, helping restore normal resting membrane potential and stabilizing conduction. If bradycardia worsens during the infusion or the Q-T interval becomes shorter, the infusion is discontinued. Calcium gluconate has a 20–30 minutes duration of efficacy.

An electrocardiogram is essential when assessing and treating these patients. In addition, a urinalysis with full sediment examination should also be performed, ideally on a sample collected via cystocentesis prior to relief of the obstruction and bladder lavage [64–67]. Many cats with UO have sterile urine but if a urinary tract infection (UTI) is suspected, a urine culture should be performed. Struvite crystalluria was once implicated in a majority of UOs but is now believed to occur when alkaline urine sits in the obstructed bladder. Two view abdominal radiographs that are positioned to include the full curvature of the urethra and entire penis are recommended to rule out radiopaque urolithiasis as a cause of the obstruction. Loss of detail in the caudal abdomen may indicate abdominal effusion or uroabdomen; however, standard radiography is not sensitive or specific for bladder rupture, and if uroabdomen is suspected contrast cystography/urethrography or abdominal ultrasound are more sensitive imaging modalities [64–67].

Maintenance fluid therapy is driven by the patient's degree of dehydration, maintenance needs, and ongoing losses through the urinary tract. Fluid therapy is essential to treat hypovolemic shock, support renal function, replace losses, and resolve hyperkalemia. Cats may experience UOP >25 ml/kg/h following relief of a UO and if these losses are not replaced with IV fluid therapy, the patient is at risk for ongoing volume depletion [68]. Once azotemia has resolved, urine production usually decreases, and IV fluids can then be weaned by 25% every 6–12 hours if urine production continues to decrease along with the fluid rate [64–68]. The fluid rate drives diuresis to some extent, so if the UOP is not falling in conjunction with the fluid rate, the rate may need to be increased and weaning attempted later. Many cats have occult heart disease

and are at risk of fluid overload when receiving aggressive fluid therapy. All UO cats should be monitored closely for evidence of fluid intolerance via serial body weight, frequent respiratory rate and effort monitoring, thoracic auscultation, and physical examination to check for chemosis, nasal discharge, and limb edema.

The value of decompressive cystocentesis in UO patients has been debated [69–71]. Decompressive cystocentesis can be performed quickly with minimal sedation, relieves back pressure and pain due to the obstruction, may improve renal function by allowing glomerular filtration to resume, may make catheterization easier, and yields a sterile urine sample for analysis. Concerns exist about bladder rupture or leak if a large needle puncture or repeated needle puncture is performed, although a study involving 45 cats indicated that risk is low for uroabdomen when decompressive cystocentesis is performed on blocked cats [71].

A urinary catheter is placed to relieve the obstruction as soon as possible. For indwelling placement, a long catheter made of soft material is ideal, such as a red rubber (polyvinyl), infant feeding tube, or Slippery Sam™ (Surgivet, polytetrafluoroethylene) catheter. Catheters are also available with a flush-through stylet that does double duty to both unblock and remain as an indwelling catheter (MILA International, tomcat/small animal urinary catheter). Research has demonstrated that the use of a 3.5 Fr indwelling catheter is associated with a decreased risk of re-obstruction within 24 hours of catheter removal in comparison to the use of a 5 Fr catheter (~7% versus 19%) [69, 70].

Analgesia should be provided on presentation and tailored to the patient's pain score and stability. Opioids and their derivatives such as buprenorphine are common choices. If desired, a coccygeal epidural can be administered prior to de-obstruction to minimize the need for systemic analgesia and anesthesia. Sedation or general anesthesia are required for de obstruction; common drug choices include ketamine (2–5 mg/kg IV) with diazepam (0.2–0.5 mg/kg IV) or midazolam, ketamine with acepromazine (0.005–0.05 mg/kg IV), propofol, or alfaxalone [66, 67, 69, 70]. If apnea-inducing drugs such as propofol or alfaxalone are used, the patient should be intubated to provide manual ventilation. The patient should only be anesthetized after hypovolemia, hypothermia, bradycardia, and hyperkalemia have been addressed.

Once the obstruction is relieved, the bladder is emptied and lavaged with sterile saline to remove debris. Chilled sterile saline can be used to enhance vasoconstriction and minimize hemorrhage if the urine is grossly bloody but may contribute to hypothermia. Once the obstruction is relieved, the bladder lavaged, and the indwelling catheter sutured in place, a closed collection system is attached (Figure 17.5). To preserve and protect the urinary catheter, UO patients should be fitted with an Elizabethan collar prior to anesthetic recovery. Nursing care includes cleaning the catheter, ports, and connections with dilute chlorhexidine, monitoring UOP and adjusting IV fluid rate, accordingly, checking for kinks and further obstruction, and assessing the patient's pain score, appetite, and demeanor.



Figure 17.5 A closed collection system is essential for quantifying urine output and adjusting fluid therapy to match losses, especially if post-obstructive diuresis is suspected. *Source:* Kelly M. Foltz, CVT, LVT, RVT, VTS (ECC).

Analgesia should be provided for 5–7 days after de-obstruction. The use of nonsteroidal anti-inflammatory drugs such as meloxicam and robenacoxib is controversial due to the associated risk of acute kidney injury (AKI) [69, 72]. Adjunctive analgesics, such as gabapentin, are helpful to treat pain through novel pathways. Gabapentin is also effective for anxiety when dosed at 50–100 mg/cat Q8–12 hours [1]. Antimicrobials are NOT indicated without confirmation of UTI to target therapy or as prophylaxis against catheter-associated UTI [69].

Urethral antispasmodics have historically been recommended, including acepromazine, phenoxybenzamine, and prazosin [69]. Initial studies conferred an advantage to cats who received prazosin (lower recurrence of UO); however, two recent studies indicate that prazosin may have limited utility in the management of feline UO [73, 74]. Another novel treatment, the installation of pentosan polysulfate sodium into the bladder, had no discernable effect on recurrent UO or clinical signs in cats who received it three times within 48 hours [75].

Documented re-obstruction rates range from 30 to 43% and one study found a re-obstruction rate of 36% in a 3-year period; in another retrospective study of 157 cats, 24% had a repeat obstruction within 30 days [64–66, 70]. Many studies have investigated the relationship between age, weight, degree of azotemia, urinary catheter size, USG, urine pH, diet, analgesic selection, and use of antispasmodic drugs on the recurrence of UO without finding direct correlations. In these studies, various combinations of increased water consumption, increased number of litter boxes available, and other husbandry changes were implemented to decrease risk, but only increased water consumption correlated to a decreased incidence of UO. Technicians should counsel clients that modifications to the cat's environment, diet, and stress level are warranted and that UO may recur. Perineal urethrostomy performed by a boarded veterinary surgeon is an option for cats with recurrent UO; although not without risk, it can improve outcomes.

17.8.4 Hematologic

17.8.4.1 Transfusion Medicine

A wide variety of disease processes cause or result in anemia in the feline patient, and it may be helpful to think of the causes of anemia as falling into one of three categories: red cell loss, inefficient erythropoiesis, or hemolysis [76, 77]. In addition to the treatment of anemia, blood transfusion is also recommended for patients with hemorrhage, hypoalbuminemia, coagulopathy, and thrombocytopenia [76, 77]. For more information about anemia and blood banking, refer to Chapter 21: "Hematology." When considering blood component therapy for any patient, it is important to consider potential risks versus benefits, as blood transfusions are not benign [77].

Current medical quality standards dictate that donor whole blood (WB) is further processed to safely meet the needs of patients with specific pathologies. Fresh WB contains RBCs, WBCs, plasma, albumin, platelets, and clotting factors that can be processed into stored whole blood, packed red blood cells (pRBCs), plasma (liquid, fresh frozen, or frozen plasma), platelet concentrate, cryoprecipitate, cryo-poor plasma, platelet-rich plasma, lyophilized platelets, and albumin [77]. The composition, processing, and storage of these products along with indications for their use will not be discussed here. Transfusion of whole blood increases the risk of reaction and fluid overload in feline patients and precise, targeted replacement therapy is preferred unless massive hemorrhage dictates administration of whole blood. Massive transfusion is defined as the transfusion of WB or component products that are equal to or greater than the patient's total blood volume in a span of 24 hours OR the transfusion of WB/component products equal to half the patient's blood volume in a 3-hour period [77]. Due to additives in blood component products (anticoagulant, preservative solutions, etc.), if massive transfusion is indicated, FWB is preferred to multiple component transfusions [77]. A cat is considered "naïve" to transfusion if it has never received any exogenous blood component therapy before. Technicians should always ask clients about a patient's transfusion history prior to administering any blood product.

17.8.4.2 Feline Blood Types

Two blood groups have been identified in domestic cats: the AB group and the Mik antigen group (first noted in 2007). Within the AB group, the major types are A, B, and AB [78–80]. Approximately 95% of domestic mixed breed cats in the United States are blood type A, 5% are type B, and <1% are type AB [78]. There may be breed predilections for blood type with some exotic and Oriental pure-breed cats having populations that are almost 50% type B; however, blood typing should be performed on all feline patients since blood type cannot be assumed based on breed or haircoat [78]. Cats with type A blood have innately occurring weak anti-B antibodies that induce a hemolytic reaction if the cat receives type B blood. In contrast, type B cats have anti-A alloantibodies that cause acute, severe, and potentially fatal adverse reactions if these cats receive type A blood. Cats with type AB blood have both A and B antigens on the surface of their RBCs; historically, type AB or type A blood has been recommended for these cats but the discovery of the Mik antigen group and the discovery of transient AB antibodies indicate that type AB cats naïve to transfusion should be crossmatched to their donor [78, 80–83]. Blood type is also important when treating the "fading" kitten, as neonatal isoerythrolysis may result if a type B queen is bred to a type A tom.

Blood type is easily determined in the clinic through the use of commercially available typing kits that use lyophilized monoclonal antibodies on a card with wells to induce agglutination (RapidVet-H by DMS Laboratories) or immunochromatography, antisera, and capillary action on a dip strip (Quicktest by Alvedia; Figure 17.6). Accuracy has been estimated at 89–91% for the antibody kits and 93% for the immunochromatography kits [78, 79]. Both kits are widely available, easy to use, and reliable. If more extensive screening is required, testing through a reference laboratory can identify further blood types. Blood typing identifies RBC surface antigens but cannot determine antibodies to those antigens in the donor or recipient [78, 79]. Type-specific plasma should be administered to cats [84].

Crossmatching is essential to identify potential incompatibility between donor and recipient and is considered a minimum standard of care [78–80]. The major crossmatch tests the compatibility between donor RBCs and recipient plasma, while the minor crossmatch tests the compatibility between donor plasma and recipient RBCs [78–80]. The tests can be performed in the clinic using donor and recipient blood, normal saline, and a centrifuge or by using a commercially available crossmatching kit (RapidVet-H by DMS Laboratories). Instructions for in-clinic crossmatching are widely available through a variety of sources and will not be discussed here.

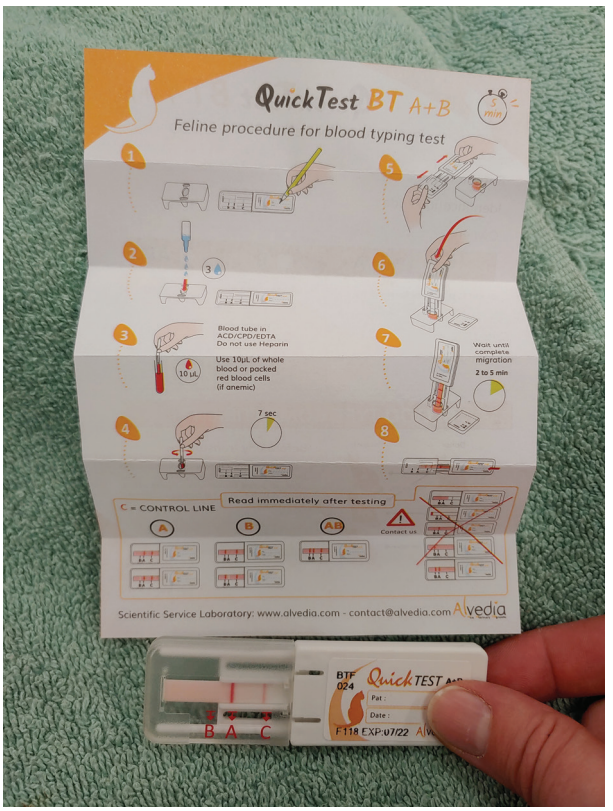


Figure 17.6 Immunochromatography blood typing kit for cats; this patient is type A. *Source:* Kelly M. Foltz, CVT, LVT, RVT, VTS (ECC).

17.8.4.3 Transfusion Reactions

Transfusion reactions are classified as acute (occurring during or within 24 hours of transfusion) or delayed (occurring more than 24 hours after transfusion). Reactions to blood products occur for a variety of reasons that can be classified as immunologic or nonimmunologic. The Association of Veterinary Hematology and Transfusion Medicine (AVHTM) has created the Transfusion Reaction Small Animal Consensus Statement (TRACS) guidelines [85–87] that address hemolytic, allergic, and febrile nonhemolytic transfusion reactions. In addition, the guidelines discuss transfusion-related acute lung injury (TRALI) and transfusion-associated circulatory overload (TACO). More information about transfusion reactions is found in Tables 17.5 and 17.6.

TRALI is an acute nonhemolytic immunologically mediated transfusion reaction associated with transfusions defined by acute respiratory distress, hypoxemia, and noncardiogenic pulmonary edema (NCPE) during or within 6 hours of transfusion [85]. It has not been reported in feline patients to date. In contrast, TACO is associated with increased circulating blood volume due to transfusion resulting in hydrostatic pulmonary edema [85]. Clinical signs include tachypnea, respiratory distress, jugular vein distention, cough, crackles, or orthopnea. Radiographic findings differ from the characteristic appearance of TRALI with pleural effusion, vessel distention, and cardiomegaly considered pathognomonic for TACO [85]. TACO is more likely in patients with a history of cardiac disease, renal insufficiency, lung disease, or chronic anemia and is also associated with large volume or rapid transfusions. Patients with TACO should receive prompt oxygen supplementation while the transfusion is slowed or stopped. Diuretic administration is helpful for these patients to decrease their circulating fluid volume [85].

17.8.4.4 Transfusion Administration

Packed RBCs raise PCV more effectively at a lower volume than whole blood and are preferred in anemic patients. Numerous evidence-based guidelines for the collection, processing, storage, and administration of feline blood products are available, including those from the International Society of Feline Medicine in 2021 [80] and the TRACS guidelines [85–87]. Equations for the calculation of blood volume to administer to achieve a desired PCV will not be discussed here.

An administration set with an in-line or attached filter should be used with all products, including plasma [77, 78, 84–87]. Products do not need to be warmed unless the patient is very small or a rapid, large volume is needed; frozen plasma is thawed prior to use in a water bath according to current guidelines. Asepsis should be preserved throughout the administration process. While gravity flow is preferred for blood transfusions to preserve the integrity of living cells, this technique presents challenges in determining accurate flow rates as patients move their limbs or reposition themselves; in addition, flow is correlated to the IV catheter site and size. A blood-rated pump should be used since the use of incorrect equipment predisposes the patient to a transfusion reaction, damages, and wastes product, and incurs unnecessary costs to clients when the desired result is not achieved. Based on the TRACS guidelines, administration of feline RBC products (including WB) using a syringe pump and an 18µ microaggregate filter provides acceptable in vivo survival of RBCs [86].

Table 17.5 Comprehensive list of potential feline transfusion reactions, including classification, etiology, examples, actions, and preventative measures [77–80, 85–87].

Feline transfusion reactions					
Type	**Characteristics**	**Etiology**	**Example**	**Action**	**Prevention**
Hemolytic Immunologic					
Acute hemolytic (AHTR)	Occur within 24 h of transfusion	Type II hypersensitivity, Ag–Ab reaction involving IgM or IgG	Blood type incompatibility	Alert clinician immediately, stop transfusion, treat for anaphylaxis	Crossmatching, use of type- and crossmatch-compatible products
Delayed hemolytic	Between 24 h and 28 d post-transfusion	Extravascular hemolysis	Incompatible blood time administered for initial transfusion	Report any precipitous decline in PCV or hematocrit; report an increase in bilirubin	Crossmatching, use of type- and crossmatch compatible products
Neonatal isoerythrolysis	"Fading" kitten(s), tail tip necrosis, pigmenturia	Type B queen is mated to a tom with an incompatible blood type (A or AB)	Neonates with the tom's blood type develop hemolytic anemia when they ingest colostrum from the queen	Alert clinician, do not permit further colostrum consumption, treat for anemia with compatible product	Blood type breeding pairs
Nonhemolytic Immunologic					
Febrile non-hemolytic (FNHTR)	Most common in cats; temperature >102.5º Fr or increase >1.8 Fr over baseline within 4H of transfusion	Immunologic reaction to donor WBCs or platelets Pro-inflammatory cytokine activity in blood product	Fever noted in first 30 min of transfusion, may persist for ≤20 h	Alert clinician, slow or stop the transfusion	Leukoreduction of product
Acute hypersensitivity	Present during transfusion or up to 4 h following completion	Type I allergic reaction	IgE-mediated mast cell activation resulting in anaphylaxis	Alert the clinician, and stop the transfusion. Consider antihistamines. Treat for anaphylaxis if the reaction is severe	Pre-treatment with antihistamines in animals with a documented history of this reaction. A slower than usual administration rate can also be considered

			Anaphylactoid reaction due to allergens in the product (not IgE mediated)	Alert the clinician and stop the transfusion. Consider administration of antihistamines. Treat for anaphylaxis if severe reaction	Pre-treatment with antihistamines in animals with a documented history of this reaction. A slower than usual administration rate can also be considered
Transfusion-associated acute lung injury (TRALI)	Acute, immunologic reaction with complex etiology. No feline reports in the peer-reviewed literature	Ag–Ab interaction in the lung parenchyma	Acute hypoxemia and NCPE during or within 6 h of transfusion in patients with no prior history of lung injury	Not reported in felines to date	Not reported in felines to date
Nonimmunologic	–	–	–	–	–
acute	Variable based on etiology	Electrolyte derangement	Citrate intoxication (hypocalcemia resulting from chelation of calcium)	Alert the clinician if clinical signs are noted (arrhythmia, tetany, vomiting). Slow or stop transfusion. Treat severe reactions with supplemental calcium	This reaction is rare but can be seen in animals with liver disease
		Contamination of blood product	Bacterial colonization	Stop transfusion, alert clinician, and reserve product for culture and in-clinic Gram staining	Scrutinize blood units carefully for bubbles, clots, or discoloration prior to administration. Use strict asepsis when collecting from donors and preparing any product for administration. Administer transfusions within a 3–4 h time frame
		Mechanical damage to blood product	Incompatible pump, wrong size filter, high flow rate	Alert the clinician if hemolysis is noted on PCV during transfusion or after completion. Stop transfusion	Strict compliance with recommendations about pumps, filters, administration sets, and flow rates

(Continued)

Table 17.5 (*Continued*)

Feline transfusion reactions

Type	Characteristics	Etiology	Example	Action	Prevention
		Other physical damage to blood product	Overheating, freezing, incorrect storage temperature, incompatible fluids or drugs administered concurrently	Alert the clinician if damage is suspected	Store products in compliance with current guidelines. Verify compatibility with blood product(s) prior to administration of fluids or drugs
		Coagulation disturbance	Embolus due to clotted product	Alert the clinician and stop transfusion if signs consistent with a thromboembolic event are noted; if PTE is suspected, supplement O_2	Older blood (>7 d) may be implicated
		Acidosis and hyperammonemia	Administration of aged RBC product(s) high in lactate and ammonia (storage lesion)	This reaction is rare but may be indicated by neurologic signs consistent with hyperammonemia	Avoid the use of RBC product(s) that are close to expiration
Transfusion-associated circulatory overload (TACO)	Acute onset of dyspnea during or following transfusion	Increased blood volume results in hydrostatic pulmonary edema	Transfusion is administered to a patient with cardiac disease	Alert clinician, stop transfusion, administer furosemide	Screen for cardiovascular disease prior to transfusion; calculate transfusion volume carefully
Delayed nonimmunologic	May not be detected for months or years following transfusion	Infectious disease transmission between donor and recipient	Recipient acquires FeLV or FIV following transfusion	Usually undetected at the time of infection	Screen blood donors using recommended guidelines. Purchase products from reputable blood banks.
			The recipient acquires heartworms following transfusion.	Usually undetected at the time of infection	

Table 17.6 Clinical signs of transfusion reactions in feline patients [77–80, 85–87].

Clinical signs of transfusion reaction
Angioedema
Arrhythmia
Collapse
Diarrhea
Erythema
Hemoglobinemia
Hemoglobinuria
Icterus
Lethargy
Pruritis
Ptyalism
Pyrexia
Tachycardia
Tachypnea
Tremors
Urticaria
Vomiting
Weakness

When using an in-line filter, the recommended micron size is 170–260 μm; in contrast, when administering transfusions of ≤ 50 ml WB or ≤ 20 ml pRBCs are ordered, smaller microaggregate filters are recommended [78, 86]. If using the HemoNate™ filter, care should be taken to follow the manufacturer's instructions regarding when the filter should be changed [78, 86]. Administration of blood in the same line or catheter with hypotonic fluids, hypertonic fluids, drugs, and fluids containing calcium and/or glucose is contraindicated, but normal saline 0.9% or Plasmalyte can safely be administered [80]. If fluids or drugs cannot be paused during a transfusion, a second catheter may be required. When using a central or multilumen PICC line, solutions do not mix; however, compatibility should be confirmed prior to administration. The transfusion is started at a low rate, and the patient is monitored every 10–15 minutes during the first hour of infusion as the flow rate is slowly increased until a maximum flow rate is reached [80]. If the patient is severely compromised and rapid infusion is called for, products can be bolused with the understanding that a reaction or cell damage may occur. Monitoring includes temperature, pulse, respiratory rate/effort, oral mucous membrane color and CRT, mentation, BP, and a visual check for erythema, urticaria, nausea, and angioedema every 10–15 minutes during the transfusion. Transfusions should not exceed 4 hours in duration once the product is connected to the patient, and assessment of a PCV 15 minutes into the transfusion is recommended to check serum for evidence of hemolysis that may indicate HTR. According to the TRACS guidelines, a PCV can be checked immediately following completion of a transfusion [86]. All physiologic data, flow rate, response to therapy, PCV values, and other notes should be recorded in the patient's medical record.

17.8.4.5 Xenotransfusion

Xenotransfusion of canine blood to cats has garnered attention in veterinary emergency and critical care. The practice was first documented in 1968 and is typically resorted to when feline blood products are unavailable in a time frame that will benefit the patient [88]. Multiple reports exist in the peer-reviewed literature of canine blood being successfully administered to feline patients with positive outcomes [86, 88–90]. Single xenotransfusion is well documented and it has been equally well documented that repeated xenotransfusion results in a significantly increased risk of fatal transfusion reactions for feline recipients [86, 88–90]. DHTRs are also documented as a sequel to xenotransfusion at a median of 1–2 days post-transfusion [88–90]. Crossmatch compatibility of canine to feline RBCs is poor, even in cats that are naïve to

canine blood. The average lifespan of canine RBCs administered to cats appears to be ≤4 days with antibodies produced within 4–7 days of transfusion. Fatal anaphylaxis may occur if canine blood is transfused after this period; once a cat has received canine blood, it should never receive it again. The TRACS guidelines state that canine-to-feline xenotransfusion should only be considered if 1) the feline patient is expected to die without receiving blood products and 2) every effort has been made to locate type-compatible and crossmatched feline blood [85–87]. Clients should be clearly apprised of the risks and sign a consent document prior to the xenotransfusion.

17.8.5 Sepsis

It is unclear how many cats are treated annually for sepsis and septic shock, but one study estimated mortality rates of 40% [91], while another estimated 33% [92]. Hepatic abscesses, pyothorax, and septic peritonitis were associated with mortality rates of 20–80% in another peer-reviewed study [92]. The limited investigation of sepsis in cats indicates that septic peritonitis and urosepsis are more common in this patient population [92].

Sepsis is currently defined as "life-threatening organ dysfunction caused by a dysregulated host response to infection" and septic shock as "a subset of sepsis in which profound circulatory, cellular, and metabolic abnormalities are associated with a greater risk of mortality than sepsis alone" [92, 93]. Septic shock is properly classified as a type of distributive shock, but these patients also experience hypovolemic and cardiogenic shock [91]. In a healthy cat, the response to infection is complex and efficient but in sepsis, it is believed that the chain of events is unbalanced toward inflammation with an overabundance of cytokines causing systemic illness unrelated to the initial insult [93, 94]. Gram-negative bacterial species with bacterial cell walls containing endotoxin or lipopolysaccharide are believed to be more virulent [92, 93]. Sepsis is characterized by a variety of responses to infection that may be persistently pro-inflammatory, hypoimmune, generalized, or result in immune paralysis [93, 95, 96]. Proposed mechanisms of cellular, organ, and tissue injury include ischemia, direct cellular damage, and accelerated apoptosis (programmed cell death) [93, 94]. Cell damage brings endothelial repercussions including separation of tight cellular junctions, disruption of the endothelial glycocalyx, and thrombosis of the microvasculature [93, 97–99]. As the vessels leak, organ edema results while thrombi disrupt perfusion by obstruction of the microvasculature. Vasoplegia contributes to persistent hypotension (<65 mm Hg) and potentiates widespread tissue and organ damage if uncorrected, resulting in MODS [93, 100]. AKI, cardiovascular dysfunction, and critical illness-related corticosteroid insufficiency (CIRCI) have also been documented [100–102]. In addition, a growing body of research indicates that damage to the endothelial glycocalyx, a gel-like layer of proteins that lines blood vessels and regulates their permeability, plays a large role in the pathophysiology of sepsis [91, 98, 99].

Technicians should have a strong index of suspicion for sepsis in any critically ill cat. The diagnostic approach relies on CBC data, imaging, physical examination and vital sign assessment, blood pressure measurement, fluid analysis, culture and susceptibility data, and clinical experience [93, 94, 103]. To conclusively diagnose sepsis, the infection must be confirmed via culture of blood, urine, bile, cavitary effusion, or respiratory secretions [93]. In addition, organ dysfunction is diagnosed via chemistry assay or other function tests [93]. Persistent hypotension or hypoglycemia may be noted along with hypoalbuminemia. Technicians should keep in mind that bacterial culture takes time to yield results, but in-clinic Gram staining is inexpensive and may help target antibiotic therapy until culture and susceptibility results are available.

Management of the septic feline patient is focused on fluid therapy, antibiotic therapy, maintaining normotension and perfusion, and supportive care. If isotonic crystalloids are insufficient and hypotension is refractory, colloids are considered but are controversial due to the increased risk of negative outcomes and AKI associated with their use [91, 100–103]. Following fluid resuscitation, early use of pressor agents is recommended (norepinephrine, dopamine, dobutamine, and/or vasopressin alone or in combination) [104, 105]. Norepinephrine is the drug of choice due to its α-adrenergic effects on vasoconstriction and its ability to improve microvascular circulation. [93, 104, 105] It is dosed at 0.1–1 mcg/kg/min followed by dobutamine at 5–15 mcg/kg/min if myocardial depression is suspected [91, 93, 104, 105]. Sepsis causes reduced circulating volume, vasoplegia, and altered myocardial function that negatively impact cardiac output and perfusion, but pressor agents improve vascular tone and myocardial contractility [91, 93, 104, 105].

Following fluid resuscitation and pressor therapy, the source of infection is identified, and source control is initiated. Source control includes surgical exploration and excision of diseased tissue, copious lavage, resection and anastomosis or other surgical repair, and/or repair of ruptured or dehisced incisions. Current guidelines recommend the early administration of antimicrobial agents (ideally within the first hour of diagnosis) to patients with suspected sepsis or septic shock [93, 95]. The antimicrobial choice is based on the suspected organism causing the infection, drug spectrum of action,

Table 17.7 Clinical signs of fluid intolerance [35–38].

Signs of fluid intolerance
Increased respiratory rate and effort
Restlessness
Edema of limbs, face, or ventrum
Chemosis (conjunctival edema)
Pulmonary crackles
Clear nasal discharge
Cough
Increased body weight >10% over baseline
B-lines on thoracic POCUS

and target tissue; broad-spectrum antimicrobial use is considered appropriate until culture and susceptibility results are available at which time antimicrobial choice, dose, and duration of therapy are revised [93, 95, 106].

Septic patients are among the most critically ill a veterinary technician will encounter in clinical practice [94]. Monitoring is comprehensive and time-consuming, encompassing serial physical examinations, serial vital sign assessment, continuous DAP or serial NIBP measurement to calibrate pressor therapy and gauge response to treatment, repeated assessment of CBC, chemistry, and blood gas assays, and monitoring fluid dynamics, incisions, bandages, and medical devices such as chest tubes, drains, or urinary catheters [94]. Positive fluid balance has been directly linked with increased mortality in human sepsis patients; given the occurrence of occult cardiac disease in cats, their smaller size, and the potential for lung injury secondary to fluid overload, feline sepsis patients should be monitored closely for evidence of fluid intolerance [91]. Table 17.7 lists the clinical signs of fluid intolerance. In addition, serial AFAST/TFAST is advantageous for monitoring cavitary effusion and assessing the patient for thoracic B-lines that may indicate fluid overload [91]. Most of these patients require nutritional support via an enteric feeding tube (See Chapter 12: "General Feline Nutrition" for further information).

17.8.6 Trauma

In cats, ER trauma presentations commonly include vehicular trauma, dog attack, wild animal attack, fall from height, head trauma/traumatic brain injury (TBI), spinal trauma, fan belt injury, strangulating/ligature injury, burns (thermal or chemical), and impalement/penetrating FB injuries [107–109]. Physiologic differences exist between canine and feline patients that inform some of their trauma epidemiology [110–112].

The Veterinary Committee on Trauma (VetCOT) has made progress in establishing comprehensive databases on veterinary trauma and accrediting veterinary trauma centers [107]. A 2023 VetCOT retrospective analysis of 3895 feline trauma cases from the registry during a 30-month period between 2017 and 2019 found that more cats were presented for blunt trauma than penetrating [107]. A second VetCOT registry study from 2023 evaluated the utility of the animal trauma triage score, modified Glasgow coma scale (MGCS), patient age, and patient weight against outcome in 1065 cats with bite wounds, finding that older cats were less likely to survive [113].

For a more in-depth review of the physiology and care of wounds, see Chapter 13: "Wound Care and Bandaging." Due to their size, feline patients rarely present with only one type of trauma, and long-term hospitalization with staged surgery may be required [114–116]. Initial goals include the evaluation of cardiac, pulmonary, and neurologic function and rapid intervention for respiratory compromise, shock, and pain (see the section "Triage" of the feline patient in this chapter [114–116]. When performing imaging on feline trauma patients, care must be taken not to stress the patient or allow it to struggle [114, 116]. The role of pain in trauma should not be overlooked, and appropriate analgesia should be provided via a multi-modal approach [1, 114–117]. For in-depth analgesic recommendations that are beyond the scope of this chapter, the reader is directed to Chapter 7: "Analgesic Considerations for the Feline Patient" and Chapter 8: "Introduction to Feline Pharmacology."

The role of corticosteroids in trauma is debated. There are significant and potentially negative effects of shock that are mediated by steroids, including hyperglycemia, sodium retention, GI damage, and increased BUN [115, 118, 119]. If a

patient has documented CIRCI, physiologic doses of steroids may be beneficial; however, the understanding of veterinary CIRCI is evolving and the diagnosis should be made with caution [102, 117, 119]. Currently, glucocorticoids are not recommended in patients with trauma, hypovolemic shock, or hemorrhagic shock [102, 115, 117, 119]. If hypotension is persistent, colloid solutions or vasopressor agents should be administered instead of steroids as discussed in sections on shock and sepsis in this chapter. It is also important to note that steroids provide no analgesia and are not recommended for patients with traumatic brain injury [115, 117, 119]. Many of these patients require nutritional support, see Chapter 12: "General Feline Nutrition," for more information.

17.8.7 Traumatic Brain Injury

Head injury is a common presentation in traumatized cats and may be accompanied by facial or jaw fractures and ocular or periorbital injury [118–123]. The soft tissue structures of the brain, its vasculature, and cerebrospinal fluid (CSF) are contained within the skull. The brain consumes enormous amounts of glucose and is also reliant on oxygen, water, and other metabolites for function and repair [121]. Within the skull, pressures are maintained in tight ranges to protect brain function. The vasculature of the brain can maintain constant intracranial pressure (ICP) and cerebral blood flow independent of systemic blood pressure through the influence of arterial carbon dioxide on blood vessel diameter [118–123]. Elevations in ICP due to hemorrhage, edema, or displacement of brain tissue that cannot be compensated for through adjustments in the volume of CSF or blood result in damage to the parenchyma of the brain [118–121].

TBI is divided into primary and secondary injury. Primary injury is comprised of the injuries sustained at the time of head trauma; of these, concussion is the mildest followed by contusion/bruising and laceration, the most severe [118–121]. The secondary injury occurs minutes to days after the initial trauma and can be mitigated, unlike primary injury. Secondary injury results due to the release of excitatory neurotransmitters, edema development, oxygen depletion, cell damage from electrolytes like calcium and sodium, lactic acid and nitric acid buildup, and accumulation of reactive oxygen species [118–121]. Systemic abnormalities like acid–base imbalance, hypotension, hyperthermia, hypercarbia, and glucose irregularities further potentiate TBI. Systolic Doppler blood pressure should be targeted at ≥ 90 mm Hg in the initial management of these patients [120], and a comprehensive neurologic exam should be conducted prior to the administration of analgesia and after assessment for cardiovascular stability and respiratory compromise to provide the best lesion localization and inform prognosis [118–121].

The Glasgow Coma Scale was developed in the 1970s at the University of Glasgow in Scotland as a tool to evaluate levels of consciousness in human beings and the first peer-reviewed publication of the instrument appeared in 1974. In the intervening years, veterinary neurologists have developed a MGCS to classify the severity of brain injury in domestic dogs and cats, first appearing in ~1983 (Table 17.8). No laboratory testing is required to use the MGCS. The MGCS can be used throughout a cat's hospitalization (as frequently as every 15–30 minutes) to assess response to treatment with the caveat that most research on the MGCS has been conducted in dogs [113, 118–121].

Supplemental oxygen should be administered to all cats with TBI. Treatment for increased ICP includes the use of hyperosmolar agents such as mannitol and hypertonic saline along with judicious fluid therapy (15 ml/kg) to reverse hypotension, address hypovolemia, and avoid hypertension while maintaining cerebral blood flow [119–121]. Mannitol, an osmotic diuretic, enhances cerebral blood flow and is dosed at 0.25–1.0 g/kg IV over 20 minutes as needed or Q8H [119–121]. It should not be used in hypovolemic patients. Hypertonic saline 7.5% has osmotic effects and can be used in hypovolemic patients at a dose of 3–5 ml/kg IV over 15 minutes (duration of efficacy approximately 75 minutes) [119–121, 123]. In addition to its osmotic effects, it provides volume expansion capability and some positive inotropic effects. Procedures that may transiently increase ICP such as jugular venipuncture or nasal feeding tube placement should be avoided in head trauma patients [119–121, 123]. If the patient is having seizures, first-line therapy is an anticonvulsant (midazolam at 0.2–0.5 mg/kg IV or levetiracetam IV at 20 mg/kg) [120–122]. If seizure activity is not controlled with intermittent dosing or a CRI of benzodiazepines, it may be necessary to intubate the patient and start a CRI of propofol. Advanced imaging (CT or MRI) is optimal; should general anesthesia be necessary; inhalants are contraindicated and TIVA should be used [120–122].

Patients with TBI should be kept calm and comfortable with a priority placed on anxiolysis and analgesia since both anxiety and pain can increase systemic blood pressure and ICP [120–123]. Opioids are optimal since they can be titrated to effect, potentially administered as a CRI, and partially or completely reversed if needed [1, 119, 121]. The use of ketamine and alpha-2 adrenergic agonists is controversial [119–121]. Nursing care of the TBI cat is centered around maintaining

Table 17.8 Modified Glasgow Coma Score [124].

Assessment	Score
Motor Activity	
Normal gait and spinal reflexes	6
Hemiparesis, tetraparesis, +/− decerebrate activity	5
Recumbent, intermittent extensor rigidity	4
Recumbent, constant extensor rigidity	3
Recumbent, constant extensor rigidity with opisthotonus	2
Recumbent, muscle hypotonia, depressed or absent spinal reflexes	1
Brain stem	
Normal PLR and oculocephalic reflexes	6
Slow PLR and normal-to-reduced oculocephalic reflexes	5
Unresponsive miosis OU with normal-to-reduced oculocephalic reflexes	4
Pinpoint pupils with reduced-to-absent oculocephalic reflexes	3
Unilateral unresponsive mydriasis and reduced-to-absent oculocephalic reflexes	2
Unresponsive mydriasis OU and reduced-to-absent oculocephalic reflexes	1
Level of consciousness (LOC)	
Intermittently/occasionally alert and responsive to the environment	6
Depressed or delirious; responsive but may be inappropriate	5
Semi-comatose, responsive to visual stimuli	4
Semi-comatose, responsive to auditory stimuli	3
Semi-comatose, only responsive to noxious stimuli	2
Comatose and unresponsive to repeated noxious stimuli	1
Aggregate scores 3–8: grave prognosis	
Aggregate scores 9–14: guarded prognosis	
Aggregate scores 15–18: good prognosis	

normal ICP, providing recumbent care, ensuring pain is controlled, monitoring neurologic function, seizure watch and intervention, and providing early supplemental nutrition [119–123]. Elevation of the head and trunk by approximately 30° is associated with decreased ICP if the jugular veins are not occluded [119–123]. Some clinicians prefer permissive/mild hypothermia and tight glycemic control in these patients. If the cat is comatose and/or intubated to protect the airway, nursing care becomes intensive.

17.8.8 RECOVER Cardiopulmonary Resuscitation

All technicians working in the emergency environment should be competent in CPR techniques. Prior to the advent of the RECOVER guidelines in 2012, veterinary professionals used a variety of cardiopulmonary resuscitation techniques based on the American Heart Association human CPR guidelines [125–130].

Basic RECOVER life support (BLS) has four components: recognition of impending or active arrest, quality chest compressions, prompt airway management, and precise manual ventilation using a C, A, and B prioritization model (circulation, airway, and breathing) [126, 130]. Signs of impending arrest include changes in pupillary size, progressive bradycardia, increased respiratory fatigue, involuntary urination or defecation, and an erratic respiratory pattern with or without agonal breathing. The target rate of chest compressions is 100–120 bpm regardless of the patient's size or species. In cats, the cardiac pump technique is recommended with full recoil of the chest allowed in between compressions to allow the heart

chambers to refill. When using the cardiac pump technique, external compressions are applied directly over the level of the patient's heart with a one- or two-handed technique [126, 130–132]. Compressions are initiated ASAP, even if the patient's heart has not stopped completely, and continued during intubation, drug delivery, and vascular access attempts. Once the patient is intubated, carefully controlled breaths are given at 10/minute, taking care not to over-inflate the lungs or hyperventilate the patient [126, 130–132]. Chest compressions are continued for a minimum of 2 minutes before switching compressors to ensure compression quality is maintained. Monitoring recommendations during RECOVER CPR include ECG, $ETCO_2$ (end-tidal carbon dioxide), and blood gas or blood lactate [128].

Advanced life support (ALS) includes BLS plus the addition of drug therapy, correction of acid-base imbalances, and defibrillation of shockable rhythms (pulseless electrical activity or PEA and ventricular fibrillation) [127, 130–132]. Recommended drugs for CPR include epinephrine, atropine, vasopressin, and sodium bicarbonate [127, 130–132]. If an analgesic or anesthetic drug is suspected to play a role in the arrest, it is reversed ASAP with the appropriate reversal agent. Anti-arrhythmic drugs such as lidocaine or esmolol are recommended if indicated. If the patient does not already have an IV catheter, one can be placed in a peripheral vessel or jugular vein via conventional means or venous cutdown; alternatively, an IO catheter can be placed in adult animals using a specialized power driver or a hypodermic or spinal needle in pediatric or neonatal patients [127, 130–132]. Any drug administered IV during CPR should be followed with a larger-than-normal volume of flush since the patient's circulation is reliant on external chest compressions. If vascular access is not established, some drugs can be administered via the endotracheal tube using the NAVEL acronym (naloxone, atropine, vasopressin, epinephrine, lidocaine); however, there is no consensus for the dilution of these drugs when administered intratracheally [130–132]. The return of spontaneous circulation (ROSC) is correlated with $ETCO_2$ measurements >20 mm Hg in cats [127, 130].

If ROSC is achieved and the patient begins breathing on their own, post-CPR care is comprehensive and intensive with an emphasis on managing acid–base disturbance, monitoring for re-arrest, addressing underlying disease, and monitoring for organ damage such as AKI [129]. High-quality BLS and ALS can improve CPR outcomes to ~50% in patients who were anesthetized at the time of their arrest [125–127, 129–132]. Although 35–45% of patients achieve ROSC, survival to discharge following CPA and CPR averages 2–10% in veterinary patients [130, 131, 132]. Most animals who undergo CPR will re-arrest. In the summer of 2024, revised and updated RECOVER CPR guidelines were published, and refer to the RECOVER initiative website at https://recoverinitiative.org/ for information about CPR technique, training, and instructor certification [133].

17.9 Diagnostic Techniques

In the veterinary ER and ICU, a wide variety of diagnostic techniques are used. Readers are directed to the respective chapters of this text for further information. In general, when performing diagnostic sampling on feline patients, care should be taken to be respectful of the patient while being as vessel-sparing as possible. Central venous catheters or other long-term sampling catheters are recommended for critically ill patients as they permit on-demand sampling with minimal stress or handling needed; as an alternative in the diabetic patient, cutaneous glucose monitoring devices are a reasonable choice for similar reasons. Care should be taken not to over-sample from feline patients lest iatrogenic anemia result. As noted above, when performing diagnostic imaging, cats should be handled gently and with the minimum of contact necessary for good image quality, particularly cats in respiratory distress. Hands-free imaging techniques using sedation or anesthesia are less stressful for patients, protect personnel from ionizing radiation, save time, improve efficiency, and improve image quality. Technicians in the ER and ICU should not hesitate to collaborate with clinicians in the sedation of patients that may be distressed by handling or the clinic environment.

The veterinary ER and ICU are complex, high-stakes environments where veterinary technicians are called upon to use all of their skill, knowledge, and creativity to impact outcomes. The feline patient in this environment presents unique opportunities and challenges due to its ethology, anatomy, physiology, and environmental needs. In this setting, veterinary technicians should remember to center the patient's needs in everything they do, "think slow to go fast," and that "prior planning prevents poor performance."

See the companion website for further clinical references.

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18

Endocrinology

Paula Plummer, LVT, VTS (ECC, SAIM, CP-fe)

TECHNICIAN TIDBITS

- Polyuria/polydipsia (PU/PD) assessment in the feline patient can require investigative work due to lifestyle, access to water sources, and shared water bowls.
- The renal tubular threshold for glucose is 14–16 mmol/L, 250–290 mg/dl.
- When glucose exceeds the renal threshold, osmotic diuresis occurs, causing PU/PD.
- Advanced catheter placement will reduce pain from repeated venipuncture in patients requiring serial sample collection in endocrine patients.
- Stress is a common result of hyperglycemia, so it is important to differentiate stress factors and the presence of persistent hyperglycemia in the feline patient.

The endocrine system is a complex body system that constantly adjusts and combines activities of other body systems by regulating hormones. The central nervous system, thyroid gland, parathyroid gland, adrenal glands, gastrointestinal tract, endocrine pancreas, kidneys, gonads, and the placenta are all considered part of the endocrine system.

Hormones are chemical messengers that are transported through circulation after being produced by glands. When they reach their specified location, hormones play a role in metabolism. See Figure 18.1 for a summary of the endocrine system and Table 18.1 for a summary of hormone functions discussed in this chapter.

18.1 Patient History and "History Gathering Questions"

Taking a patient history is one of the first skills taught to veterinary technicians, as it is something that is done every day. This skill is exactly that, a skill, with expertise being fine-tuned and developed throughout most of the veterinary technician's career. Learning which questions to ask and how to ask them will provide the information needed to assist the entire team in their journey with the patient – from arriving to a diagnosis to providing nursing care that will benefit the individual. The history of an endocrine patient can be complex, with the patient offering only subtle clinical signs (CS) for the veterinary team and the owner to go off of. Below are examples of history-gathering questions that can provide the veterinary technician clues to what the patient is experiencing at home.

- Can you tell me about your pet's urination habits?
- How often do you clean the litter box?
- Please describe your pet's appetite.
- Is your pet always hungry, even after meals?
- How often do you hear your pet vocalize?
- Please describe your pet's activity level.
- How often do you see your cat drinking water?
- Can you describe any new behaviors your pet may have?
- Can you describe the interaction habits with your pet?
- Does your pet have any other concurrent medical conditions?
- Please list any medications and special diets your pet has been on in the last 6 months.

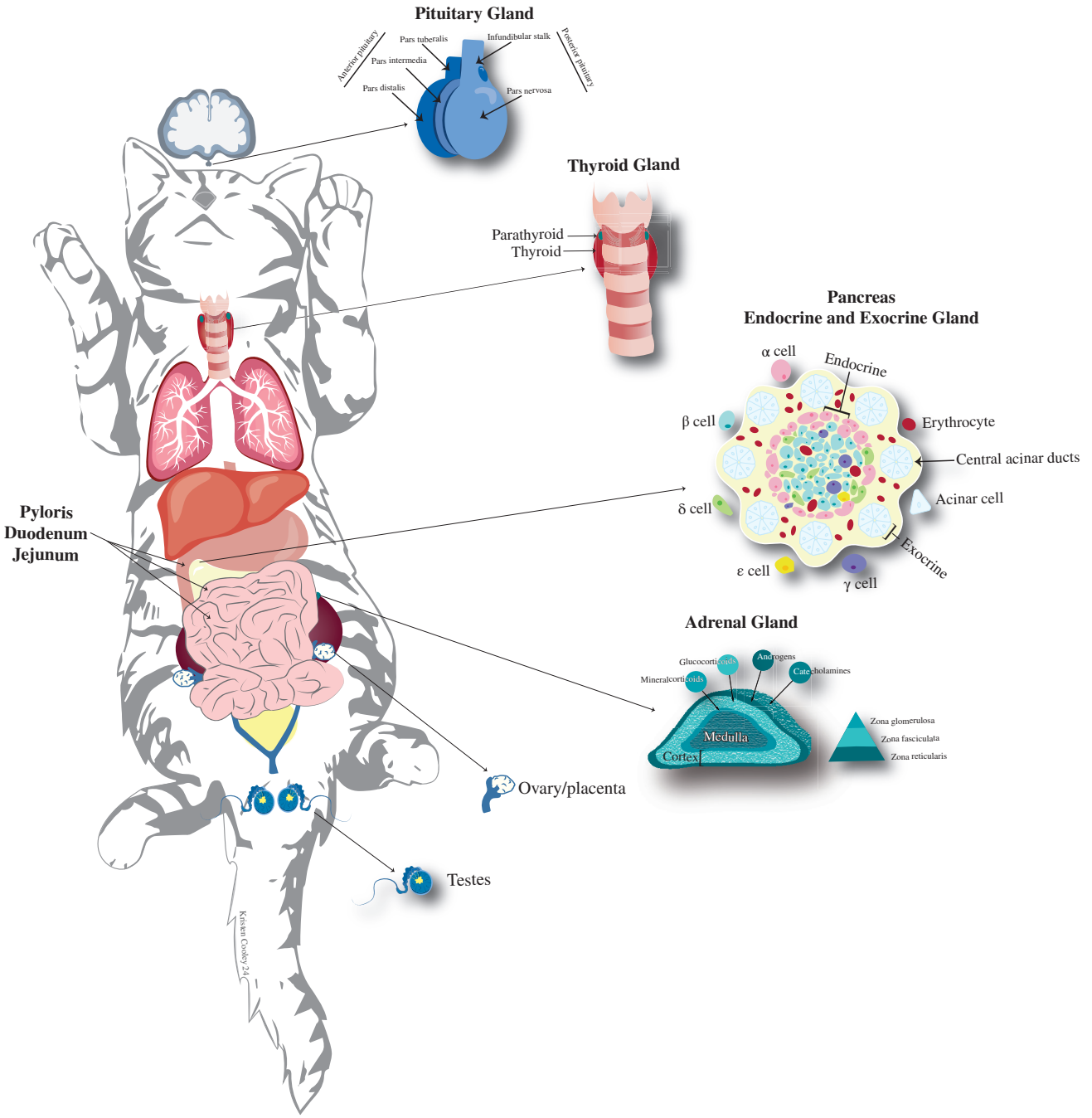


Figure 18.1 Figure of the anatomical feature of the hormone system. *Source:* Kristen Cooley.

18.2 Clinical Signs

CS for the endocrine patient can vary in severity depending on disease progression, therefore complicating distinct symptoms to identify each endocrine disorder. Several endocrinopathies exhibit PU/PD, weight loss, an unkempt haircoat, polyphagia, or lethargy. However, specific CS can distinctly identify certain endocrinopathies in addition to the CS previously described. For example, pituitary dwarfism will exhibit proportional dwarfism, dermatologic signs such as a kitten haircoat, alopecia around the neck, caudal aspect of the hind limbs and trunk, hyperpigmentation, and thinness of skin. Acromegaly will specifically exhibit an enlarged head, paws, or body, and prognathia inferior. Classic hyperthyroid CS include weight

Table 18.1 Hormone functions summary [1].

Hormone	Location of secretions	Function
Somatotropin (growth hormone)	Anterior pituitary gland, mammary gland	Promotes the growth of the entire body by affecting protein formation, cell multiplication, and cell differentiation.
Adrenocorticotropic hormone (ACTH)	Anterior pituitary gland	Regulates cortisol and androgen production.
Thyroid stimulating hormone (thyrotropin)	Anterior pituitary gland	Controls secretion of thyroxine and triiodothyronine from the thyroid gland.
Antidiuretic hormone (vasopressin)	Posterior pituitary gland	Controls water excretion from the kidneys into the urine to control water concentration within the body. Secretion is regulated by the extracellular fluid osmolality, blood pressure, and blood volume.
Insulin-like growth factor (IGF-1)	Posterior pituitary gland	IGF-1 and the growth hormone work together and separately to stimulate growth and regulate metabolic processes.
Thyroxin (T4)	Thyroid gland	Regulation of metabolic rate, fetal growth, core body temperature, alteration of heart rate, muscle contraction, and how food moves through the digestive tract.
Triiodothyronine (T3)	Thyroid gland	Regulation of metabolic rate, fetal growth, core body temperature, alteration of heart rate, muscle contraction, and how food moves through the digestive tract.
Calcitonin	Thyroid gland	Control the formation and regulation of calcium and phosphate metabolism in conjunction with Vitamin D and the parathyroid hormone.
Parathyroid hormone	Parathyroid gland	Regulation of calcium, phosphorus, and magnesium in bone and circulation.
Insulin	Beta cells of the islets of Langerhans (pancreas)	Lowering glucose levels in the body. Absorption of blood glucose, amino acids, and fatty acids in the blood into cells and used for energy.
Glucagon	Alpha cells of the islets of Langerhans (pancreas)	Aids in metabolism and the use of glucose in the pancreas to raise blood glucose levels.
Catecholamines (dopamine, norepinephrine, epinephrine)	Adrenal medulla	Increase heart rate, blood pressure, respiratory rate, and mental alertness. Produce peripheral vasoconstriction to redirect blood to vital organs.
Mineralocorticoids (aldosterone)	Zona glomerulosa of the adrenal cortex	A corticosteroid that regulates electrolyte secretion of the kidney, specifically the reabsorption of sodium and excretion of potassium.
Glucocorticoids	Zona fasculata in adrenal cortex	A corticosteroid that plays a vital role in glucose, fat, and protein metabolism affecting most body systems. Essential glucocorticoid is cortisol.

loss despite a ravenous appetite, hyperactivity, increased vocalization, and hair coat changes with some not exhibiting any of the aforementioned CS. Hypercortisolism CS includes truncal alopecia, skin thinning, and a "pot belly" appearance. See each section of the chapter for CS specific to each endocrinopathy.

18.3 Physical Examination Findings

Physical examination (PE) findings for endocrinopathies include alopecia, hyperpigmented skin, weight loss, dehydration, heart murmur, gallop rhythm, neuropathies, lameness, plantigrade stance, large head, paws, or body, prognathia inferior, unkempt haircoat, a pot belly' appearance, or findings due to unregulated diabetes mellitus (DM), depending on which endocrinopathy is present. See each section of the chapter for PE findings specific to each endocrinopathy.

18.4 Specific Nursing Care Considerations

Basic nursing care techniques include monitoring patient vitals, reducing the risk of decubital ulcers by rotating recumbency every 4 hours if patients are unable to move themselves, maintaining catheters, and keeping the patient clean and dry. For patients with a urinary catheter, the collection system will require frequent emptying and measurement, and as the catheter will need to be cleaned regularly. Patients on intravenous (IV) fluids will require fluid maintenance and cleanliness, as well as monitoring fluid intake and output for unstable patients. Patients that require multiple daily samples, such as those undergoing glucose curves or general glucose monitoring, may benefit from the placement of a sampling catheter to reduce the incidence of venipuncture for obtaining samples. The veterinary technician must be the patient advocate, therefore requesting advanced catheter placement for those patients to reduce pain from repeated sample collection, as well as maintaining a low-stress environment for the recovering patient.

18.5 Endocrine Disorders

18.5.1 Disorders of the Pituitary Gland

18.5.1.1 Hyposomatotropism or Pituitary Dwarfism

In the feline patient, pituitary dwarfism, aka also known as congenital hyposomatotropism is a rare condition resulting from hyposecretion of the growth hormone (GH) and the insulin growth factors (IGF-1) from the hypothalamus/pituitary axis or pituitary organogenesis. The pathophysiology of this disease has been studied in the canine patient; however, in the feline patient, the lack of studies is due to the rarity of the disease. As in human medicine, the canine and feline patients can have a decreased growth rate due to endocrine and nonendocrine etiologies. A nonendocrine etiology can include a small stature, which is not considered pathological but just a variation of normal, as well as congenital, malnutrition, chronic diseases, or dysfunction of an organ(s). Endocrine etiologies include GH deficiency, GH insensitivity, hypothyroidism, (endogenous or exogenous) excess, or unregulated DM [1].

A common age for clinical presentation is 3–5 months old. Clinical presentation could include the complaint of failure to thrive due to the size of the individual or in comparison to littermates. There is no gender predilection for this condition. However, in the canine patient, unilateral or bilateral cryptorchid and persistent estrus are commonly noted in the pituitary dwarf patient. A heart murmur due to patent ductus arteriosus (PDA) can be seen. As a young patient, their attitude is alert and even normal.

It is common for a complete blood count (CBC), biochemistry panel, and urinalysis to reveal other medical conditions such as renal disease, hypothyroidism, or gastrointestinal parasites and not reveal related information directly due to pituitary dwarfism. Once an endocrine etiology is supported for the small stature of the feline patient, an endocrine assessment should begin, proving to be challenging to come to a definitive diagnosis. IGF-1 concentrations will be decreased; however, these results alone will not provide a definitive diagnosis. Feline growth assays are available from commercial laboratories. However, it is important to note that the natural pathophysiology of the GH levels will wax and wane in circulation; therefore, a single result will not determine a diagnosis. In the canine counterpart, a positive result from a GH stimulation test can lead to a definitive diagnosis; however, there is a lack of information about this diagnostic test in the feline patient. Assessment for hypothyroidism should also occur during the assessment to determine if pituitary dwarfism is the correct diagnosis [1].

Treatment of pituitary dwarfism in the canine patient involves the administration of synthetic progestogens. In the reported feline cases, therapy was not initiated for hyposomatotropism [2, 3].

18.5.1.2 Diabetes Insipidus

Diabetes insipidus is either nephrogenic or hypothalamic in origin. Central diabetes insipidus (CDI) is a condition that causes primary PU due to a lack of appropriate amounts of vasopressin secreted by the hypothalamus or pituitary gland. In CDI, the nuclei of the hypothalamus and/or the loss of axons that carry vasopressin to the posterior to the anterior gland are destroyed. CDI can be caused by any condition that damages this system. The feline patient may experience CDI due to traumatic brain injury or idiopathic causes; however, conditions, such as neoplastic and infectious (toxoplasmosis) have been noted less frequently [4].

Nephrogenic diabetes insipidus (NDI) results from the nephron inadequately responding to vasopressin. NDI is classified as either a primary or secondary condition. Primary NDI is a rare disorder with an unknown etiology and has yet to be reported in feline patients [4, 5]. Secondary NDI is acquired due to disease processes such as hyperthyroidism, hepatic insufficiency, hyperadrenocorticism, or severe electrolyte derangements, resulting in an inappropriate response to vasopressin, causing CS. The owner will note CS of PU/PD.

The diagnosis of diabetes insipidus (DI) can be challenging, with the first step being the determination of the degree of PU/PD. Assessment of PD is the first step. However, the patient's lifestyle, access to other water sources, and shared water bowls as a sources of intake should be eliminated. In cases where the owner is unable to accurately assess PU, urine-specific gravity can be used. See Chapter 11: "Interpretation of Common Diagnostic Test Results," for urine-specific gravity assessment. CBC, biochemistry panel with electrolytes, and urinalysis are also necessary. An endocrine assessment as well as advanced imaging, may be required to rule out other causes of PU/PD.

In the canine patient, a desmopressin trial, also known as a water deprivation test, is commonly performed to diagnose CDI. However, this diagnostic proves to be exceptionally challenging due to the complexity of urinary catheterization in the female feline patient. Assessment of the results would not mimic the canine patient, as cats have the capability to concentrate urine more efficiently than their counterpart. The modified version of the desmopressin trial involves administering desmopressin over a 5–7-day period and quantifying water intake, urine output, and urine specific gravity for improvement. All other endocrine considerations should be ruled out before performing this diagnostic, as a degree of response to the modified desmopressin trial would be noted in other endocrine disorders [4].

18.5.1.3 Hypersomatotropism (Acromegaly)

Hypersomatotropism is more commonly referred to as acromegaly. For many years, it has been thought to be a rare endocrinopathy; however, recent studies have revealed that it is not as rare as originally thought. One study showed that as many as one in three cats with an increased IGF-1 high enough to be suggestive of acromegaly [6].

During acromegaly, there are chronically increased levels of GH in circulation, causing growth that increases the size of bone, liver, or soft tissue leading to the known characteristics of an acromegalic cat. Metabolically, GH and IGF-1 affect insulin metabolism, carbohydrate metabolism, hepatic glucose production, and decrease glucose uptake in extrahepatic tissue, potentially causing insulin resistance. The most common cause of acromegaly in feline patients is the presence of a functional adenoma with the occasional occurrence of somatotrophic hyperplasia [7] (see Figure 18.2).

The common signalment for acromegaly is a male/neutered, domestic shorthair or domestic longhair cat. The average age is 10–11 years; however, cats between the ages of 4 and 17 years have been diagnosed.

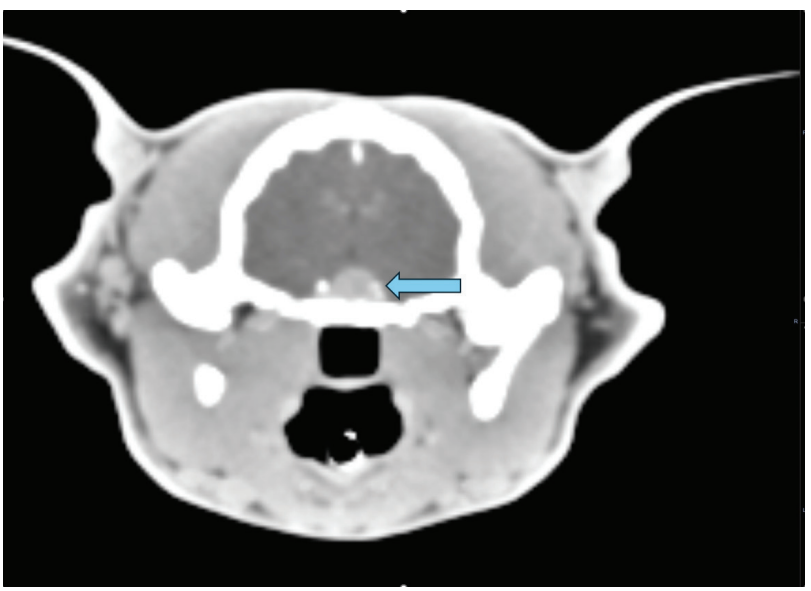


Figure 18.2 A CT image of a patient with a functional adenoma (blue arrow) as the cause of Acromegaly. *Source:* Linda Knight, LVT.

CS include PU/PD, polyphagia, and concurrent insulin-resistant DM. On abdominal palpation, renomegaly and/or hepatomegaly will be found. Other CS and PE findings include plantigrade stance, indicating diabetic neuropathy; large head, paws, or body; prognathia inferior; heart murmur or gallop sound on cardiac auscultation; neurological signs, lameness; or respiratory stridor on thoracic auscultation.

Routine lab work, such as CBC, biochemistry panel with electrolytes, and urinalysis, will not show specific changes to acromegaly. However, the patient is commonly diabetic; therefore, hyperglycemia and glucosuria will be present in lab work. Diagnostic imaging, such as thoracic and abdominal radiographs and ultrasound, is supportive of acromegaly but does not provide a diagnosis. Endocrine assessment with increased GH and IGF-1 is diagnostic of the disorder, in conjunction with all other supportive diagnostics, PE findings, and CS [8]. Magnetic resonance imaging (MRI) and contrast-enhanced CT can identify a pituitary adenoma.

Treatment therapies include hypophysectomy (surgical excision of the pituitary mass) or stereotactic radiation therapy (SRT) to control concurrent medical conditions. Samples collected during excision should be submitted for histopathology. Historically, GH concentrations immediately decline, and postoperative patients recover swiftly, reversing insulin resistance and the systemic effects on the body [9]. One study showed hypophysectomy to be definitive cure for cats with acromegaly, due to the low death rate and high potential for DM remission [10].

SRT has been shown to be an effective and safe therapy for feline acromegaly in recent years. Studies show a marked reduction in insulin requirements or diabetic remission due to SRT. Complications noted include hypothyroidism and progressive neuropathy [11]. The prognosis for the untreated acromegaly feline patient is poor to guarded. If treated via surgical excision or SRT, those patients have a good outcome, and the survival rate can extend for years.

18.5.2 Diseases of the Thyroid Gland

18.5.2.1 Hyperthyroidism

Feline hyperthyroidism is a common endocrinopathy in feline patients over the age of 10 years, affecting approximately 10% of the population [12, 13]. This disease causes increased production and secretion of the thyroid hormones, thyroxine (T4) and triiodothyronine (T3). Due to the thyroid hormones affecting many different functions in various body systems, it is considered a multi-systemic disease. An enlarged thyroid gland (unilateral or bilateral) palpation on PE, due to an adenoma or adenomatous hyperplasia, is a classic indicator of the disease. Less frequently, an enlarged lobe due to thyroid carcinoma is diagnosed. There is no gender predilection for this common disease. It has been reported that Siamese and Himalayans are at decreased risk for developing hyperthyroidism [12].

Common CS are as follows: weight loss despite a ravenous appetite, hyperactivity, increased vocalization, changes in hair coat quality, PU/PD, vomiting, diarrhea, behavior changes, or tachycardia. The severity of CS noted varies with each patient. The CS of an advanced disease state can include anorexia, emaciation, and severe dehydration.

Palpation of the thyroid gland is paramount, along with an accompanying client history, to initiate clinical suspicion of the disease. Other PE findings can include poor body condition, a dull hair coat, dehydration, tachycardia, and hyperactivity. Due to the presence of hypertension in hyperthyroid patient, a complete fundic examination should be performed to assess the status of retinal detachment.

Once an elevated total T4 is noted on lab work, a diagnosis of hyperthyroidism can be made. Submission to a commercial laboratory for serological diagnostic for evaluation of total T4 is recommended. Further diagnostics should be pursued on patients in an inconclusive total T4.

A radioactive thyroid scan is a diagnostic tool indicated in patients with an enlarged thyroid to aid in the diagnosis of metastatic neoplasia. After the technetium IV injection, a ventral, left and right lateral images of the thyroid and thoracic regions are acquired. Trained personnel or a radiologist can determine a positive thyroid scan [14].

Common abnormalities on a biochemistry panel of a hyperthyroid patient include increased alanine aminotransferase, alkaline phosphatase, aspartate aminotransferase, BUN, creatinine, and hyperphosphatemia levels. The urine specific gravity is commonly above 1.035 on urinalysis in hyperthyroid patients.

Treatment options for feline hyperthyroidism include medical management, surgical intervention via thyroidectomy, or radioactive iodine therapy. The recommendation from the veterinarian overseeing the patient's care is multifactorial. The individual patient's health status, the presence of concurrent medical conditions (renal, cardiac, or neoplasia presence) are medical factors taken into consideration. Owner wishes, patient medication compliance, patient lifestyle, and availability of therapies are nonmedical considerations that the owner and veterinary team should consider when making therapy decisions.

Initially, the patient should be treated with antithyroid medications to regulate quantities of thyroid hormones in the body. For example, in patients requiring surgical intervention, such as thyroidectomy, antithyroid medications will reverse the hormonal effects on the body, making the patient a better anesthetic candidate by reversing cardiac or renal hyperthyroid-induced abnormalities. Renal function abnormalities can be hidden, and when therapies with antithyroid medications are initiated, renal abnormalities may be revealed. This change could alter future therapy recommendations from the veterinarian.

Antithyroid oral medications include methimazole or carbimazole. Methimazole (oral or topical) is the drug of choice for daily oral hyperthyroidism treatment in feline patients. This drug does not stop the excretion of the thyroid hormone; it stops iodine oxidation once the hormone is released. T4 concentrations will normalize within 2–4 weeks after treatment initiation; therefore, monitoring should coincide with this timeline after initial treatment begins and at dose changes. Side effects of methimazole include neutropenia, thrombocytopenia, scabbing lesions on the pinna, hepatotoxicity, anorexia, vomiting, lethargy, renal decompensation, and, rarely, myasthenia gravis. Ideally, monitoring of the CBC and biochemistry panel at the same intervals as the serum T4 monitoring guidelines previously stated should occur.

Iodine-131 (I-131) advantages for feline hyperthyroidism therapy can be enticing for the "hard to medicate" patient due to the elimination of administration of twice-daily medication. Other positive treatment qualities for a patient could be the elimination of anti-thyroid drugs reactions and elimination of the risk of anesthesia during the thyroidectomy. However, specific hospital protocols and safety precautions required for patients undergoing I-131 therapy are indicative of specialized training for the personnel interacting with the patients in the hospital. An isolation ward to house the patient is required, along with staff education on safety precautions of radiation therapy. The trained personnel should only interact with the patient as well as litter boxes, and food and water bowls, while wearing proper PPE, including laboratory coats, disposable exam gloves, and dosimeter monitors. Radiation levels should be monitored daily and recorded in the patient's chart to ensure the level of radiation is decreasing, following local and state regulations on the required millirem per hour recommendation for patient discharge. Home care instructions as well as client education for the postradioactive iodine patient are specific.

Typically, I-131 will restore the patient to a euthyroid state in a single dose. Hormone concentrations will normalize within 2 weeks of therapy. However, approximately 5% of patients who undergo this therapy option will not become euthyroid after one treatment and will require a second dose of I-131 [13, 15].

The surgical treatment of choice for hyperthyroidism is thyroidectomy. An uncomplicated surgical candidate is one with a low anesthetic risk. The advantages of a thyroidectomy are that it is 90% efficacious and/or curative [13] and the disadvantages include the cost of the procedure and hospitalization, with the risk of nonreversible hypoparathyroidism and the anesthetic risk. Postoperative patients should be monitored for 7 days for CS of hypocalcemia, either in the hospital or at home by the owner, at the veterinarian's discretion. Horner's syndrome, laryngeal paralysis, damage to the laryngeal nerve, and permanent hypothyroidism are postoperative complications to be considered with a thyroidectomy.

Iodine-restricted diets are available as a treatment modality for hyperthyroid patients. While on this diet, the patient must be fed exclusively this diet. One study showed that six out of eight cats achieved a normal total T4 value within 4 weeks of starting an iodine-restricted diet, proving to be an acceptable therapy option [16]. Proper client education regarding the disease process, medication administration, or diet transition is key to successful therapies. See Chapter 5: "Client Education and Communication Topics," for the Feline Owner for client education suggestions.

18.5.3 Diseases of the Parathyroid Gland

Diseases of the parathyroid gland include hyperparathyroidism, hypoparathyroidism, hypocalcemia, and are extremely rare in feline patients. The three hormones that play a primary role in the regulation of calcium metabolism are 1, 25-dihydroxycholecalciferol (calcitriol), parathyroid hormone (PTH), and vitamin D. Calcitriol is a steroid hormone formed from vitamin D through hydroxylation in the liver and kidneys. Its main role is to increase calcium absorption from the intestines. PTH is secreted by the parathyroid glands, mobilizing calcium from bone and increasing urinary phosphate excretion. Vitamin D increases calcium and phosphorus concentrations in the gastrointestinal tract and bone resorption resulting in calcium homeostasis. Cats synthesize vitamin D differently from other mammals requiring the vitamin through diet and not through their skin after sunlight exposure. Ionized calcium, which is the free form of calcium in circulation, plays a vital role in blood coagulation, muscle contraction, and nerve function. Low levels of calcium can result in hypercalcemic tetany, which is due to increased connectivity of the motor nerve fibers. This condition can cause extensive spasms in the skeletal muscles, especially the muscles of the extremities and the larynx.

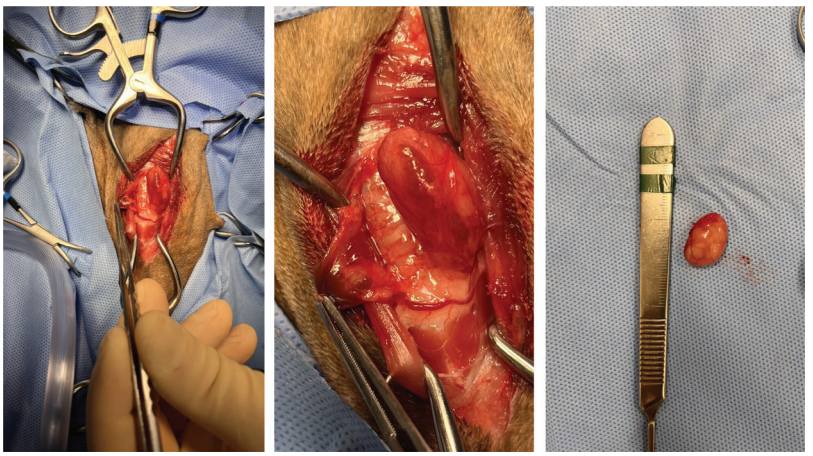


Figure 18.3 A parathyroid adenoma in a feline patient. *Source:* Jacob Helmick, DVM, DACVS SA.

18.5.3.1 Hypoparathyroidism

Hypoparathyroidism is considered extremely rare in feline patients with the reported cases having etiologies of postoperative thyroidectomy and immune-mediated destruction of the parathyroid gland. Hypoparathyroidism is correlated with hypocalcemia in the cases reported resulting in a variety of CS, including lethargy, tetany, muscle tremors, seizures, weakness, disorientation, inappetence, mydriasis, or cataracts. Once treatment is established with injectable or oral supplementation of calcium and vitamin D, depending on the severity of hypocalcemia, and the control of concurrent medical conditions, the prognosis does remain good with life-long supplementation and the lack of complications [17].

18.5.3.2 Hyperparathyroidism

Hyperparathyroidism and correlated hypercalcemia are also considered extremely rare endocrinopathies in feline patients. Once hypercalcemia is identified on a biochemistry panel, other differentials must be ruled out before diagnosing primary or secondary hyperparathyroidism can be made. CS can be nonspecific, including lethargy, anorexia, vomiting, PU/PD, and lower urinary tract signs, more commonly than diarrhea, neurologic signs, weight loss, and constipation [18]. CBC, PTH, parathyroid hormone-related peptide, and Vitamin D results are useful diagnostic tools for these patients. Advanced imaging can aid in diagnosing etiology of hypercalcemia. Primary hyperparathyroidism is diagnosed with a persistently elevated ionized calcium and PTH and is frequently due to parathyroid adenoma with a parathyroidectomy being the treatment of choice (Figure 18.3). Secondary hyperparathyroidism (SHPT) can be due to nutritional deficiencies or chronic kidney disease (CKD). Treatment for SHPT due to dietary and renal etiologies can include feeding an appropriate commercial diet [19].

18.5.4 Diseases of the Adrenal Gland

18.5.4.1 Hyperadrenocorticism (Cushing's Syndrome)

Hyperadrenocorticism (HAC), or Cushing's syndrome, is defined as excessive exposure to glucocorticoids, mainly cortisol. This endocrinopathy is considered rare in feline patients. Naturally occurring HAC is either pituitary- or adrenal-dependent, with approximately 80% of these cases resulting from a pituitary tumor that autonomously releases adrenocorticotropic hormone (ACTH) by a functional adenoma of the pituitary gland. The remaining cases occur due to adrenal adenoma or carcinoma [20].

HAC is typically observed in the middle-aged cat without sex or breed predilection. The CS may be progressive over a prolonged period before the owners become aware. Common CS are PU/PD, polyphagia, abdominal enlargement (pendulous abdomen caused by weakening of the abdominal muscles), truncal alopecia, panting, lethargy, generalized muscle weakness, and thinning of the skin.

Findings of a stress leukogram; neutrophilia, monocytosis, lymphopenia, eosinopenia, with polycythemia and lipemia, can be seen on a CBC. Hyperglycemia, decreased BUN, hypercholesterolemia, and increased alkaline phosphatase can be

seen on a biochemistry panel. A low specific gravity of less than 1.020 and proteinuria can be found on urinalysis. These findings are not specific to hypercortisolism and are commonly a result of comorbidities such as unregulated DM or CKD; therefore, endocrine-specific diagnostics should be pursued.

The urine cortisol-to-creatinine ratio diagnostic test is valuable in ruling out HAC when negative therefore, it should be included in a patient workup. This urine test provides a database on the presence of chronic cortisol secretion. With stress as a factor of cortisol secretion, sample collection should occur at home with nonabsorbable litter, a first-morning catch, and the owner bringing the sample to the hospital immediately for submission. When a positive result occurs with supportive CS and history, it is supportive of over-secretion of cortisol and therefore supportive of HAC, but not diagnostic. Further endocrine testing would be warranted in this circumstance where a negative result and the lack of supportive CS would rule out the endocrinopathy.

A low-dose dexamethasone suppression test (LDDST) may be used to confirm a diagnosis of HAC and has the potential advantage of differentiating HAC due to a pituitary or adrenal origin of the disease. A high-dose dexamethasone suppression test (HDDST) can be performed when LDDST is nonconfirmatory; however, the same advantages and disadvantages are present in both tests. Currently, the ACTH stimulation test is not recommended as a diagnostic for the diagnosis of HAC in feline patients. However, this test can be useful for medical therapy monitoring and in cases when iatrogenic HAC is suspected. It is important to note the sampling handling differences between the ACTH stimulation test and endogenous ACTH stimulation test for reliable results. The endogenous ACTH stimulation test does require an EDTA blood tube versus a red top that is used for the ACTH stimulation test, as well as a lower shipping temperature. See the "Diagnostic Techniques" section of this chapter for sampling instructions for LDDST, HDDST, and ACTH stimulation test, and endogenous ACTH stimulation test protocols.

Once HAC has been diagnosed, advanced radiographic imaging can be performed to assess surgical or radiation options for the patient. An abdominal ultrasound, CT, or MRI can define a tumor of the adrenal gland. Simply finding adrenal enlargement with any imaging modality does not confirm a diagnosis of hypercortisolism. Identification of pituitary enlargement on CT or MRI can make the clinician highly suspicious of pituitary-dependent hypercortisolism. In cases where a clearly defined mass is not identified on imaging, it is important to remember that microscopic abnormalities can cause pathologic disease as well.

Exploring treatment options such as surgery or medical therapies can be complex and is often determined by understanding owner wishes, the accessibility to a skilled surgeon, as well as the individual needs of the patient. Reports of successful surgical excision of pituitary and adrenal-dependent HAC have been reported. However, lifelong hormone supplementation, induction of other endocrine diseases (DM, diabetes insipidus, and hypoadrenocorticism) immediately and long-term postoperatively should be considered preoperatively [20]. Owner compliance and finances for long-term therapy should all be considered in treatment selection for each case. An alternative therapy recently explored is radiation therapy for pituitary-dependent HAC. This modality has been used with limited success. However, patients receiving radiation therapy have had tumor shrinkage and increased survival time [20, 21].

Medical therapies can be explored when the tumor is inoperable, in the presence of metastasis, or when the owner wishes not to include surgery. It is important to understand that this should be considered a palliative option due to these reasons or to gain control of concurrent medical conditions. Currently, trilostane (Vetoryl®, Dechra Ltd.) is the only drug of choice for feline pituitary and adrenal hypercortisolism. Trilostane inhibits the synthesis of glucocorticoids and mineralocorticoids. Surgical cases should receive a trial period of trilostane for disease control to limit potential surgical complications. There are differences in therapy administration including differences in dosing ranges and timing intervals of medication administration.

An ACTH stimulation test should be performed 2–3 hours after administration of trilostane at an interval of 7–10 days after treatment initiation, at 30 days, and then every 90 days thereafter [20, 22]. Timing of monitoring intervals should be altered for case-specific situations such as regulation or complications. Patients with other concurrent medical conditions, such as DM or chronic kidney disease would require close home monitoring for their resolution or decrease in medical therapies during medical treatment of hypercortisolism. See Chapter 5: "Client Education and Communication Topics for the Feline Owner," for topics to discuss with owners.

The prognosis is guarded, with each case differing due to concurrent medical conditions and associated complicating factors, making the selection of appropriate treatment options challenging. Often, due to the myriad of factors surrounding this diagnosis, owners choose humane euthanasia shortly thereafter.

18.5.5 Disorders of the Endocrine Pancreas

18.5.5.1 Diabetes Mellitus

DM is a common endocrinopathy diagnosed in feline patients. DM is separated into types I and II, with cats exhibiting type II most frequently. Type I is typically seen in the canine patients and is caused by a reduction of insulin caused by destruction or lack of secretion in the beta cells of the pancreas. Type II is caused by insulin resistance or dysfunction of beta cells. See Table 18.1 for a summary of the functions of diabetic hormones. When insulin is unable to lower blood glucose levels, it is termed insulin sensitivity or insulin resistance. When the sensitivity of insulin is decreased, the body needs more insulin to have the same effect as a normal body. When the body does not have the ability to function normally, consistent hyperglycemia occurs, causing beta cell toxicity causing further dysfunction of the cells. Regulation of glucose levels resolves glucose toxicity resulting in diabetic remission. Diabetic remission is not clearly defined in the feline patient. However, it is considered when CS resolve, blood glucose is constantly normal, and all therapies associated with DM can be successfully discontinued [23].

Risk factors for DM include genetics, obesity, gender, glucocorticoids, dry food consumption, being a greedy eater, and lifestyle. Multiple studies have shown that obesity is a risk factor due to abnormal hormonal release and inflammatory mechanisms resulting in insulin resistance with progression over time to DM [24, 25]. Male cats are more predisposed, but females can also develop DM. If patients are on medications such as glucocorticoids, it will put them at risk of developing DM due to the drug lowering insulin sensitivity. When patients exhibit other DM risk factors, glucocorticoids should be administered with caution. Burmese, Norwegian Forest Cat, Tonkinese, and Abyssinian are considered risk breeds [25, 26].

Common CS noted by owners are PU/PD, inappropriate urination, and polyphagia with the presence of weight loss. Advanced cases are described as the patient being lethargic, unkempt haircoat and reduction of interaction at home. PE findings can include over-conditioning to varying degrees, reduction of muscle mass in varying degrees, or unkempt haircoat. Advanced cases can have a plantigrade and/or palmigrade posture, lethargy, or depression.

A CBC, biochemistry, and urinalysis are recommended diagnostics for DM in feline patients, ensuring the patient is fasted to acquire the most accurate results. Persistent hyperglycemia and glucosuria in patients with appropriate CS of DM are confirmation of a diagnosis. Once glucose levels exceed the renal tubular threshold (14–16 mmol/L, 250–290 mg/dl), the kidneys are no longer able to filter the excess; therefore, the excess will result in glucosuria leading to osmotic diuresis and PU/PD. Stress is a common result of hyperglycemia, so it is important to differentiate between stress factors and the presence of persistent hyperglycemia in the feline patient. Fructosamine can be used if other diagnostics are inconclusive. Fructosamine is the average blood glucose over the past one to 2 weeks. This number is only an average and does not indicate the severity of daily fluctuations; therefore, it should not be used to adjust insulin doses but can be a useful aid in diagnosis or treatment plans in specific situations. Commonly cats will have concurrent medical conditions at the time of diagnosis; therefore, a complete workup should be appropriately performed to rule out any concurrent conditions.

In recent years, treatment modalities and monitoring systems for veterinary patients have improved. Currently, treatment options include medical therapies, nutritional management, and management of concurrent medical conditions and their therapies. Correction of body weight will reduce insulin resistance, and in type II DM, it will improve insulin secretion potentially reducing insulin requirements and aiding in remission.

Medical management usually involves insulin administration to achieve strict glycemic control, with the goal of remission for newly diagnosed patients or the regulation of CS for those who are unable to achieve remission [27]. Insulin is classified by its duration of action. The categories include short-acting insulin, intermediate-acting insulin, and long-acting insulin. Long-acting insulins are chosen for the control of DM; see Table 18.2 for medium- and long-acting insulin use in

Table 18.2 Medium and long-acting insulin options currently available for the feline mellitus patient [23].

Insulin (Tradename)	Concentration, U/ml	Duration of action	Insulin source
Lente (Vetsulin®)	40	Medium acting	Porcine
PZI (ProZinc®)	40	Long acting	Human
Glargine (Lantus®)	100	Long acting	Human
Detemir (Levemir®)	100	Long acting	Human



Figure 18.4 A feline patient with continuous glucose monitoring in place for home monitoring. *Source:* Samantha Grosse, LVT.

feline patients [23]. When glargine or detemir insulin is chosen in conjunction with dietary management, with a low carbohydrate diet, the remission rate can be as high as 80% in the newly diagnosed patient [27].

Monitoring for patients receiving insulin can occur at home or in the hospital using continuous glucose monitoring (CGM) (Figure 18.4) or spot checks with a glucometer. A CGM offers a stress-free diagnostic method with a technological advantage, between the client and the managing hospital using an electrochemical sensor attached to a monitor that is placed subcutaneously on the patient. Due to the availability of multiple CGM devices, the following manufacturer recommendations for sensor placement, calibration timing, and recording methods should be adhered to for accuracy. Spot checks with a glucometer can achieve the same goal of a glucose curve whether in the hospital or at home. However, each sample will be collected individually at designated times by pricking the pinnae or paw pad to obtain glucose result using a veterinary-approved glucometer with a species-specific calibration setting. Glucose curves should be performed 7–14 days after an insulin dose occurs or in the presence of hypoglycemia CS [28]. Refer to the "Diagnostic Techniques" section of this chapter for AlphaTrak utilization and glucose curve interpretation.

Other medical treatment options for the otherwise healthy, newly diagnosed feline DM patient include the administration of sodium–glucose cotransporter inhibitors (SGLT2) to control glucose levels in circulation. Once glucose is filtered from the kidneys, it will not be reabsorbed back into circulation staying in the urine to be excreted. Therefore, it is important to note that patients receiving therapy with this class of drugs will always have the presence of glucosuria. This newly Food and Drug Administration (FDA) approved for cats provides a class of drug providing glycemic control without the need for insulin injections accompanied by a minimal risk of hypoglycemia. During patient selection for SGLT2, ketonemia must be screened for; if present, insulin should be chosen as the treatment of choice.

Currently, there are two SGLT2 FDA-approved drugs for use in newly diagnosed, otherwise healthy diabetic cats: bexagliflozin and velagliflozin. Bexagliflozin is a once-a-day, oral medication (tablet) that has been shown to reduce hyperglycemia and CS in initial studies. In a recent study, this therapy modality was determined to have 84% success rate as well as improving the client's quality of life [29]. Velagliflozin is a once-daily oral medication (liquid) to be administered with a small amount of canned food. In a baseline controlled-field study, more than 80% of the participants had a decrease in blood glucose (BG) to normal during the study [30].

Patient monitoring while on an SGLT2 will include a PE, BG curves, the presence of blood beta-hydroxybutyrate (BHB) with a bedside ketone meter, and fructosamine periodically. Although multiple bedside ketone meters are available on the market, only Precision Xtra (Figure 18.5) has been proven accurate in cats [31]. Anytime the BHB is above the reference range or if diabetic complications arise, the patient should have SGLT2 therapy discontinued and be transferred to insulin. It is important to note the difference between ketone testing in blood versus urine. Most of the ketones produced during diabetic ketoacidosis (DKA) are BHP, in comparison to the other ketones, acetoacetate, and acetone. Urine ketone measuring methods will only detect acetoacetate, therefore missing the BHP marker for DKA as well as a subjective determination of color change of the medium on the test strips makes a less valuable diagnostic tool. The ketone meter will not only test for the correct biomarker, but it will also quantify the amount of ketones present in circulation and detect complications earlier due to the elimination of half-life in renal physiology [32]. Should patients experience DKA while on an SGLT2, they will not exhibit hyperglycemia. See the "Diabetic Complications" section of this chapter for further explanation of euglycemic diabetic ketoacidosis. Nutritional management with a low-carbohydrate, high-protein diet is the current recommendation for the feline DM patient.

Client education for the DM patient can be extensive, including topics such as using home monitoring devices, nutritional management, diet changes, monitoring for CS, and the importance of recording home monitoring and other changes noted in the patient. See Chapter 5: "Client Education and Communication Topics," for the Feline Owner for details on the DM feline patient.

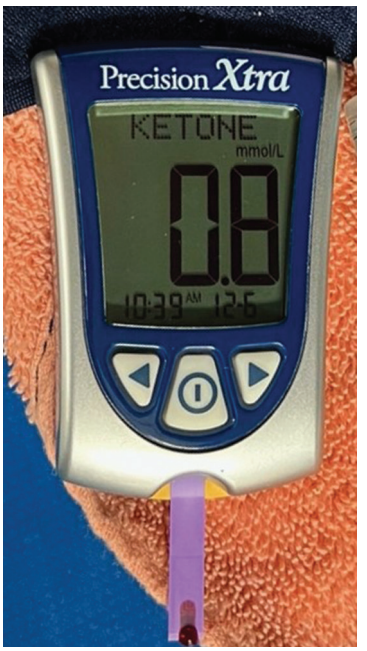


Figure 18.5 Precision Xtra ketone meter used during diabetic mellitus patient monitoring. *Source:* Kymber Hammond, LVT.

18.5.5.1.1 Diabetic Complications

18.5.5.1.1.1 *Insulin Resistance*

Insulin resistance is a condition in which a normal dose of insulin produces a less-than-ideal clinical response, requiring a higher dose of insulin to achieve the desired response to therapy. Without a clearly defined measure of resistance, this complication should be suspected in patients with inconsistent regulation, requiring frequent dose changes. At this point, an investigation of concurrent medical conditions should be initiated. Common causes for insulin resistance in cats are acromegaly, exogenous steroid administration, hyperthyroidism, obesity, concurrent infections, pancreatitis, and hepatic, renal, or cardiac disease. Once concurrent diseases are diagnosed and regulated, the degree of resistance can be reduced. However, some disease processes will make diabetic regulation challenging as the concurrent disease advances. During this time, close monitoring should be initiated, with insulin requirements potentially changing frequently.

18.5.5.1.1.2 *Diabetic Ketoacidosis*

DKA is a result of an improper balance in the concentrations of all the diabetic hormones. An insulin deficiency in the body is counter-regulated by an excess of catabolic hormones, especially glucagon. Due to a series of pathophysiological events, an unregulated diabetic will progress from osmotic diuresis due to glucosuria to an excess of ketone formation and a counteracting buffering system of bicarbonate; however, the continued ketone formation will shift back into the circulation, causing ketonemia. Excessive ketonemia will naturally progress to ketonuria due to overproduction and the kidneys not being able to keep up during filtration.

During osmotic diuresis, the loss of glucose, sodium, potassium (negatively charged electrolytes), and water occurs as a result of negatively charged ketone loss in the urine by excreting sodium and potassium (positively charged electrolytes). When total body water is significantly decreased (hypovolemia), hypovolemic shock is inevitable if untreated, resulting in prerenal azotemia and a decreased glomerular filtration rate. This increases the number of ketones and glucose in the blood, eventually resulting in metabolic acidosis.

Metabolic acidosis (the most common acid/base disturbance of DKA) develops due to several reasons, but commonly results in an elevated anion gap. The increased anion gap in DKA is due to the amount of unmeasured anions in circulation, is increased due to the overproduction of ketoacids and the decrease in bicarbonate concentration. Metabolic acidosis due to DKA is the result of increased production of acidic ketones, lactic acid due to the impaired tissue perfusion from dehydration, shock, and reduced renal excretion of hydrogen ions. When left untreated, further advancement causes mixed acid/base disturbances. Neurological compromise leads to respiratory depression (respiratory acidosis), with vomiting and diarrhea resulting in metabolic alkalosis. See Chapter 10: "Critical Thinking and Kirby's Rule of 20," for blood gas interpretation guidelines.

CS severity will vary and can include PU/PD, lethargy, weakness, hyperventilation, anorexia, vomiting, diarrhea, weight loss, or depression. Many of these patients will have an underlying or secondary disease accompanied by CS, associated with the respective disease processes. Other CS include abdominal pain, neurological abnormalities (ranging from depressed mentation to abnormal gait to coma), weight loss, muscle wasting, or cataracts.

The initial database in the unstable patient includes blood glucose, packed cell volume/total solids (PCV/TS), urinalysis, ketones, venous or arterial blood gas CBC, and a biochemistry panel with electrolytes. The diagnosis of DKA is confirmed by the presence of hyperglycemia, glucosuria, ketonuria, and metabolic acidosis. Other abnormalities noted in the database can include hyponatremia, hypochloremia, hypokalemia, increased anion gap, and azotemia. Other diagnostics will vary depending on the other CS present to support concurrent medical conditions as the root cause of the DKA event.

The initial treatment of DKA patients will include addressing dehydration, acid/base balance, and electrolyte derangements. Rapid fluid replacement to correct deficits, initially with a balanced electrolyte solution accompanied by aggressive patient monitoring to assess further decline, will become a priority for technicians during this phase of therapy. Careful consideration should be given to not rehydrating the patient too quickly, making neurological conditions worsen or overhydrate the patient.

Acute changes in body weight can be a sign of improper changes in fluid administration. Any patient who is losing weight while on fluid therapy is not receiving adequate amounts of fluid and measuring fluid intake and output should be considered. This process will closely quantify fluid output (urine, diarrhea, vomitus) in comparison to fluid intake (IV fluid therapy, oral intake) to calculate the presence of a deficit to include in replacement fluid considerations. Monitoring blood pressure, heart rate, and respiratory rate is also essential to detect early signs of improper rehydration strategies. In patients experiencing hypervolemia, increased nasal discharge, chemosis, increased respiratory rate, pulmonary congestion, crackles, and eventually pulmonary edema will develop. See Chapter 10: "Critical Thinking and Kirby's Rule of 20," for further information.

Rehydration alone will improve hyperglycemia, acid/base status, and electrolyte imbalances. Therefore, IV fluids should be administered for no longer than 6 hours before the initiation of insulin therapy [33]. Supplementation of electrolytes may be required additionally due to the dilution effect of fluid administration and considered on an individual basis. Re-evaluation of the patient's values will be required at this time before the initiation of the above therapies mentioned. Once tissue perfusion is restored and proper urine production is restored metabolic acidosis will be improved. Proper tissue perfusion will also help reduce the amount of lactate in the body, helping to reduce the amount of sodium and potassium, restoring electrolyte derangements. Repeating blood work can be necessary every 2–6 hours (depending on patient needs) initially, then decreasing in frequency as the patient becomes stable.

Insulin therapy protocols will vary depending on the severity of the patient, traditionally with regular insulin administered as a constant rate of infusion (CRI), for unstable patients or intramuscularly (IM) for stable patients. However, recent studies reveal that intermittent injections of longer-acting insulin, such as glargine, in certain patients are showing positive outcomes for DKA patients [34]. Some patients will benefit from protocols in which insulin doses can be adjusted frequently, such as an insulin CRI. See Table 18.3 for an example of an insulin CRI recipe. When making an insulin CRI, it

Table 18.3 Example insulin CRI recipe.

Mix 1.1 U/kg of regular insulin into 250 ml bag of 0.9% saline
Once the saline/insulin solution is made, 50 ml is to be run through the IV tubing and discarded
Administer insulin CRI based on blood glucose levels
Check blood glucose levels every 2 h

Table 18.4 Insulin CRI and dextrose administration guide for the DKA patient.

Blood glucose, mg/dl	Insulin rate, ml/h	Fluid/dextrose concentration
250–399	10	0.9 % Sodium chloride
200 249	10	0.9% Sodium chloride + 2.5% dextrose
150–199	5	0.9% Sodium chloride + 2.5% dextrose
100–149	5	0.9% Sodium chloride + 5% dextrose
<100	Stop	0.9% Sodium chloride + 5% dextrose

must be in a separate bag of fluids from replacement fluids as well as being administered through a fluid/syringe pump to ensure accurate dose administration.

However, for those that are more stable (euvolemic and eating/drinking), an IM or SQ protocol can be initiated. Regular insulin is suggested in the initial treatment of DKA. The initial frequency of administration is every 1–2 hours, with the dose being adjusted based on how quickly the reduction in glucose values occurs each hour. If the glucose is reduced too quickly, it can result in cerebral edema and coma, to avoid this the maximum drop in blood glucose should not exceed 75 mg/dl/h, 4.2 mmol/L/h. Therapy is adjusted to reach blood glucose of 250–300 mg/dl, (14–16.7 mmol/L); however, if blood glucose falls too low (less than 180 mg/dl, 10 mmol/L), a dextrose solution will be initiated to counteract the decreased glucose level. See Table 18.4 for an insulin CRI and dextrose administration guide [35]. Any patient receiving these suggested protocols should be hospitalized in a 24-hour care facility with appropriate monitoring capabilities.

Once the patient's blood glucose is consistently <250 mg/dl (14 mmol/L) and they are eating, a longer-acting insulin can be initiated. During the transition phase, smaller doses of the longer-acting insulin can be chosen to reduce the incidence of hypoglycemia. Blood glucose and electrolyte monitoring should be continued frequently to ensure the continuation of desired results. In the occurrence of hypoglycemia, the patient should receive immediate therapy with a 50% dextrose IV bolus and discontinue the insulin CRI until further notice.

Other avenues for supportive therapy in the DKA patient will include therapies for concurrent medical conditions and meeting nutritional requirements. Often, patients who voluntarily eat will recover quicker; however, many will not voluntarily eat despite the technician's best efforts. Therefore, a feeding tube to provide enteral nutrition should be considered. See Chapter 12: "General Feline Nutrition," for feeding tube recommendations. The prognosis of DKA is variable and dependent upon complication factors and concurrent medical conditions. However, avoiding triggering events and managing concurrent medical conditions will prolong survival rates.

18.5.5.1.1.3 *Euglycemic Diabetic Ketoacidosis*

Should a patient experience DKA while on an SGLT2, they will not exhibit hyperglycemia due to the inhibition of the protein absorption being blocked by the natural pharmacokinetics of the drug, thus causing euglycemia in this complication. This is termed euglycemic DKA (eDKA). During eDKA other CS of ketosis, such as lethargy, anorexia, vomiting, and weight loss, will be present. Frequent monitoring of ketonuria and elevated levels of blood BHB, along with home monitoring for CS will prevent or promote the early detection of eDKA. During this event, the SGLT2 should be discontinued, and all other DKA therapies should be initiated as stated above. Due to new treatment options for DM patients, knowing the current patient therapies is necessary to correctly treat DM complications.

18.5.5.1.1.4 *Hyperglycemic Hyperosmolar Syndrome*

This is an uncommon, life-threatening complication of diabetes in cats. Hyperglycemic hyperosmolar syndrome (HHS) is diagnosed when the feline patient exhibits hyperglycemia, above 600 mg/dl (33 mmol/L), hyperosmolality above 350 mOsm/kg, and dehydration, with the absence of ketosis. Patients can show neurological CS such as abnormal pupillary light response, circling, behavior changes, or seizures with this syndrome. Some patients are nonresponsive to anticonvulsants and only respond to insulin therapy and rehydration in these situations. Neurological CS are assumed to occur due to cerebral dehydration secondary to hyperosmolality.

The treatment and therapies of HHS and DKA are similar with the goals to correct dehydration, restore electrolyte losses, and provide adequate insulin to correct any metabolic defects, with the same prognostic indicators in both disease processes.

18.5.5.1.1.5 *Hypoglycemia*

Hypoglycemia is considered a complication of DM due to insulin overdose, the patient not responding to insulin therapy correctly, or improper insulin administration. This complication can be avoided through client education to ensure the client understands how to accurately measure and administer the correct insulin dose and appropriate CS to monitor in the home environment. CS of hypoglycemia include ataxia, weakness, behavioral abnormalities, depression, shaking, seizures, coma, or even death. When the CS of hypoglycemia are first recognized, owners can offer food or apply Karo® syrup to the mucous membranes of the patient until veterinary treatment can be initiated. Once the patient has arrived at the hospital, 50% dextrose can be administered per the request of the veterinarian. Once an IV catheter is placed, a dilution of 1:4 of 50% dextrose can be administered. The bolus can be repeated as necessary during continued patient monitoring.

18.6 Diagnostic Techniques

18.6.1 Low-dose Dexamethasone Suppression Test

Supplies: Supplies of choice to perform venipuncture (needle or butterfly catheter and syringe), red top tube- 3, an assistant for handling and occlusion of the vessel (Note: extreme care should be taken during handling to avoid iatrogenic trauma, such as skin tearing).

Performing the diagnostic: Obtain a baseline sample of 3 ml of whole blood and place in red top tube, administer 0.1 mg/kg of dexamethasone intravenously, obtain another sample at 4 and 8 hours after dexamethasone was administered (Note: each sample should be allowed to clot, then centrifuged and the serum separated before submission to a commercial laboratory for analysis).

A normal adrenal gland would respond to the dexamethasone administration with a reduction of plasma cortisol concentration that persists for longer than 8 hours. The normal response to glucocorticoid administration would be suppression below the laboratory reference range at the 4- and 8-hour samples. The lack of suppression on LDDST is diagnostic of HAC. If the 4-hour value is less than 50% of the baseline or both the 4 and 8 hours values are less than 50% of the baseline it is diagnostic of pituitary-dependent disease. If less than 50% suppression occurs on the LDDST at the 4-hour time point, or both the 4- and 8-hour values are above the cutoff, this result can still be suspicious for HAC with supporting CS and history. In this situation, further endocrine testing would be warranted [20, 36].

18.6.2 High-dose Dexamethasone Suppression Test

Supplies: Follow the same supply list as the LDDST.

Performing the diagnostic: Obtain samples at the same time intervals as the LDDST, administer 1 mg/kg of dexamethasone intravenously, and follow the same sample handling as the LDDST.

Follow the same method for evaluation as the LDDST.

18.6.3 ACTH Stimulation Test

Currently, there are multiple protocols published for performing an ACTH. Take note to follow each protocol carefully for the most accurate results. When performing therapy monitoring, the test should be initiated 2–3 hours after the administration of trilostane with a meal. Follow the pharmaceutical recommendations of ACTH guidelines for disease management.

Supplies: Supplies of choice to perform venipuncture (needle or butterfly catheter and syringe), red top tube- 3, assistant for handling and occlusion of the vessel (Note: extreme care should be taken during handling to avoid iatrogenic trauma such as skin tearing.)

Performing the diagnostic: Obtain a baseline sample of 3 ml of whole blood and place in red top tube, administer synthetic ACTH 125 mcg/cat as per manufacturer protocols, and obtain samples 30- and 60-minutes postsynthetic ACTH administration [20]. (Note: each sample should be allowed to clot, then centrifuged, and serum separated before submission to a commercial laboratory for analysis).

18.6.4 Endogenous ACTH Stimulation Test

Supplies: Supplies of choice to perform venipuncture (needle or butterfly catheter and syringe), plastic EDTA tube-2, assistant for handling and occlusion of the vessel (Note: 1. Extreme care should be taken during handling to avoid iatrogenic trauma such as skin tearing, and 2. each sample should be put on ice immediately following collection and processed in a cold centrifuge. Shipping overnight on dry ice to a commercial laboratory is mandatory).

Performing the diagnostic: Obtain a baseline sample of 3 ml of whole blood and place in red top tube, administer synthetic ACTH 125 mcg/cat based on manufacturer guidelines, obtain another sample 60 minutes after synthetic ACTH was administered [20].

18.6.5 Blood Glucose Curve

Spot checks can be performed every 2–4 hours as indicated by the clinician in the hospital or at home via spot check on a glucometer or using a CGM device. AlphaTrak is the veterinary-approved glucometer for use in feline patients (Figure 18.6). The glucometer requires a drop of blood to perform the test. The sample can be received by pricking the marginal ear vein on either pinnae or an accessory pad.

Blood glucose curve steps:

1. Feed the patient a normal meal
2. Perform a baseline BG
3. Administer insulin as prescribed

Perform a BG every 2 hours or 3–4 hours for feline patients receiving glargineInterpretation of a BG curve can be performed in a graph format. The first step in assessing the BG curve is assessing the nadir. The nadir is the lowest level of the BG with the BG being between 100 and 150 mg/dl, occurring as soon as 1–3 hours after insulin administration, depending on the type



Figure 18.6 AlphaTrak 3 glucometer. *Source:* Paula Plummer.

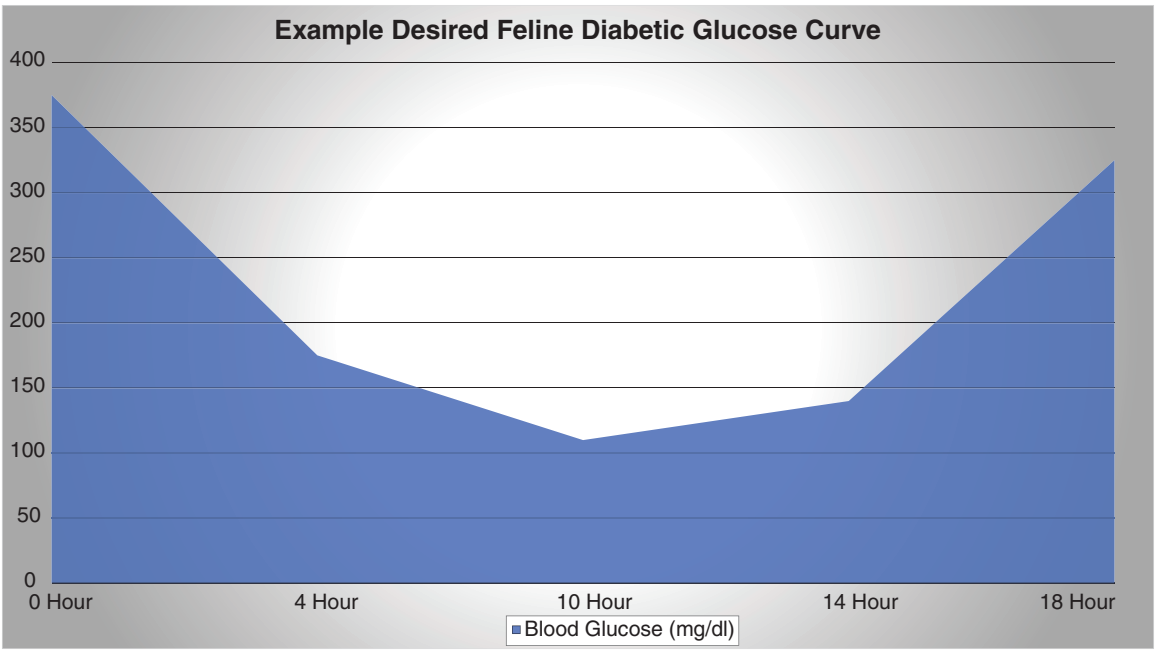


Figure 18.7 Example of a desired feline diabetic glucose curve with blood glucose levels between 120 and 300 mg/dl most of the day.

of insulin administered. The BG should be between 120 and 300 mg/dl for most of the time between insulin administration. In situations where the numbers fall outside of the ranges, the clinician should reconsider insulin doses. See Figure 18.7 for an example of a desired glucose curve. When analyzing BG curves, the Somogyi response should be considered with inappropriate hypoglycemic results. The Somogyi response is a phenomenon that occurs more often when insulin is being overdosed causing significant hypoglycemia in a short time after insulin administration. As a result of the hypoglycemia, the body responds by rapid release of diabetogenic hormones and in return increases the glucose putting the patient in a state of hyperglycemia. Due to the increased secretion of diabetogenic hormones such as cortisol and the GH, insulin resistance can be induced. This response can last for 24–72 hours. If misdiagnosed, insulin doses can be increased furthering the overdose, impacting the physiological response even further. Cats are more sensitive to this phenomenon than dogs.

The veterinary technician's role with the endocrine patient plays a significant role in their recovery. Endocrine disorders are complicated and challenging for every member of the veterinary team. From recognizing CS, identifying PE findings, obtaining samples for diagnostics to conducting treatment plans, technicians are a valuable asset to the patient, client, and veterinary team.

See the companion website for further clinical references.

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19

Gastroenterology

Chastity Ketchum, LVT, VTS (Internal Medicine-SA)

TECHNICIAN TIDBITS

- Obtaining a complete history is of the utmost importance to help define a problem list and develop a differential diagnosis and treatment plan.
- Physical assessments should be performed on every patient in a consistent manner.
- The ability to make good observations of a cat's demeanor, respiratory effort, and body language is an undervalued skill that takes years of active practice to master.
- Distinguishing vomiting from regurgitation is important to determine the origin of the illness.
- Diagnosing a disease or ailment should come second to treating a cat's clinical signs.
- Appropriate handling and storage of samples decrease the difficulty in interrupting results.

Gastrointestinal (GI) disease in a cat can often be frustrating due to its likely chronicity, subsequent changes in routine social interactions with pet parents, and the struggles of living with a cat that is vomiting and/or experiencing diarrhea. GI disease also leads to notable changes in a cat's body condition, often due to the loss of muscle mass. This subsequently leads to generalized weakness, hiding (or other changes in behavior), and contributes to poor interactions with pet parents. In the author's experience, these are reasons cats seem to "commonly" have GI disease. The clinical signs are apparent to the pet parents and can often progress without treatment within a short time frame. GI disease can also be frustrating and costly to effectively diagnose and treat. Treatment often takes several weeks to months to show a notable improvement in body condition and de-escalation of frequency or severity of clinical signs. The veterinary technician plays a key role in setting pet parents' expectations for recovery from a GI disease or living with a cat that has chronic enteropathy. The veterinary technician often needs to counsel clients on nursing care, disease pathology, and treatment. Chapter 5: "Client Education and Communication Topics for the Feline Owner" reviews strategies for counseling clients.

The GI system is composed of the primary GI tract and exocrine organs, such as the liver, biliary tract, and pancreas. The GI system's main role is to provide nutrition via digestion/absorption of essential nutrients and to excrete waste. The cat, being an obligate carnivore, has some unique adaptations to its GI system. Some of these adaptations were useful prior to the domestication of the cat, such as sharp spines or papillae located on the dorsal aspect of the tongue. These papillae were used to help grip and tear flesh from prey. The domestic cat also has narrowly spaced teeth. This narrow spacing adapted their mouths for their preferred small prey, which mainly consisted of birds and rodents. The cat's diet is naturally low in carbohydrates; thus, its saliva does not contain the digestive enzyme amylase. After mastication, food boluses enter the esophagus and are propelled downward by peristalsis. The distal one-third to one-half of the cat's esophagus is composed of smooth muscle in comparison to the dog's esophagus is comprised completely of striated-muscle. This variation helps cats by way of stronger peristaltic motion [1, 2]. This adaptation was likely needed for the cat's esophagus due to its carnivorous diet. Stronger peristaltic motion helps move meat, bone, and hair from prey.

Historically, cats are agile, carnivorous hunters, typically eating smaller prey, such as birds or small rodents. A cat's GI system has evolved to accommodate smaller, more frequent meals. Unlike the dog, the cat's salivary glands do not produce the enzyme amylase to aid in the breakdown of carbohydrates. The cat's stomach is smaller in size compared to the dog's and lacks the ability to store and digest food over a longer period of time. The fundus of the stomach is also more glandular, which aids in breaking down protein in the cat's diet. The glands in the stomach are a high secretory function of the mucosal epithelium. These glands produce mucus, hydrochloric acid, and pepsin. The higher concentration



Figure 19.1 A cat eating a bird. *Source:* Wiley Media Manager, losonsky/Adobe Stock Photos

of these specific "gland cell" types helps aid in the breakdown, both chemically and mechanically, of a carnivorous diet. The intestines are also shorter in overall length due to the decreased need for time to process, and absorb carbohydrates from their diet. Cats do require some forms of carbohydrates for micronutrients and fiber is important in keeping the biome healthy. The shorter length of the intestines is compensated by an increased height in the villi that line the intestines. The intestinal villi are finger-like projections that line the intestinal lumen for the absorption of nutrients. The cat's absorption capacity of nutrients from its diet is less superior due to these adaptations. This supports the cat's need for smaller, more frequent meals (Figure 19.1).

During a fasting state, the stomach is typically empty, aside from swallowed saliva, cellular debris, particles of food and mucus. A mechanism that is in place to empty these contents is called the migrating motility complex (MMC). The ability of the MMC to completely empty the stomach is remarkable and is referred to as "the housekeeper of the GI tract." Motilin, a GI hormone, is responsible for regulating the MMC. Cats (and rabbits) lack MMC and rely on a less effective emptying pattern known as migrating spike complex (MSC) [3]. This unique physiological factor may contribute to delayed gastric emptying, reported as vomiting, regurgitation, or hyporexia in cats with GI disease.

In cats, the merging of both the pancreatic and bile ducts as both enter into the duodenal papilla likely contributes to the cat commonly developing diseases of infection and inflammation in the liver, pancreas, and GI systems. The ducts are a conduit for bacteria from the small intestine (duodenum) to reach the pancreas and the biliary tree [4]. Biliary tract disease is very common in cats (second only to hepatic lipidosis) in the United States. In Europe, biliary tract disease is the most common liver disease in domestic cats [5]. The cat's pancreas has lower activities of amylase, meaning cats poorly utilize carbohydrates as an energy source for the cat. The cat relies on high-quality, digestible protein intake as an energy source. Complex dietary carbohydrates are essential in the cat, however, for supporting the cat's microbiome, motility, intestinal water absorption, and fecal pH [6].

19.1 Patient History and "History Gathering Questions"

The ability to obtain a complete history and perform a patient assessment are vital skills for the veterinary technician. Interviewing clients takes practice, experience, and often patience to provide the veterinarian with information. Patient assessment starts with observation but also includes a physical examination. The first step in obtaining a thorough history is a basic understanding of "why" the patient is presenting to the veterinary facility. This will enable the veterinary technician to prepare for interviewing the client. In order to prepare, the veterinary technician should review the patient's previous medical history and reason for the appointment or presenting complaint. This information is often found on

Box 19.1 Example of dietary history.

A 13-year-old, female/spayed DSH presents with a mildly decreased appetite for one week. The patient typically eats four ounces of dry kibble in the morning and three ounces of the canned food in the evening. The patient has been avoiding dry food entirely and eating only 50% of canned food daily. The client notes weight loss.

the appointment schedule and in any provided medical records. Ideally, previous medical records should be obtained in advance of the scheduled appointment or minimally gathered at presentation to the veterinary facility.

When interviewing a client, having a set of goals in mind is helpful. The veterinary technician should establish the clinical sign(s) and/or problem list and the duration, frequency, and severity of the (these) clinical sign(s). The ability to establish clinical sign(s) and a problem list in a clear and organized manner is the foundation of a comprehensive patient evaluation. Veterinary technicians should eliminate as much subjectivity from the history as possible.

Dietary or nutritional history is of the utmost importance in all patients but arguably plays a key role in GI disease. Nutrition is typically one of the foundations of therapy for many GI diseases. Starting with the patient's appetite, the veterinary technician should establish the normal or baseline appetite of the patient when it is not ill. Food consistency preferences, such as canned, canned with sauce, kibble, or fresh food, can aid in making recommendations for the patient in the treatment plan (Box 19.1). See below for examples of questions that clients can be asked about patients experiencing GI conditions:

- "When was your pet last normal?"
- "What is your pet's normal appetite or normal approach/behavior around feedings?"
- "What has changed in regard to your pet's litter box habits?"
- "Do you notice any changes when you clean the litter box?"
- "Have your pet's social interactions with you, other family members, or pets changed?"
- "Have any therapies for your pet's diarrhea (or vomiting, regurgitation, or loss of appetite) helped in the past?"
- "How is your pet fed: meals/free fed/timed meals?"
- "Does your pet have a preference for the type of food (consistency)?"
- "Is there any particular time during the day or night when your pet feels most ill or has episodes (vomiting, diarrhea, or change in behavior)?"
- "Have you noticed any changes in your pet's thirst or urinations?"
- "Have you needed to refill your pet's water bowl (s) at a different interval than usual?"

19.2 Clinical Signs

The common clinical signs that are associated with GI disease (Table 19.1) should be graded in severity (mild, moderate, marked) and frequency. Frequency should be provided as the number of times per week or month, not by using subjective terms, such as "occasional," "sometimes," or "rarely."

Vomiting is a common clinical sign of GI disease. The veterinary technician should describe when the vomiting occurs (after/before meals, anytime, hours after eating, etc.) along with a description of the vomitus (e.g., liquid, foam, bits of food, undigested food, etc.). The veterinary technician must also establish that the patient is truly vomiting. Clients use the term "vomiting" to describe regurgitation, coughing, or when vomitus is found. Videos of the cat during a "vomiting" episode from the owner may help to discern true vomiting from other clinical signs (Box 19.2). See below for an example of a concise, objective history of vomiting.

Box 19.2 Example of clinical history with vomiting as compliant.

A 6-year-old female/spayed DSH presents with moderate vomiting for an 8-week duration. The client has witnessed vomiting. The vomitus consists of yellow liquid with small bits of kibble; volume varies from 1 to 3 ounces. Vomiting occurs typically within 2 hours of eating.

Table 19.1 Common clinical signs, history, and physical assessment findings in GI disease.

Clinical signs	History findings	Physical assessment findings
Vomiting	Abdominal contractions, low head carriage, sternal to sternal-lateral position, with changes in behavior noted (running, hiding); patient and client know that vomitus is inevitable and productive. Projectile and forceful ejection. More food than liquid is often noted in vomitus. +/− Change in behavior (less social interaction, sleeping in odd places, not climbing or jumping).	+/− Abdominal discomfort, +/− weight loss (fat and muscle loss). Abdominal palpation finding may include a mass effect (mass, foreign object, large fecal balls), thickening of bowel loops or "ropey" intestinal loops, in stomach or intestines. +/− Cervical neck discomfort (esophagitis, esophageal foreign body), +/− enlarged liver on palpation (hepatic insufficiency, hepatic lipidosis), +/− change in mentation and/or responsiveness (hepatic encephalopathy). +/− palpable thyroid slip (hyperthyroidism), +/− weight loss. +/− Increase in heart rate, dry-tacky mucus membranes, changes in pallor, temperature, temperament, mentation, and changes in respiratory effort/rate.
Regurgitation	No visible abdominal contraction, neutral to low head carriage, often unexpected; patient and client not expecting, vomitus pours from mouth, +/− visible – patient may swallow contents, gagging, chewing maybe noted, +/− occurs at rest or when rising from lying position, +/− associated with eating or drinking, often more liquid than food. +/− Change in behavior (less social interaction, sleeping in odd places, not climbing or jumping).	+/− Abdominal discomfort, abdominal palpation findings may include a mass effect (mass, foreign object, large fecal balls) cranial abdomen is most likely more affected (stomach, small intestines), +/− weight loss (maybe to lesser extent than vomiting), change in body condition score and/or muscle condition score, nasopharyngeal signs, bilateral nasal discharge, ptyalism. Cervical neck discomfort (esophagitis, esophageal foreign body), +/− enlarged liver on palpation (hepatic insufficiency, hepatic lipidosis). +/− Change in mentation and/or responsiveness (hepatic encephalopathy). +/− Increase in heart rate, dry-tacky mucus membranes, changes to pallor, temperature, temperament, mentation, changes in respiratory effort/rate.
Hyporexia/Anorexia	Behavioral changes during or around feeding time (food avoidance, interest in food but not eating), changing of diet to entice (+/− helpful for short term), addition of enticers on to food. +/− Change in behaviors (less social interaction, sleeping in odd places, not climbing or jumping).	Weight loss, change in body condition score and/or muscle condition score, +/− wet mouth from nausea, +/− ptyalism, +/− abdominal discomfort, +/− palpation of mass effect (neoplasia, foreign body, large fecal balls) in intestines. +/− Increase in heart rate, dry-tacky mucous membranes, changes to pallor, temperature, temperament, mentation, changes in respiratory effort/rate.
Change in fecal consistency (diarrhea)	Change in frequency of litter box, excessive digging in the litter box, spending more time in the litter box, +/− tenesmus, vocalizing in litter box, inappropriate defecation (outside litter box), leaking fecal material/incontinence, stool consistency is watery-loose, containing frank red blood or mucus. Change in behavior (less social interaction, sleeping in odd places, not climbing or jumping).	+/− Weight loss, fluid or fecal distention of intestinal contents on abdominal palpation. +/− discomfort/pain on abdominal palpation; +/− mass effect on abdominal palpation (neoplasia, foreign body). +/− Increase in heart rate, dry-tacky mucus membranes, changes to pallor, temperature, temperament, mentation, and changes in respiratory effort/rate.

Diarrhea is another common clinical sign of GI disease in cats. The client should be provided with a fecal scoring chart [7] to determine the characteristics of the stool. Removing subjectivity and description from characterizing stools will help identify small, large, or mixed bowel diarrhea (Table 19.2). This will instruct the veterinarian on differentials for diagnosing the location of the disease and prescribing therapy. The quantity and frequency of stool produced are also useful in determining location of the disease/cause of the diarrhea. Figure 19.2 displays a fecal score of 7 (4–5, reference interval 1–7) (Box 19.3). See below for an example of a concise, objective history regarding diarrhea.

Table 19.2 Differentiating small bowel, large bowel, and mixed bowel diarrhea.

Location affected for diarrhea	Common characteristics
Small bowel	Often normal frequency, increased to normal volume, +/− tenesmus (uncommon)
Large bowel	Very increased frequency, but may be normal; often decreased volume (due to increased frequency) but can be normal, +/− hematochezia, mucus, tenesmus
Mixed bowel	Change in frequency, larger volume, +/− hematochezia, mucus, tenesmus

Box 19.3 Example of clinical history with diarrhea as compliant.

An 8-year-old male/neutered Persian presents for moderate intermittent diarrhea of 6-month duration. The stool is described as a fecal score 6, occurring two to three times daily for 10–14 days, and then gradually returning to a fecal score of 4. The client notes frank-red-blood in approximately 50% of the fecal score 6 stools produced.

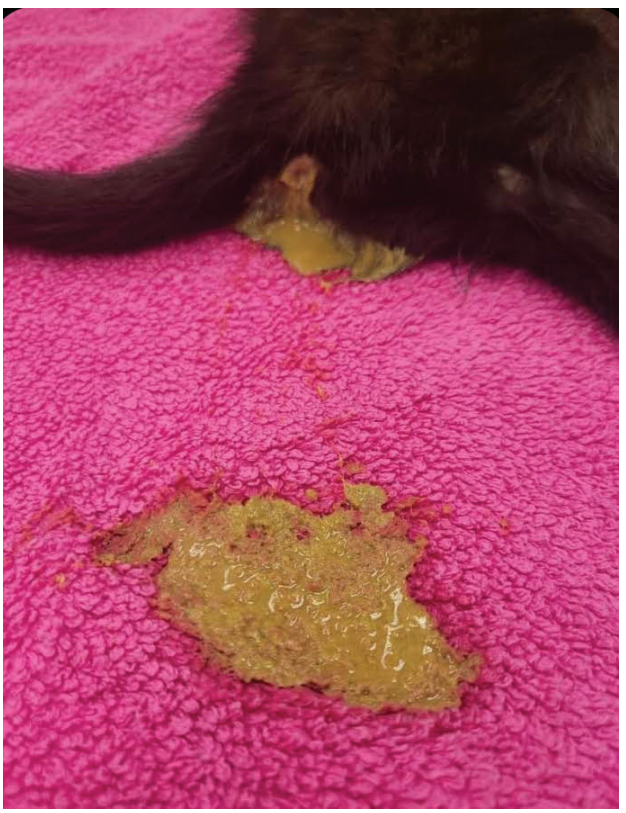


Figure 19.2 A shelter kitten with a fecal score of 7/7. *Source:* Christine Prior, DVM.

19.3 Physical Examination Findings

Physical assessment always starts with observation and obtaining vital statistics. The veterinary technician should observe the patient's interactions with stimuli, the client and responsiveness/mentation. The patient's resting respiratory rate/effort and heart rate may be affected by stress or illness. The veterinary technician should observe the patient's inspiratory and expiratory effort while the patient is minimally stressed (in the carrier, seated on the client's lap, exploring the exam room).



Figure 19.3 A feline patient receiving a thorough physical examination. *Source:* Maria Sbytova/Shutterstock

Vital statistics should always include a nutritional assessment. The nutritional assessment includes body weight, body condition score, and muscle condition score. This nutritional assessment will be used to monitor response to therapies, especially in patients with weight loss or change in body condition scores as a sequela to GI disease. A thorough physical assessment from nose to tail should be completed by the veterinary technician (Figure 19.3).

Common findings in a cat with GI disease include a change in body condition score, overall weight loss, decreased muscle mass (epaxial, thighs, skull), sunken eyes, unkempt coat (dull, flaky skin), poor/changed mentation, abdominal discomfort, and "ropey" or thickened palpation of intestines. Cats that present with concerns for constipation can have varying distention of the large intestines and/or colon with fecal matter.

19.4 Specific Nursing Care Considerations

The veterinary technician should provide a quiet environment with appropriate husbandry to decrease stress in hospitalized cats with GI disease. Cats with GI disease may often be hyporexic to anorexic and decreasing stress can help to aid in improving their appetite. Some examples of husbandry considerations include the following: housing in an area of the hospital dedicated to cats only, decreasing the brightness/lighting in the room, providing a box or hiding area in the kennel, soft-clean bedding (especially in cats with decreased muscle/fat mass), keeping food and water bowels away from litter pans, and keeping other cats out of eyeline. Cats may also benefit from the use of pheromone diffusers or sprays, and enrichment. Enrichment may include short, supervised time outside the kennel in a secured exam room, prey-drive toys (feather wands, catnip toys, balls), and spending time with their pet parent.

Cats should be kept clean from any fecal matter or urine that may come in contact with their fur or coat. Veterinary technicians should clean the cat with warm water and a nondetergent shampoo, such as "baby-shampoo." Using a warm bowl or pan of water versus running water at a sink/tub is much more readily accepted by most cats. The practice of "tail wrapping" to avoid contact of diarrhea to the tail and decrease fecal scalding should be done with the utmost caution. "Tail-wrapping" is the use of a soft bandage around the tail that is then adhered by tape to the proximal end of the tail. This method can lead to the bandage becoming soiled (possibly soaked through to the skin). The "tail-wrap" can also cut off circulation to the tail if not applied appropriately and is cumbersome/stressful to some cats. If employing a "tail-wrap" the veterinary technician should frequently check and change the bandage. Cats that are weak or unable to move away from their voided urine should be kept clean and dry by bathing. The use of moisture-wicking bedding may be helpful.

Feeding a cat with GI disease is of utmost importance. The cat requires consistent protein intake due to their high-protein metabolism. The cat initially should be offered a diet that is enticing and may be more readily acceptable than a therapeutic

diet. Therapeutic diets should be introduced after a cat's appetite improves and when they are not in a stressful environment for long-term benefits. Cats should be offered small meals frequently. Sometimes offering a different feed consistency can also be of benefit as well. Cats can quickly develop food aversion from their normal diet as they associate the food with feeling ill. Offering a variety of warmed canned or pureed foods, freshly cooked meat (chicken, shrimp, beef), and dry kibble can be of benefit. Offering feed should be timed carefully with antiemetics and appetite stimulants. Providing these medications prior to offering feed can be of great value. Feed that is not accepted readily by a cat should be removed so that it does not spoil or contribute to food aversion.

19.5 Gastrointestinal Disease in the Feline Patient

19.5.1 Inflammatory Bowel Disease

Small intestinal inflammatory bowel disease (IBD) is an umbrella term that encompasses different types of IBDs. The most common type of IBD is lymphocytic-plasmocytic enteritis (LPE). Cats can also be diagnosed with eosinophilic enteritis.

Idiopathic inflammation is likely caused by an inappropriate response to bacterial or dietary antigens by the cat's immune system. It is an "overreaction" to commonly found antigens present in the intestinal lumen. It is unknown why some cats are affected.

Inflammatory cells, such as neutrophils, lymphocytes, eosinophils, and plasma cells infiltrate the luminal walls and cells, disrupting the absorption of nutrients. The pathogenesis of the different forms of IBD is poorly understood. Intestinal biopsies have identified abnormal cytokine mRNA expression. The primary means of developing IBD involves hypersensitivity to luminal contents. There are two main theories of the pathogenesis of IBD. A defective intestinal mucosal barrier allows for the infiltration of luminal antigens beyond the mucosal layer, inciting a hypersensitivity (overreaction) of the immune system's response. A second theory suggests that defects in the gut-associated lymphatic tissue suppressor function, which regulates immune response, predisposes cats to develop hypersensitivity to antigens [8, 9].

In cats, slow weight loss over weeks to months is the most common clinical sign along with vomiting, hyporexia, anorexia, and small bowel diarrhea. IBD is often diffuse in the GI tract, so mixed bowel diarrhea may be reported. Cats may develop sarcopenia, loss of muscle mass, with pet parents describing it as a behavior change, as the cat(s) are no longer exhibiting the ability to jump/leap onto furniture. Cats with IBD tend to be younger with a median age of 8 years old but reported in cats that are only 4–6 months old. The domestic shorthair and Siamese breeds are overrepresented, but no breed predilection or gender exists [8, 9]. Clinical signs vary in their degree of severity, depending on the location of the pathology and degree of inflammation.

Diagnosing IBD is dependent on a complete clinical history. It is important to note the frequency and characterization of clinical signs. This includes diarrhea and vomitus. History alone can be the most valuable tool to determine the location of inflammation in the GI tract. Veterinary technicians play a crucial role in history gathering, with the use of open-ended questioning along with skilled communication, is imperative (see dietary history). Physical examination findings will vary greatly from patient to patient. Muscle mass loss is a very common finding, especially along the epaxial muscles and in the pelvic limbs. Reservation of abdominal lethargic while others are very bright fat pads is often noticed in otherwise cachectic cats. Abdominal palpation may reveal diffusely thickened intestinal loops and discomfort in the cranial abdomen.

Cats should have serum levels of cobalamin and folate analyzed to determine if supplementation is appropriate. The degree and type of deficit can also aid in clinical suspicion for diagnosis (see the "Diagnostic Techniques" section for performing this diagnostic). Definitive diagnosis is often determined by histopathological findings. Biopsies obtained surgically allow for "full thickness" and for all segments of the bowel to be examined. Endoscopic biopsies are the most common type of biopsy method. Tissue samples should be set aside for flow-cytometry if alimentary lymphoma is considered.

Dietary therapy is a cornerstone in treating cats with IBD. Diets that are highly digestible and antigen-restrictive, such as hydrolyzed or novel protein diets should be prescribed when IBD is suspected. Cats with mild to moderate IBD can often respond to diet alone. Dietary factors to consider include managing cats that are hyporexic and have a decreased ability to absorb nutrients, such as cobalamin. Nutritional factors are listed in Table 19.3 (Figure 19.4).

Including other therapies depends on the severity of IBD and if a cat's response to diet alone is not favorable degree. Metronidazole is a commonly prescribed antibiotic used for the treatment of IBD (10–15 mg/kg PO twice daily) [11]. Metronidazole likely aids in treatment due to the hypothesized bacterial antigens in the intestinal lumen that contribute to inflammation and the cat's overreactive innate immune response. There is anecdotal evidence supporting the efficacy of

Table 19.3 Nutritional factors in diets [10].

Nutritional factor	Problem	At home	Recommendation
Water	Fluid loss from vomiting and diarrhea	Maintain by encouraging increase intake by mouth. Canned diets	Parenteral fluid may be required during the initial stages of treatment to improve hydration.
Fat	Calorie deficit	Improved palatability, increase in energy density	15–25% fat dry matter
Protein	Muscle/tissue loss	Hypoallergenic protein source	Highly digestible (>87%), 35% protein dry matter
Fiber	Loss of volatile fatty acids, diarrhea	Supplementation via diet and fiber sources add to a diet	7–15% dry matter of insoluble fiber
Probiotics	Immune hyperactivity, off-balance biome	Supplemented into diet	Research is needed, daily dosing may be of benefit



Figure 19.4 Highly digestible, palliative diets with GI disease can be the cornerstone of therapy for feline patients. *Source:* Anneka/Shutterstock

metronidazole in the treatment of IBD in cats [8, 11, 12]. For severe disease, especially in rare cases where hypoalbuminemia is noted, it is warranted to start corticosteroid therapy, prednisolone (2.2 mg/kg/day) [13]. Parenteral supplementation of cobalamin in cats with decreased serum concentrations may sometimes resolve diarrhea at a dose of 25 μg/kg SC, weekly for 6 weeks then once monthly thereafter. Cats that tolerate oral administration of pills can be transitioned to an oral supplement after 3–4 months of parenteral therapy. Table 19.4 lists other therapies for IBD.

When financial constraints forbid diagnostic histopathology, treatment with diet and prednisolone tends to lessen clinical signs and improve quality of life. Cats that have refractory clinical signs with prednisolone, diet, probiotics, and other adjunct therapies (metronidazole, etc.) should be tried on chlorambucil.

Cats with an identified primary indicating cause of inflammation tend to respond best. Treatment of parasites, infectious bacterial pathogens should be initiated and may be curative. Cats should be monitored closely, as many of these cats have an underlying compromised immune status and likely have a primary small intestinal disease. Responsiveness to therapies ultimately determines a cat's prognosis. Many cats live long lives with IBD and succumb to other illnesses. Cats that are diagnosed later with lymphoma that had a previous histological diagnosis of LPE may not have been diagnosed correctly initially or developed lymphoma independent of IBD [11]. These cats' prognosis is dependent on the type of lymphoma (b-cell, t-cell) and response to therapies. In cats treated with chemotherapy, 50–70% achieve complete remission and live 4–12 months; however, some cats live up to 2.5 years [11].

Table 19.4 Treatment modalities for IBD in the cat [8, 12–22].

Drug	Dosage/formulation	Key points
Prednisolone – glucocorticoid	• 1–3 mg/kg PO once daily • Oral tablet or compounded solution	Induction therapy for 2–3 weeks, then tapered by 25% every 2–4 weeks. Dose-dependent side effects including the promotion of diabetes mellitus
Dexamethasone sodium phosphate – glucocorticoid	• Dose is calculated from the prednisolone dose then adjusted to account for potency. • Injectable (IM/IV/SC)	5–7 times more potent than prednisolone.
Budesonide – glucocorticoid	• 0.5–1 mg/cat PO once daily • Oral extended-release capsule must be compounded	Lag effect of 7–10 days, drugs that inhibit cytochrome P450 3A (CYP3A) can significantly increase the amount of budesonide in circulation 15 times more potent than prednisolone Works locally in the intestinal tract. Reduced side effects compared to prednisolone
Chlorambucil – alkylating agent	• Pulse therapy 20 mg/m^2 every 2 weeks or 15 mg/m^2 once daily for 4 days then repeated every 3–4 weeks OR • 2 mg PO every 2 days > 4 kg and every 3 days for cats < 4 kg	May be used with prednisolone. Complete blood counts q2 weeks initially. Expensive
Cyclosporine – reduces production of proinflammatory cytokines	• 5 mg/kg PO once or twice daily	Slow introduction at a reduced dose may improve GI tolerance Therapeutic drug monitoring can help determine appropriate dosing
Cyanocobalamin (Vitamin B12)	• 25 μg/kg or 250 μg/cat SC for 4–6 weeks, then every 2 weeks to monthly thereafter • 1000 μg/ml injectable	Failure to identify and treat hypocobalaminemia can delay clinical response
Folic Acid (B Vitamin)	• Suggested dosing ranges from 400 μg/cat to 1 mg/cat once daily	Required for nucleoprotein synthesis and normal erythropoiesis
Maropitant – potent neurokinin-1 receptor antagonist	• 1 mg/kg SC or PO once daily • 10 mg/ml injectable • Oral tablets	May cause pain when injecting May reduce visceral pain in cats Eliminated primarily by the liver, dose reduction by 50% is recommended in cats with hepatic dysfunction
Omega-3 fatty acids – eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA)	• EPA 17–25 mg/kg PO once daily • DHA 8–18 mg/kg PO once daily • Oral enteric-coated preparations)	May reduce GI inflammation
Ondansetron – serotonin receptor antagonist	• 0.1–1 mg/kg SC or PO once to twice daily • Oral tablet/solution • Injectable (SC, IV)	May improve the lack of appetite. Give 30 min prior to introducing food
Metronidazole – antibiotic	• 10–15 mg/kg PO twice daily • Oral solution, tablet, or compounded suspension	Use with caution in cats with hepatopathy. Poor palatability
Tylosin	• Extra-label suggested dosing 10–40 mg/kg 2–3 times daily • Powder, compounded capsules	Poor palatability. Sparse clinical evidence

(Continued)

Table 19.4 (*Continued*)

Drug	Dosage/formulation	Key points
Prednisolone + chlorambucil chemotherapy	• Prednisolone at 5–10 mg PO once daily • Chlorambucil 2 mg PO every 2–3 days or 20 mg/m^2 every 2 weeks	Median remission of ~ 26 months. Routine monitoring of complete blood counts every 2–4 weeks
Probiotics	• Single and multistrain commercial products	Empirically administered by most clinicians

IM, Intramuscular; **IV,** Intravenous; PO, per os (by mouth); SC, Subcutaneous.

19.5.2 Feline Parvoviral Enteritis

Feline parvoviral enteritis is caused by feline panleukopenia virus (FPV). It is spread by direct fecal-oral contact or indirectly by contamination of the environment or objects (fomites). Infected cats will continue to shed the virus for at least six weeks following infection. Dogs can also transmit the virus. Canine parvovirus (CPV) types 2a, 2b, and 2c can cause clinical disease in cats.

Feline parvoviral enteritis causes acute severe disease with the virus replicating in situ in approximately 3–9 days after infection. The virus seeks out mitotically active cells, such as in the small intestinal epithelial crypts. In some cats transient panleukopenia or relative lymphopenia is observed. FPV destroys both erythroid and myeloid colony progenitors in the bone marrow. Weight loss, large bowel diarrhea, vomiting, peripheral nonregenerative anemia, and leukopenia are all common in FPV.

Diagnostic testing begins with a complete history and physical assessment. Laboratory diagnostics for FPV include biochemical analysis, complete blood count (CBC), and SNAP® ELISA fecal testing. Weak positive results are highly likely to be definitive for FPV. If clinical suspicion persists despite a negative SNAP™ ELISA fecal test, polymerase chain reaction (PCR) is recommended. The ELISA fecal antigen test for CPV can be used to diagnose FPV infection. Please note that CPV tests have not been validated for diagnosing FPV in cats by the manufacturers. There have been studies indicating a high sensitivity in this testing method, however, a low viral load can negatively impact the ability to diagnose [14].

There is no specific treatment protocol for FPV. It is vital that barrier protection, by hospitalizing the patient in an isolation ward, is utilized. FPV is highly contagious and easily spread. Veterinary team members should wear disposable protective clothing (nonpermeable gown), gloves, and shoe booties. Disinfection should take place after cleaning of organic debris. Severely affected cats suffer from dehydration and at times hypovolemia. Fluid replacement therapy by intravenous (IV) catheterization is vital to the survival of these patients. A patient's body weight, respiratory effort, and respiratory rate should be evaluated minimally every 2–4 hours while hospitalized to avoid fluid overload and to ensure that the patient is rehydrated. Concern for the translocation of bacteria in a leukopenia patient warrants the use of a broad-spectrum antibiotic.

Adjunct therapy should include the placement of an esophageal feeding tube to start nutritional therapy once hydration has improved. In the author's opinion, it is not advisable to wait until the complete correction of volume status. Cats must be started on nutritional therapy as soon as possible due to their need for consistent protein intake. Esophageal feeding diets are composed of ~ >70% water, per os water. Enteral water does not carry the same risks or electrolyte-shifting properties as IV fluid therapy replacement crystalloids and to a lesser effect maintenance fluids. Advanced nursing care, including patient warming, comfortable husbandry, and cleanliness, is essential for successful outcomes. Antiviral agents, such as feline interferon have varying results in the treatment of FPV [15, 16].

FPV is much easier to prevent than to treat. There are highly effective vaccines available to protect cats from this deadly virus. All cats should be vaccinated regardless of lifestyle. Further reading is available in Chapter: 9: "Feline Immunology and Current Vaccination Guidelines."

The cat's biome should be addressed by including a diverse population of prebiotics and probiotics once feeding has started. Adjunct therapies to support the cat such as ondansetron or maropitant, to treat nausea. Anti-diarrheal medications are typically not useful in cats with FPV and should be avoided to lessen the stress to cats and caregivers.

FPV has a varied prognosis as it is dependent on the patient's hydration, nutrition, and leukopenia status at diagnosis. Responsiveness to treatment in the first 24–48 hours of therapy is vital to making a prognosis. Generally, this disease has a poor prognosis.

19.5.3 Colitis

Inciting or contributing factors to colon inflammation are similar to other areas of the bowel. They include parasitic, uremic, traumatic, bacterial, and, in some geographical-regions, fungal. Colitis occurs as a result of inappropriate mucosal immunoregulation. In cats, stress colitis should be considered in those with other known intestinal disease or dietary sensitivities. In most cases, the inciting factor(s) is undetermined. Infectious pathogens, food sensitivities, stress and parasites are all considered as factors in developing colitis, but none of these have been proven.

Colitis may occur alone or along with generalized inflammation of the GI tract. Colitis is the resulting inflammation that occurs after mucosal injury. Once the mucosal layer is injured, infiltration of some combination of white blood cells (neutrophils, eosinophils, lymphocytes) will ensue. Fibrosis secondary to chronic injury/inflammation may occur as well as ulceration. Goblet cells that line the lumen of the colon are stimulated to produce excess mucus. Excess mucus in the large intestinal tract acts as a barrier protectant, trapping pathogens. The large intestine's ability to absorb water and vital electrolytes is greatly reduced as well as colonic motility. Inflammation results in the colon's sensitivity to filling or stretching of the lumen. The increased sensitivity results in a sense of urgency to defecate more frequently. Inflammation in the colon can also result in abdominal sensitivity and discomfort.

Histopathology of the colon classifies colitis into four forms, depending on the type of cells found infiltrating the individual layers of the intestine (mucosal, lamina propria, muscularis).

- Eosinophilic
- Neutrophilic
- Lymphocytic-plasmocytic (most common, 90%) [17].

Cats tend to be middle-aged and more commonly purebred. Cats with eosinophilic inflammation are often younger and may have hypereosinophilic syndrome. The most common clinical sign of colitis is large-bowel diarrhea. Large bowel diarrhea is characterized by increased frequency of defecation, small volume, mucoid, and hematochezia with straining or tenesmus. Vocalizing due to the pain or discomfort of defecating is common in cats. Cats may begin to associate their designated litter box with pain. This can result in defecating outside the litter box (inappropriate defecation). Weight loss can occur secondary to decreased caloric intake along with vomiting due to straining to defecate. Physical exam findings are often unremarkable.

Diagnosing colitis starts with a complete history with an emphasis on diet, travel, boarding, and husbandry. Physical assessment of the cat should include a body condition score, weight and palpation of the abdomen, and rectal examination. Fecal analysis for pathogens, CBC, urinalysis, and metabolic biochemistry analysis should be performed. In most cases, the results of the aforementioned testing are normal. Rarely, peripheral eosinophilia is present. Rectal cytology may be useful for identifying inflammatory cells, neoplastic cells, and certain types of pathogenic agents (e.g., *Histoplasma capsulatum, Clostridium perfringens*). Cats should be screened for feline immunodeficiency virus/feline leukemia virus, and a thyroxine level should be considered in cats over the age of 7 years [18].

Dietary testing (trials) is recommended in cats prior to more advanced and invasive diagnostics. Dietary trials are a diagnostic tool/test to determine the role diet that diet has in both treatment and diagnosis. Veterinarians and veterinary technicians should spend time educating pet owners on the importance of dietary testing (trials). Diet trials can be conducted using a variety of hydrolyzed protein diets (ideal) and/or novel proteins. Finding a diet that a cat will enjoy eating may take some time but the results are well worth the effort. Response to dietary trials varies among patients and in the literature. Most cats will respond to a diet to some degree in the first 2–3 weeks. If a poor response is noted, feeding a higher fiber content diet or low-residue diet containing fructooligosaccharides is recommended.

Colonoscopy would likely be recommended if there is an inadequate response to diet. Histopathology will most likely be able to characterize inflammation and help with treatment planning. Biopsies can also be submitted for fluorescence in situ hybridization (FISH) testing, a newer and sensitive method to identify the types of bacteria found in tissue. FISH testing is performed on formalin-fixed tissue samples.

Nutritional management of colitis in the cat is the foundation of treatment. All cats with all types of colitis benefit from nutritional modulation. Cats diagnosed with lymphocytic-plasmocytic colitis typically respond to dietary management alone. Lymphocytic-plasmocytic colitis accounts for ~ 90% of all diagnosed colitis on biopsies [19].

If pathogens or parasites are determined, the treatment of these primary infections should be initiated. It is important to frequently follow up with the client to ensure that therapies resolve clinical signs. Opportunistic infections can occur in cats with underlying intestinal disease.

Antibiotic stewardship is advised when using tylosin and metronidazole in colitis. In many cases, cats will respond to fiber without the need for antibiotic therapy. Metronidazole may reduce inflammation in dietary refractory cases. Metronidazole may have immunomodulatory effects on cell-mediated immunity in the intestinal tract. There is good anecdotal evidence attesting to efficacy of its use in treating inflammatory bowel disease in the cat [8, 12, 21]. Tylosin may also be effective in treating cats with colitis, but there are sparse studies that offer any proof.

The use of probiotic therapy in cats specifically diagnosed with colitis is lacking in the literature. In one study, 53 cats were treated with a probiotic alone and showed improvement in fecal scores (from 6.0 to 4.4, normal interval 4–5) [13, 20]. Thirty-eight of the pet owners (72%) reported improvement in their cat's diarrhea, and 13 (24%) reported no significant change [21]. In this isolated study, there is evidence that probiotics may likely be beneficial to cats with colitis. The largest obstacle in treatment with probiotics is client compliance and a cat's willingness to consume the therapy.

Immunosuppressive drug therapies, such as cyclosporine, prednisolone, dexamethasone sodium phosphate, budesonide, and chlorambucil should be considered after histopathology. Refer to the section on IBD.

The prognosis for cats with colitis is generally good with treatment, especially if a primary bacterial or parasitic infection is diagnosed and successfully treated. Lifelong dietary management is indicated in most cases.

19.5.4 Megacolon

Constipation, an infrequent or difficult defecation of dry fecal matter, is an unfortunate and common problem in cats. Megacolon is a term that is used to describe a dilated, incompetent, and often flaccid colon. There is an extensive list of differential diagnoses for idiopathic megacolon in cats. The causes of constipation in cats include metabolic (dehydration, hypocalcemia, chronic kidney disease), pharmacologic (anticholinergics, diuretics, opioids), neuromuscular (cauda equina syndrome, lumbosacral disease, sacral spinal cord deformities), mechanical (intraluminal, extraluminal), and environmental/behavioral (inactivity, unkempt litterbox, competition). The etiology of idiopathic megacolon remains widely not understood [20, 22].

There are two mechanisms that have been shown to lead to the development of megacolon in cats: dilation and hypertrophy. Cats who develop idiopathic dilated megacolon are at the end-stage of the disease. These cats have lost complete colonic function and typically require a colectomy. Hypertrophic megacolon develops in cats secondary to intraluminal or extraluminal obstruction. If the obstruction is treated early, often with surgical intervention, it may not progress to dilated megacolon. Studies by Washabau, et al. have suggested that idiopathic (dilated) megacolon is due to a dysfunction in neurotransmitters in colonic smooth muscle [20].

Cats may be of any age, sex, or breed. Middle-aged cats, with a mean age of 5–8 years, male domestic shorthair, domestic longhair, and Siamese cats are overrepresented. Presentation and clinical signs are largely dependent on the chronicity of constipation and the degree of bowel distention with feces. Cats are typically presented due to the absences of stools, increased frequency to the litterbox, tenesmus, and vocalizing during defecation. Cats may also vomit after straining to defecate. A tell-tale sign of constipation is hard-dry fecal balls (fecal score 1–2, normal interval 4–5). Cats may also have intermittent diarrhea with or without frank blood or mucus secondary to mucosal irritation [13, 20]. Figure 19.5 shows a cat with tenesmus due to constipation.

Physical examination may reveal a large tubular dorsal-caudal structure in the abdomen (the colon), signs of dehydration (unkempt coat, positive skin turgor), and abdominal discomfort. Digital rectal examination of the pelvic canal should be done under sedation or anesthesia. If abdominal palpation is not able to be performed due to large habitus or fearful-guarded behavior, abdominal radiography is recommended. Caudal spinal cord function should be evaluated by neurological assessment [20].

Diagnosis of constipation requires a complete medical and dietary history. An emphasis on preexisting trauma, litterbox habits, changes in water consumption, behavioral changes, diet changes, fecal score, and ambulation (gait). Physical assessment, combined with abdominal radiography and history, is usually all that is required to diagnose constipation. The primary cause of constipation sometimes needs to be further investigated in order to identify and treat. Cats should have metabolic screening laboratory analysis performed (CBC, biochemistry, and urinalysis). Cats over the age of 7 years should have thyroid level(s) evaluated. Idiopathic dilated megacolon is a diagnosis of exclusion. The approach to diagnostics can be suggested by an adequate history and a complete physical examination including neurologic and digital rectal examination [20, 22].

The therapeutic plan depends greatly on the severity of constipation and underlying cause. Some cats may not require medical intervention with the first episode, but rather a change in diet. Mild-moderate recurrent constipation requires medical intervention, often with an outpatient procedure. Moderate to severe constipation often requires sedation, anesthesia,



Figure 19.5 A cat with tenesmus due to constipation. *Source:* ivanoliantofoto/Adobe Stock Photos

and hospitalization measures. Pet parents of cats that have recurrent moderate to severe constipation, obstipation, or megacolon need extensive education about their pet's condition. These cats should never have "normal stools" but rather looser-soft stools (fecal score 5, normal interval 4–5). Providing the fecal scoring chart to clients and recommending maintaining a daily defecation diary are of utmost importance. The following information summarizes common therapeutic recommendations based on severity and occurrence of constipation.

Mild recurrent constipation

- Dietary fiber, dietary change
- Dioctyl sodium sulfosuccinate or petrolatum, +/– cisapride

Moderate recurrent constipation

- Enemas, +/– manual removal of feces (de-obstipation)
- Dietary fiber, dietary change
- Lactulose, Cisapride
- +/– ranitidine, +/– bisacodyl
- Hydration – subcutaneous fluids, increase in oral fluid intake (canned food, water fountains).

Severe recurrent constipation, obstipation, or megacolon

- Hypertrophy
  - Pelvic osteotomy or colectomy
- Dilation
  - Colectomy

Dietary fiber, such as psyllium husk (1/2–2 tsp/meal), cereal grains (1–4 tsp/meal), and wheat bran (1–4 tbsp/meal), are well tolerated and effective treatments. Fiber's beneficial effects in constipation include increased fecal water content, decreased transit time (improved motility) and increased frequency of defecation. Emollient laxatives, such as dioctyl sodium sulfosuccinate (DSS) are available in pediatric rectal suppositories, Docusate sodium (50 mg capsule/day). Hyperosmotic laxatives, such as lactulose stimulants colonic fluid secretion and propulsive motility. Lactulose osmotically retains water in the bowel to soften fecal material (0.5 ml/kg, PO 2–3 times daily, or 5–10 ml/cat PO 2–3 times daily). The stimulant laxative product, bisacodyl, increases the propulsive activity of the bowel and is contraindicated for bowel obstruction (5 mg/cat). Cisapride is a colonic prokinetic agent that improves colonic motility by activating smooth muscle

contractions. It is used as an extra label in cats (0.1–1 mg/kg PO 2–3 times daily). Note that cats with chronic obstipation and dilated megacolon typically do not benefit from cisapride. The ability of the muscle to meaningfully contract is so limited that stimulation from the use of the pharmacological pathway utilized by cisapride is not helpful. Ranitidine is an H2-receptor antagonist and is reportedly able to influence colonic motility by inhibiting acetylcholinesterase. This in turn increases the amount of acetylcholine available to stimulate smooth muscle contraction in the colon [13, 20, 22]. Hydration is important for normal colonic function, and cats should be well hydrated to benefit from osmotic laxatives as well as promotility agents. Increasing consumption of dietary water by feeding canned diets (~ 70% water) and offering a variety of water outlets (bowls, running water fountains) may improve enteral water intake. Cats with moderate recurrent constipation can also benefit from 2 to 3 times weekly dosing of subcutaneous crystalloid fluids.

Cats with mild-moderate recurrent constipation typically have a good prognosis with medical management. It is best to prevent these cats from becoming dilated megacolon cats. Cats that require a colectomy generally have a good prognosis after recovery; however, these cats may be subject to fecal incontinence [20].

19.5.4.1 Enemas and De-obstipation

Enemas are not required to be "medicated" and in the author's experience, the use of warm water with mild soap is very productive in softening stools (5–10 ml/kg). Enemas should be administered slowly with a 10–12 French catheter every 6–12 hours, under sedation as required. Always avoid enemas containing phosphate in cats, as excessive absorption can lead to hypernatremia, hyperphosphatemia, hyperosmolality, and shifts in electrolytes.

19.5.4.2 De-obstipation Procedure

Manual removal of fecal impaction in cats is rewarding in that it elevates discomfort and mechanical obstruction of feces. Cats should be heavily sedated or under general anesthesia. Sedation protocol for otherwise healthy, well-hydrated cats: buprenorphine 0.02 mg/kg (oral transmucosal), midazolam 0.2 mg/kg IV/IM, dexmedetomidine 3–10 μg/kg IM [23]. General anesthesia protocol for cats: premedication gabapentin 100–200 mg PO/cat 6–12 hours proceeding procedure; buprenorphine 0.01–0.02 mg/kg IM or IV 15–30 minutes prior to the procedure; induction: ketamine 2 mg/kg, and propofol 2 mg/kg IV, and midazolam 0.25 mg/kg IV. Intubated and maintained on isoflurane gas inhalant [24]. See Chapter 6: "Anesthesia Considerations for the Feline Patient," for further reading on other sedation and general anesthesia protocols. Cats benefit from being well-hydrated prior to the de-obstipation procedure. Subcutaneous (SC) fluids given at home the night before or IV fluid therapy prior to and day of the procedure is recommended.

1. Patients are placed in sternal recumbency with appropriate monitoring and warming measures.
2. Warm water is instilled into the colon by lubricating a 10–12 Fr red-rubber catheter and inserting 4–6 inches into the anus.
3. Pushing and pulling the warm water gently into the colon to lavage fecal material can help to break up concreted balls of stool. Alternatively, a retention enema of 5–10 ml/kg of water for 10 minutes may also rehydrate some fecal matter.
4. Remove the catheter from colon.
5. A lubricated, gloved finger is inserted into the anus 2–3 inches and fecal matter is scooped from the colon and removed. Repeat as required until the colon has been evacuated of fecal material. To aid in removal, the nondominant hand can gently apply pressure to the colon by palpating the abdomen and "milking" stools downward.
6. Intermittently administering warm-water enemas may help with extraction of feces.
7. Once all fecal material has been manually removed, an abdominal radiograph is recommended.

Note: *Manual extraction of feces is uncomfortable during and after the procedure. The use of analgesia is warranted.*

19.5.5 Intestinal Obstruction

GI foreign bodies are not uncommon in dogs and cats, however most of the available literature details are from dog populations. A retrospective evaluation of the surgical treatment of foreign bodies in cats by Gollnick et al. reviewed 56 cats from August 2009 to August 2021 who had surgery performed at Georgia Veterinary Teaching Hospital. The conclusion in this study discovered that cats undergoing surgical removal of foreign bodies did very well, with a low incidence of postoperative complications [25].

Table 19.5 Terminology used to describe intestinal foreign body obstruction.

Intestinal obstruction terminology	
Simple intestinal obstruction	Uncomplicated obstruction without the presence of leakage or decreased intestinal integrity.
Incarcerated intestinal obstruction	Occurs when a loop of intestines becomes trapped as it slipped through a herniated abdominal wall or similar rent.
Linear intestinal obstruction	Most commonly occurs with thread, string, or fabric material but can be a plethora of objects. The foreign object becomes fixed/anchored at one point and then continues on distally in the intestinal tract. The peristalsis movement of the intestines may cause them to become stacked or pleated around the foreign material.
Intussusception	Any segment of intestines fold in or telescope into an adjacent segment of intestines, ileocolic is most common site.
Septic peritonitis (secondary to intestinal obstruction)	Leakage of luminal contents (fluid, bacteria, and others) into the peritoneal cavity, causing sepsis.

Intestinal obstruction occurs when the lumen of the intestines is obstructed by a foreign object or, to a lesser extent, infiltrative disease. Sequelae caused by intestinal obstructions include concurrent leakage from the bowel into the peritoneal cavity, circulatory compromise to the intestine, and other devitalization of the intestines. See Table 19.5 for key terminology of intestinal obstructions.

Intestinal foreign bodies alter the motility within the gut due to ischemia, inflammation, bacterial toxins, and direct mechanics. In the initial phases of the obstruction, the intestinal reflex will cause increased peristalsis in front of the obstruction (proximal), and behind the obstruction (distal) peristalsis decreases. This physiological reflex will last for a few hours until hypermotility extends further proximally from the obstruction to the duodenum. Distally, hypomotility will extend into the distal segment of the ileum (small intestinal foreign body). The increased pressure proximal to the obstruction increases the risk of intestinal wall integrity failure. This excessive pressure also causes pressure at the site of the obstruction. The surrounding tissue will have decreased lymphatic and venous drainage, leading to intestinal wall edema. Full-thickness wall necrosis can ultimately occur, breaking down the mucosal barrier, leading to barrier dysfunction and contamination of the peritoneal cavity. The mucosal layer in the small intestines proximal to the obstruction is stimulated to secrete water and electrolytes into the lumen. This further contributes to fluid and electrolyte loss. The intestinal flora alters and increases the populations of flora, causing an imbalance of microbes [26].

The most common clinical signs in cats with intestinal foreign bodies are persistent vomiting followed by hyporexia to anorexia, small bowel diarrhea, and malaise [8, 27]. The severity of these signs is indirectly related to the location of the foreign body and the duration of obstruction. Dehydration and electrolyte derangements are common due to fluid sequestration and loss. Physical assessment findings may include palpation of a mass-like structure within the tubular structure of the intestines, discomfort, or pain. Dehydration and malaise are also common findings. The severity of changes noted on the CBC and biochemistry panel is dependent on the severity and duration of the obstruction. Changes seen may include neutrophilic leukocytosis, neutropenia, hemoconcentration, mild-moderate prerenal azotemia, and electrolyte disturbances (hypochloremia, hypo/hypernatremia, hypokalemia) [26].

A diagnosis is often made by history and physical examination, but direct diagnosis by diagnostic imaging is recommended. Abdominal radiographs and ultrasonography are useful in determining the location of obstruction, complications, such as peritoneal effusion and/or intussusception or plication.

Patients who are ≥5% dehydrated should undergo fluid resuscitation to help with perfusion to the intestinal tract, improve blood pressure, and promote favorable outcomes. Parenteral analgesia should be instituted at admission to the hospital. Some intestinal foreign bodies will pass into the colon with rehydration, analgesia, and nursing care. Repeated imaging to monitor progress as well as patient re-assessments are important to good outcomes. Antibiotic therapy is essential when the likelihood of intestinal wall integrity is questionable.

Parenteral antibiotic administration should begin in the preoperative phase and continue the postoperative depending on surgical findings. Small intestinal foreign bodies are best removed by laparotomy and enterotomy(s). When devitalized

intestines (or intussusception) are determined or questionable, removal by dissection is recommended. Postoperative care includes continuation of analgesia, IV fluid therapy, and nursing care. Reassessment of preoperative laboratory findings will aid in the weaning and discontinuation of fluid therapy. Dysmotility is common postoperatively and should be monitored. Monitoring for regurgitation, anorexia, vomiting, and abdominal discomfort will aid in identifying dysmotility. The use of focused-ultrasound imaging of the intestines for peristalsis may also aid in identifying dysmotility. Nutrition should be started early in cats (and dogs) despite enterotomies or resection. Nutrition plays a key role in maintaining the enteric brush border and feeding sooner will improve outcomes [26].

Prognosis following surgical removal of a foreign body is typically very good with an emphasis on earlier detection leading to the best outcomes. Pet parents should be educated about the potential for additional foreign bodies in the future. Once a cat gets a taste for hair ties there is no stopping them!

19.5.6 Hepatic Lipidosis

Hepatic lipidosis (HL), a primary disease that is caused by prolonged food deprivation, is not a GI disease per se; however, is important in mentioning due to the liver's responsibility in metabolizing amino acids, among other contributions to the GI tract. When cats suffer from prolonged food deprivation, peripheral fat mobilization occurs and often quickly overwhelms the liver's capacity to redistribute or use fat for energy. HL is often a sequela to a primary GI disease that causes hyporexia or anorexia to occur in cats. Identifying and/or starting empirical therapy to treat a cat for clinical suspicion of a primary GI disease is imperative to preventing/treating HL. This is especially true for obese cats but is not limited to affecting only them. HL is not an inflammatory disease, however, as aforementioned is commonly a sequela to a primary GI disease that is often inflammatory. Severe cholestasis (inflammatory) can also occur concurrently as the hepatocytes become distended with triglyceride vacuoles (fat). This distention causes compression of the canaliculi, contributing to or causing severe cholestasis. The inflammatory components that contribute to or cause HL in cats will often necessitate the use of anti-inflammatory glucocorticoid steroids. It is the opinion of the author that initially the use of parenteral steroids is of important to avoid a dysfunction in the GI tract. Read Chapter 22: "Hepatobiliary," for further information.

19.6 Diagnostic Techniques

19.6.1 Cobalamin and Folate

- Fasted for a minimum of 12 hours (PO water is fine).
- Serum sample of 0.5–0.75 ml.
- The serum should be separated and placed in a plain red-top tube.
- The sample may be frozen and submitted, but not required.

19.6.2 Gastrointestinal Endoscopy

1. Upper gastroduodenoscopy [28, 29].
   a. Patient preparation
      i. Fast for a minimum of 6–8 hours. It is recommended to take a lateral radiographic projection to visualize the degree of upper GI contents.
      ii. Biochemistry panel, CBC, and urinalysis prior to anesthesia
      iii. An example of an anesthesia protocol used for gastroduodenoscopy.
         1. Premedication: gabapentin 50–200 mg/cat PO the night before and morning of the procedure to lessen anxiety and decrease catecholamine and cortisol levels. Followed by butorphanol (0.2–0.3 mg/kg) IV or IM and midazolam (0.2 mg/kg) IV or IM 10–15 minutes prior to induction.
         2. Induction agents: ketamine 2 mg/kg IV, propofol 2–3 mg/kg IV to effect.
   b. Patients should be intubated with a cuffed endotracheal tube and maintained on gas-anesthetic and oxygen at the lowest mean-alveolar concentration (MAC) of the gas-anesthetic.
   c. The patient should be placed in left lateral position.

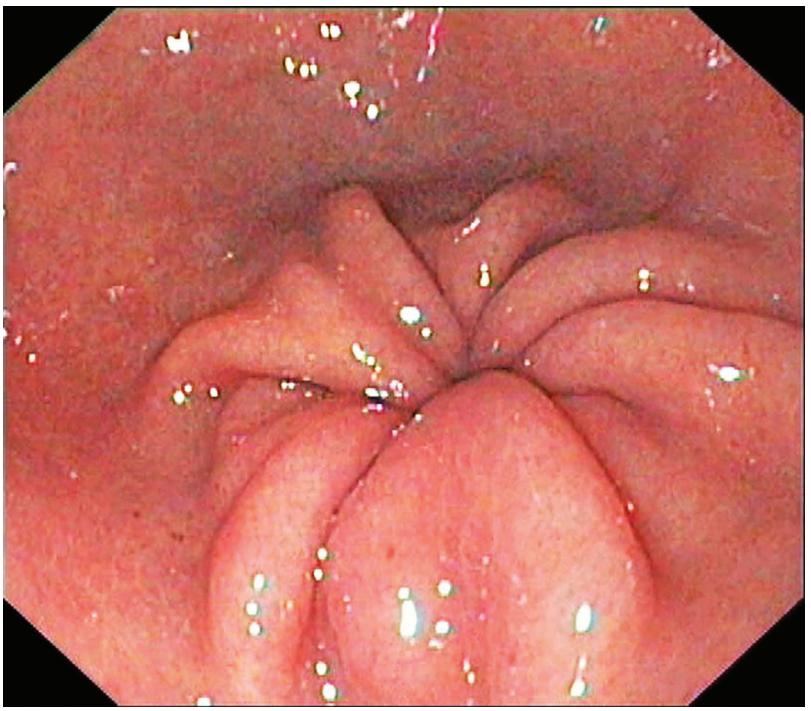


Figure 19.6 An image of the pyloric sphincter taken during an upper gastroduodenoscopy. *Source:* Science Photo Library / Alamy Stock Photo

2. Endoscopy equipment
   a. The use of commercial spring-loaded mouth gags is not recommended in cats due to the likelihood of developing Horner's syndrome post-procedure secondary to neuritis of jaw nerves.
   b. Use of a small mouth gag that provides protection to the endoscope and operator that does not exceed a ½ inch gap maybe used.
   c. The flexible endoscope should be no larger than 8 mm in diameter at a minimum 100 cm in length, and have four-way tip deflection. In smaller breeds of cats, such as Oriental lineage, which are known to have smaller antral canals, and ileocolic sphincter the use of an endoscope of smaller diameter (<6 mm) is beneficial.
   d. The biopsy channel should be at a minimum 2.2 mm, preferably ≥2.5 mm to obtain adequately sized biopsies.
   e. The endoscopy biopsy instrument.
   f. The formalin jar and cassettes to house biopsies.
   g. A 20 ml syringe with 0.9% NaCl – used to rinse the biopsied tissue off the biopsy forceps into the cassette.
3. Endoscopic biopsies flow cytometry
   a. Endoscopic tissue biopsy sample
      i. Rinsed well with 0.9 % NaCl.
      ii. Place the sample in a nonadditive vacutainer with a few drops of saline to moisten, and ship overnight (cooled) to the reference laboratory.
      iii. Most samples are submitted along with histopathology biopsies to be "held" for processing pending histopathology findings.
4. Figure 19.6 is the view of the pylorus through an endoscope.

19.6.3 Fecal Analyses

1. Coproantigen immunoassays (IDEXX Fecal Dx ® antigen tests): 1 g of fresh refrigerated fecal sample, shipped cold within 24 hours. Submitted in fecal collection container (plastic container) [28].
2. Fecal flotation: 1 g of feces suspended in a floatation solution (sugar or zinc sulfate or sodium nitrate), macerate gently, fill container with solution to form meniscus at top. Place coverslip for 15–20 minutes. Exam under microscope by placing coverslip on microscope slide.

3. Centrifugal floatation (preferred method): fecal sample placed in a centrifuge tube (blue-top test-tube container). Then gently macerated, filled with solution and a coverslip placed on top. The tube is balanced with an opposite equal centrifuge top, and both are placed in a centrifuge and spun at 1000–1500 rpm for 3–5 minutes. The cover slip is removed and examined on a microslip slide on the microscope.

GI disease in cats is commonly seen in all types of veterinary facilities. Recognizing the importance of a thorough review of clinical complaints (duration, severity), history (nutritional, lifestyle, comorbidities) is essential to diagnosing pathology. The veterinary technician assists in all aspects of patient diagnosis, examination, client education, and nursing care. Veterinary technicians should be knowledgeable about common GI disorders to empower them to assist clinicians and advocate for patient care and treatment. Common failures include not obtaining a thorough history, treatment of systemic signs, and review of previous complaints. Following a systematic approach by developing a problem list, possible differential diagnoses and developing a broad-view diagnostic plan will help to deter "miss-diagnosis."

See the companion website for further clinical references.

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20

Gestation, Lactation, and Pediatrics

Ellen M. Carozza, LVT, VTS (CP-Feline)

TECHNICIAN TIDBITS

- Stress reduction is paramount for the queen to allow her to feel safe to have kittens. Stress reduction not only prevents illnesses but reduces the possibility of her harming her litter.
- Knowing the blood types of the stud and dam in pedigree breeding can help eliminate neonatal isoerythrolysis due to blood type incompatibility.
- Utilizing diagnostic imaging via radiography and ultrasound not only can help determine the viability of kittens in utero but also allows you to determine gestation due to bone calcification after day 45 on X-ray.
- Become familiar with Appearance, Pulse, Grimace, Activity, and Respiration scoring kittens at birth. Not only does this help determine their immediate health when born, but it can also play a role in preventing sudden loss within the first few days of life. Know the common diseases that cause kitten mortality.
- Congenital defects are common, yet not all of them warrant euthanasia. Know when to advocate for care and understand the level of care necessary for minimizing mortality.

In veterinary medicine, we are taught to eliminate unnecessary animal litter to prevent pet overpopulation and disease. *More education is spent on the prevention of pregnancy vs. understanding reproduction, care of the queen and pediatrics.* Both are equally as important as we still need to be able to provide care for the animals in need. Despite our personal feelings on pregnancy termination or breeding, your goal as a technician is to understand reproduction in cats, care of the queen as her health directly correlates to the health of the kittens, how to troubleshoot and provide nursing care to our smallest and most vulnerable patients in veterinary medicine. This experience is rewarding and challenges your skills to a new level as with pediatrics as thinking outside of the box is key to successful diagnostics and nursing plans.

20.1 Breeding in Cats: So Many Kittens in Such Little Time

20.1.1 Queens

Whether controlled breeding or in community feline colonies, reproduction essentially happens the same natural way with the male cat seeking out the female in estrus (Figure 20.1). Kittens as early as 12 weeks have the ability to breed; hence, the latest recommendations by the Fix by Five campaign [1] to sterilize cats before 5 months of age to help reduce the likelihood of early pregnancy. While there is a concern with prepubertal desexing, most cats have little detrimental side effects. Cats will typically have 2–4 estrus cycles per year and can last anywhere from 15 to 22 days. Cats are spontaneous ovulators and if breeding is successful, estrus may not last longer than 4 days as well as the cat becoming pregnant by multiple suitors in that period of time. In situations where breeding does not occur (i.e., the home with no male cats present), the heat cycle can last an annoying week to 10 days with the cat parading up to anyone (usually in front of company) in hopes that breeding will occur, and this behavior will reoccur every 3–4 weeks indefinitely until sterilized. These cats can also have an estrus period typically seen as early as 1–6 weeks postpartum where she can get pregnant while still nursing the current litter of kittens [2]. The feline uterus is "Y" shaped where there are two uterine horns that connect to a single uterine body and a cervix, thus allowing a larger number of offspring with the expectation of natural selection that the majority of the litter may not survive into adulthood. Superfecundation is common in the domestic cat and tends to have anywhere from two to eight kittens (4 being a normal-sized litter, and is not dependent on the number of mating that has occurred) depending on age



Figure 20.1 Abyssinian breeding – Studs will mount the female and grasp onto the scruff pinning her down for mating. Mating is quick but can happen multiple times over the course of a few days. *Source:* Tania Andraschko.

and pedigree with little intervention needed for birth unless illness, congenital pedigree defects are present (i.e., Persians and other pedigrees with larger, rounded heads) cats that have had previous cesarean (C-sections) and bred again as well as cats bred at a very young age may need assistance. While there has been the discussion of superfetation (where a cat can become pregnant a second time while currently pregnant), it has definitely not been proven to occur, but results of this phenomenon have been reported with varying ages of kittens in the same litter [3].

In the controlled setting, breeding can be controlled with the amount of light cats are exposed to (12–14 hours or light), causing them to come into estrus earlier rather than being seasonal as their outdoor counterparts by manipulating the amount of melatonin produced. Suppressing estrus requires lower light levels of less than 8 hours per day [4]. However, in abstracts, there is little information on the feline reproductive performance under the use of artificial light [4]. Temperature seems to have a role as warmer climates tend to have longer, even year-round kitten seasons are common where thermal numbers do not shift as drastically as the environment is more ideal to continually have litters and also being closer to the equator having more light available year-round.

Artificial insemination, while rarer in cats than in canine and livestock medicine, is an option for breeders who are trying to keep a specific genetic line or prevent the extinction of particular breeds without having to physically breed the cats. While semen urethral catheterization (UrCaPl-urethral catheterization after pharmaceutical induction) collection is done typically under sedation or sperm can be obtained after neutering the male cat by squeezing or slicing the epididymis tissue for semen sampling. However, other methods, such as the artificial vagina can be used with training the male cat for sampling via this method or electroejaculation under sedation [5].

20.1.2 Toms

Male cats reach puberty between 7 and 12 months of age and the intact male cats' penile spines serve a purpose to induce ovulation in cats. The spines can be easily seen when extruding the penis to look for these barbs particularly when there is a suspicion of a potential neuter gone awry and there is perhaps that small chance where they thought the cat was a monorchid when in reality it is hosting a retained testicle (Figure 20.2). If the cat is neutered before puberty, barbs will not be present on the penis; however, if the cat is neutered *after* puberty, the spines will regress in 5–6 weeks post neuter as they are dependent on androgens; therefore, if the cat is given parental testosterone injections, the penile spines will reappear regardless of desexing due to the testosterone [6]. In rare cases of castrated cats, adrenal tumors that produce testosterone and androstenedione can produce penile barbs [7].



Figure 20.2 Cat penis barbs – Barbs are only present in intact male cats and they serve a purpose to make the female ovulate during mating. Once neutered, the barbs will disappear. In a neutered cat that has suspected retained testicles, this is an easy way to check for the cat producing testosterone. *Source:* Ellen Carozza.

In the author's opinion, we do know this; we have a population control issue that veterinary medicine should be responsible for helping reduce the population. Making spay/neuter affordable and advocating for public grants for everyone can help with population control as many pet owners cannot afford to provide care and individual rescues and Good Samaritans should not be responsible for the costs of helping the community. If you have the opportunity to help with a spay/neuter program, it is an incredibly rewarding experience and will put your skillset to practice as anesthesia and pain management may differ from what it is in standard practice, yet still provide optimal care to the patient.

20.2 Pregnancy and Birth

The hormones that control pregnancy involve estradiol-17β (estrogen), a luteinizing hormone; with the initial signal sent from the pituitary to signal that releases a surge of hormones that result in ovulation of multiple follicles and is directly related to how many times mating occurs and the level of progesterone that is necessary to maintain gestation also plays a role in mammary gland development.

Gestation in the domestic cat can vary from 52 to 74 days (average of 63–65 days) with the likelihood of complications with birth and fetal distress after 73 days. Premature birth at less than 60 days increases the likelihood of the litter not surviving along with being stillborn and mid-gestation spontaneous abortion can occur due to a multitude of issues that can happen. Environmental factors (including stress, poor nutrition, trauma, and dirty bedding/material nesting in), maternal factors including infections (bacterial/viral), and physical anomalies (uterine diseases) along with fetal issues can be causes for abortion in cats. Abortion secondary to diseases, such as feline herpes virus (FHV-1) around 5–6 weeks into gestation may result in fetal mummification and resorption. Unless a kitten is expelled, abortion may be hard for diagnosis to occur in the early stages of pregnancy [8]. At times of later abortion, it is not unheard of the cat to cannibalize the litter attempting to remove any trace of pregnancy. Communicable viral diseases that can cause abortions in cats include:

- Feline leukemia virus (FeLV)
- Calicivirus
- Feline immunodeficiency virus (FIV)
- Panleukopenia
- FHV-1

Bacterial infections include:

- *Escherichia coli* (*E. coli*)
- *Streptococcus*
- *Staphylococcus*

These bacterial pathogens that can result in abortion can be seen in normal vaginal flora. Protozoal infections, such as toxoplasmosis along with a multitude of pharmaceuticals and vaccinations can also cause abortion in cats and should be used with caution if the animal is not going to receive an abortive spay [8].

20.2.1 Determining Pregnancy in the Cat

Many times, pregnancy goes unnoticed until the cat visually looks pregnant, which is usually more than halfway through the 9 weeks of gestation to the untrained eye. Typically, fetal development cannot be palpated until at least 26–35; however, ultrasound can be utilized to determine pregnancy as early as 21 days post-mating. Fetal heartbeats for viability can be determined around 21–28 days, but it is not the best diagnostic tool to determine the number in the litter and can give false negatives for those not trained to hear fetal heartbeats via Doppler method. Radiographs can be used to determine pregnancy and the actual count when the fetuses are around 6 weeks (days 42–45 and beyond) into gestation. Fetal skeletal calcifying begins to occur around day 28 but is not readily seen on radiographs until past day 42. One of the challenges with radiographs is when the fetuses overlap with one another causing a miscount or performed too early. Radiographs beyond day 55 can provide a more accurate count for litter size. Either count spines or heads to get an accurate number. This allows the client to know how many kittens to expect in the litter to help determine if the cat may be having issues at birth and if the cat has kittens that are overly large or other factors that can result in a difficult birth that may require medical assistance.

Gestational age can also be determined using the formula: Mean litter crown-rump length (in cm) = 0.2423 × gestational age – 4.2165 [9]. In utero, each kitten has their own zonary placenta that provides nourishment through the pregnancy and an amniotic sac that wraps around them until birth (Figure 20.3).



Figure 20.3 Kitten placenta – Zonary placentas encircle the fetus. *Source*: Kalinda Clarke, VN.

20.2.2 Care of the Queen: What She Needs for a Successful Birth

Nutrition and stress reduction are key factors for healthy kittens to arrive. Focusing on the queen's pillars (see Chapter 3: "Preparing the Veterinary Hospital for the

Feline Patient," for Pillar Infographic) ensures her needs are being met for her to safely deliver and properly care for her kittens post-parturition.

20.2.2.1 The Queen's Pillars: Fulfilling Their Needs Whether a Companion Pet or Feral Cat

A feral/community cat that has been trapped and forced to have her kittens in an enclosed space to care for them is going to have a different level of stress than a companion cat. Regardless of background, all cats need to have their pillars met and the opportunity to thrive and have healthy kittens should be the goal.

It should be noted that feral cats are more likely to show protective emotions to not only themselves but their kittens as well. It is common for companion and feral cats that do not feel safe, to eliminate, and cannibalize their litter due to stress and their ability to determine if a kitten needs to be culled from the litter to spare the others.

- Provide a safe and private space for her to nest and to have her kittens.
- Provide areas of her key resources that are separated from her kittens. Her resting area with her kittens should be away from her food and litter pan. While they do not have to be in separate rooms, she should be able to get up, stretch, eat, and toilet in peace. She should be provided with a high-quality diet or fed kitten food to meet her metabolic energy requirement (MER) needs and to support the growth of her litter. After birth, the same high-quality diet should be continued to be provided.
- Provide the opportunity for her to play and fulfill her predatory behavior. While we feel most of her time needs to be with her kittens, domestic cats that are not feral may want attention and play time from their caregivers.
- Keeping a routine that is predictable involves human interaction.
- Providing an environment that respects the cat's olfactory senses.

Nesting may be seen in many cats preparing for birth and they may decide on unusual spaces or even want to have people involved with birth. Again, it is the feeling of safety the cat is looking for. While it may not seem so comfortable for us, the cats may think the spot they choose is perfect. Even if it is behind a dresser, under the bed, or in the closet. It is private, quiet, and safe for their kittens.

20.2.3 The Three Phases of Parturition

20.2.3.1 Stage 1: Relaxation and Preparation

Relaxation of the uterus, cervix, and vagina begins, and you may feel active movement with the kittens upon gentle abdominal palpation by simply placing an open hand over the belly. Many cats may be observed altering their bedding, making it as comfortable as they can, panting may occur, which is normal, and it is different from respiratory distress. When looking for vaginal discharge for the observation that birth is ready to occur, it may not be apparent as the cat may be constantly grooming her belly and vulva to encourage birth to progress as well as keeping herself clean. If this is a cat's first litter, this stage may take up to 36 hours and then suddenly progress to the next stage. Experienced cats that have had previous litters may have a very short window for stage 1 (one) before progressing.

20.2.3.2 Stage 2: Active Birth

Active birth occurs with strong uterine contractions, and one may see the start of an amniotic sac at the opening of the vulva. Usually rupturing on its own or with the aid of the queen, this fluid aids as lubrication for the kitten to be passed easily. In some cases, the outer membrane of the amniotic sac may not rupture causing the need to intervene if the cat cannot clean the kitten up fast enough, freeing itself from the capsule it has called home for the past 9 weeks. Active birth can take anywhere from 5 to 30 minutes and once the head is past the pelvis and peeking out. Generally, it should only take 1–2 pushes for the kitten to be welcomed into the world. If the cat is straining beyond 30 minutes to almost 2 hours with no progress (especially if you know the number expected for birth), the cat will need emergent medical intervention to ensure everyone is born and to prevent further distress to the mother (Box 20.1).

Box 20.1 A tip for those observing during parturition.

Many times, birth happens when we are not present. It is important not to hover as that does not respect the cat's space and can contribute to stress. If you need to watch, have a video camera available for monitoring and intervening only when necessary.



Figure 20.4 Post-parturition. *Source*: Gretchen Munderloh.

20.2.3.3 Stage 3: After Birth

After the kitten is born, the passage of any other membranes, fluid, and the placenta will be ejected and consumed by the cat. This is normal and should be allowed as this provides the cat with additional nutrients post-parturition. At this point, all kittens that have been born may already be seeking their personal spot at the milk bar to begin nursing while the queen is cleaning up the last kitten (Figure 20.4).

If at any point you notice kittens laying away from the mother, or kittens that are not cleaned and separated from their placenta, clean the kitten with a dry washcloth to stimulate breathing and tie the umbilical cord off at 1⁄4–1⁄2 inch from their abdomen using either suture material or clean dental floss with a tight square knot to prevent any wicking infection with betadine or tincture of iodine used to keep the cord clean. If the kitten is not stillborn and viable, return the kitten to the mother to encourage cleaning and nursing. If she removes the kitten away from the rest of the litter, she is giving a signal that this kitten is not healthy for them to devote attention to. This action maybe indicate the culling the kitten from the rest of the litter due to illness or underlying congenital issue we cannot visually see.

20.3 Dystocia

Dystocia can occur and it is usually seen mostly in pedigree and young cats yet, it can be managed in a few ways. It starts with the need to check on the kitten's fetal distress with the use of ultrasonography. This allows you to not only check on the viability of each kitten but the fetus's actual heart rate, which can give an indication of stress.

Fetal Heart Rates:

- >180: normal
- 150–170: moderate to severe stress
- <150: this is a life-threatening emergency, and a c-section should be performed as soon as possible [10].

In cases of emergent c-section, appropriate anesthetics should be utilized to prevent postoperative neonatal distress and poor recovery and death. Pain management must be provided to the queen regardless of nursing kittens after the fetuses are born.

If the fetuses are not in distress and the cat is deemed able to deliver the kittens vaginally after examination with ultrasound and radiography, medical management can be provided to allow natural birth.

- Medical management with oxytocin and calcium may be given and then the queen provided a safe, warm, and quiet area to give birth.
- An episiotomy may be performed to assist birth in some cases.
- Gentle traction on the neonate to assist birth- under no circumstances should the kitten be pulled out with force as injury to the queen can occur (uterine tears, torsion, soft tissue injuries to the vulva) as well as spinal, soft tissue injuries to the kitten.
- Pain management: In many cases, the queen will need some pain management to relax and allow birth to occur.

Dystocia can be obstructive due to prior injuries, internal uterine torsion, or even fetal anomalies. Functional dystocia can also be witnessed in the cat that produces weak uterine contractions and may be seen in some pedigree cats under stress, older in age, underlying comorbidities, and obese cats.

Typically, kittens will be born anywhere from 10 minutes to 1 hour apart and the cat may show signs of interrupted labor where she can delay the birth of her litter. This is particularly seen in friendly, dependent cats that want their human companion present. At times, this can also be seen with cats that are not officially bonded with a caretaker as commonly reported in the rescue setting [11]. During the rest period (24–36 hours), birth will recommence, and the cat will resume active labor, with all kittens being born with little issue. However, she should not be allowed to remain in active labor past 24 hours from the last kitten born (especially if you have a known number). When in doubt, this is considered an emergency, and the cat must be evaluated by a clinician. Any discharge from the vulva that is purulent, green/yellow in color, and frank blood with no kitten being born, is considered an emergency for evaluation of retained fetuses, uterine torsion, and infection.

Anyone assisting in the birth of kittens should be wearing clean clothing and wearing gloves to prevent any cross-contamination from our skin and clothing to the kitten's umbilical cords that can cause an ascending wicking infection into the kitten while tying off cords and handling the babies. It is no longer recommended to swing kittens to remove fluid from the pharynx but to use a bulb syringe that is narrow enough to fit into the mouth. In cases where a bulb syringe is not available, the use of a 12 Fr red rubber catheter and a syringe can be used. Using a dry washcloth or gauze, the kitten can be vigorously rubbed down and dried. Using a clean toothbrush also stimulates the cat's tongue for cleaning the kitten at birth.

20.4 Appearance, Pulse, Grimace, Activity, and Respiration Scoring in Neonates: Know Their Vitality Early on!

The kittens are here! Normally, this is where everyone peers in on the cat postpartum and points and coos at all of the adorable fuzzy beans planted at the milk bar. Yet, your job as the queen's personal nurse is not over, we need to document Appearance, Pulse, Grimace, Activity, and Respiration (APGAR_ scoring (birth assessment) for each kitten to get a baseline of their health that can indicate the chances of survival. The scoring focuses on appearance, pulse, grimace, activity, and respiration. APGAR scoring should take place immediately after birth once the kittens are clean from natural birthing or recovered from a c-section. Core body temperature and weight should be noted. Each kitten should be given their individual identification band if the cats have no distinguishable marking, and a photo should be taken for reference. Sex can be determined at birth as male kittens are born with their testicles descended; however, to the untrained eye, labial folds can give the appearance of the cat being male (Figures 20.5 and 20.6). Aside from APGAR scoring, a full TPR, and getting these babies warm, each kitten should receive an exam to check for any congenital defects that can affect their quality of life.

Congenital defects are common in cats that share genetics too closely related as seen in pedigree lines and from community cat colonies. *Not all congenital defects are grounds for euthanasia; however, many of these kittens may need to be hand reared due to the severity of the defect.* Commonly occurring defects can include but are not limited to:

- Cleft palate/cleft lip or both
- Atresia ani/rectal strictures

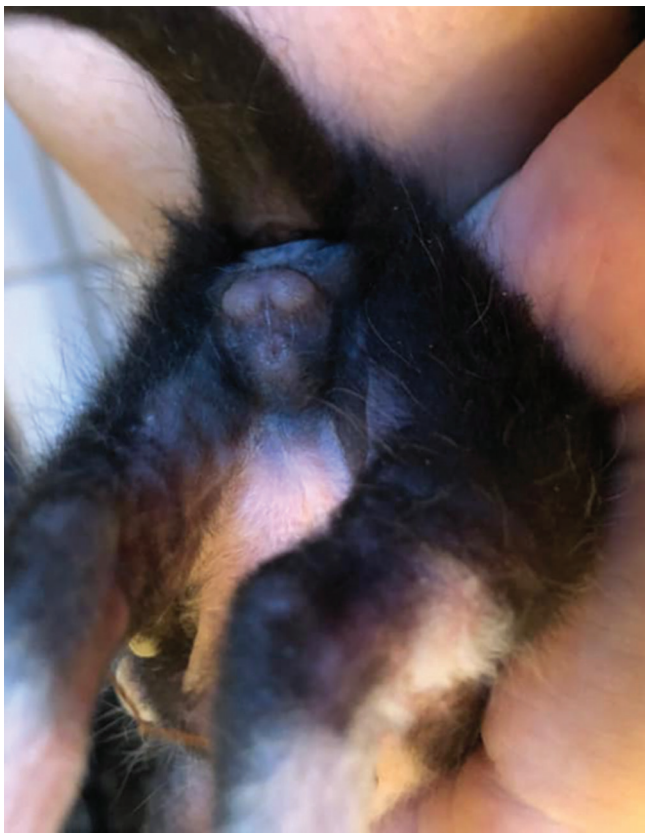


Figure 20.5 Male kitten – At birth, the sex of the male kittens can be easily determined as they are born with their testicles descended. *Source*: Ellen Carozza.

- Gastroschisis (internal abdominal organs are born on the outside)
- Limb deformities
- Extreme cases can include anomalies, such as diprosopus (two faces)
- Persistent right aortic arch
- Megaesophagus
- Hydrocephalus
- Hepatic shunts

Before taking on these advanced care orphaned cases, ask yourself the following:

- Can this kitten urinate and defecate?
- Can this kitten either be bottle-fed or tube-fed?
- Can I afford the care, have the physical capability and *support of my medical team* to do so, and can I emotionally understand that the mortality rate is higher and despite the care, the kitten may still succumb to the anomaly?

  If the answers are yes, go ahead and try! This is how you learn to care for advanced cases and educate the community how despite some challenges, these cats can make wonderful companions.

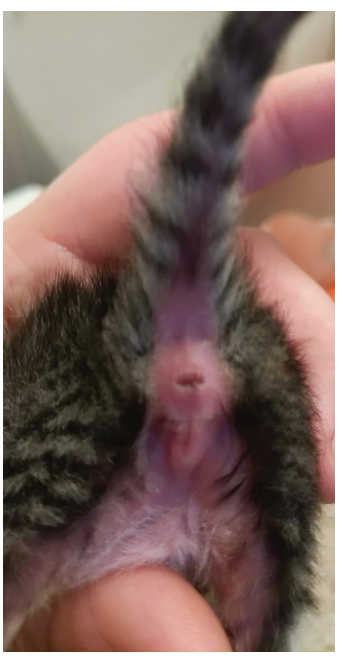


Figure 20.6 Female kitten – At birth, the sex of the female kittens can be determined; however, plump vaginal folds at times will fool the untrained eye confusing them for a scrotum. *Source*: Michelle (Meisha) Gustafson, BS, CVT.

It is extremely important to have a medical team willing to think outside of the box to provide advanced medical care to these cats. All pharmaceuticals are considered off-label use in cats less than 6–8 weeks of age unless directly stated for use. The hesitancy for anesthesia is also a common problem that occurs as modifications to doses and aesthetic machines need to be made to

accommodate such small patients. Care is entirely possible if you have a team that believes in advancing their tactics, use these cases as teaching tools and everyone has the same goal to help these kittens survive.

20.4.1 APGAR Scoring: What You Need to Look for at Birth

- Mucosal color (Figure 20.7)
- Heart and respiratory rates
- Reflex irritability: toe pinch, suckle response- do they respond?
- Muscle tone: are they active and moving?

Each parameter should be given a score of 0, 1, or 2, with 0 being the poorest score. Vitality is defined as the state of being strong and active.

- 0–3: Weak vitality
- 4–6: Moderate vitality
- 7–10: Normal vitality

Scoring of 4–6 may indicate resuscitation may be indicated while scores of <3 are indicated for emergency care. Reflexes should be paid close attention to as there is more than one evaluation to determine reflexes. Ask yourself, do these kittens have a suckle response, can they right themselves when placed on their back and root for a nipple when prompted [12]?

Kittens that have poor responses may need intervention to stimulate respiration with the use of oxygen and the acupuncture point GDV-6 (the area below the apex of the nose and the start of the split in their upper lip) using a 25 g needle if acupuncture needles are not available. At times, the use of bronchodilators may be necessary as well as the use of epinephrine. Supplemental glucose should be on hand to provide a drop of glucose under the tongue. *Refrain from using Karo (high fructose corn syrup) syrup, honey, or maple syrup in newborns as the fluid is sticky and the kitten is already in distress.*



Figure 20.7 Newborn kitten- Breed, maternal illness, and nutrition play a role in the size of the kittens and the number in the litter. *Source*: Danielle Southon, Southon Rescue.

You do not want to cause further pharyngeal obstruction with a sticky, thick substance. Use 50% dextrose orally as the solution is not viscous.

Kittens should be recovered in an incubator at 86–90 °F and kept warm until the queen can be reunited with them. *Do not give a queen still recovering from anesthesia her kittens back as she can easily injure or smother them.* If direct heat is being used, it is important that the surface they are lying on is not over 95–100 °F. *While small, they have a large surface area and are prone to overheating and dehydration through the skin- especially premature neonates.* It is advised to use a laser thermal gun to check surface area temperature and check for hot spots.

20.5 Nursing and Lactation

While we tend to take it for granted as soon as those kittens are returned to mom, we do not need to do much more. Most cats are wonderful mothers and are able to provide for their babies; however, under circumstances they may need additional support if they, themselves, are not well. Aside from pregnancy, lactation is the most energy-demanding period. Cats that are ill during birth, underweight, or too young may not be able to provide enough milk for their litter as their body wants the nutrition for itself before it can provide it to the litter. Ensure the queen is being fed enough food to meet and exceed her caloric needs. While she may still enjoy routine, having food continually available allows her to get up, eat, and drink as needed. Peak milk production occurs at 3–4 weeks, the same period as when kittens will also begin to explore and eventually wean onto a commercial diet. Nursing cats require higher ratios of protein and fats. Providing her with a high-quality diet or kitten food can easily meet those needs.

Colostrum, an antibody-rich fluid produced by the mammary glands in the first 24–48 hours of birth, is provided as the kitten's first meal. Kittens are almost agammaglobulinemic at birth, transfer of IgG from their digestive tract into their bloodstream is crucial for their survival, with IgG absorption ending at 12–16 hours after birth [13]. This fluid is also what provides immunity to the kittens. Kittens that are not provided with colostrum in the first 24 hours of life are at a higher risk of succumbing to disease than ones that have received colostrum. The use of serum or plasma for correction of failure of passive immunity in abandoned kittens can be utilized [14]. If the kitten is less than 24 hours old (ideally less than 16 hours old), serum or plasma (15 ml is the ideal amount to be given to kittens over the course of 6–8 hours can be divided into smaller increments if that amount is even available) can be given orally via stomach tubing due to the permeability of the lining of the stomach that allows for passive immunity from colostrum. *Over 24 hours old serum or plasma may be given subcutaneously. However, it does sting quite a bit and may cause the neonate to have a few moments of distress until absorbed. It is not recommended to place the serum or plasma into a fluid bubble from subcutaneous fluids.*

When dealing with cats of unknown blood type, it is safer to use a Type A cat as most domestic cats will be Type A. However, in many circumstances blood typing for the kitten may not be possible, and risks vs. benefits should be taken into the equation of making a decision to provide serum or plasma injections. In pedigree cats, knowing their blood type ahead of time when mating, can make the use of another cat in the breeding program easier as a donor as well as *preventing neonatal isoerythrolysis.*

20.6 Kitten Mortality

A number of variables can cause death within the first 2 weeks of life for kittens. From poor environmental conditions, illnesses passed from the queen to the kittens, hypothermia, low birth weight, congenital defects, infections, and hypoglycemic episodes are all factors that can contribute to neonatal death.

Feline neonatal isoerythrolysis (FNI), while considered rare, has a high mortality rate due to a queen having Type B blood and nursing kittens with Type A or Type AB blood. Maternal-derived derived antibodies (MDA) in kittens are passed through nursing as their placental type does not allow a significant passage of antibody transfer during pregnancy. Death typically occurs within the first few hours to days with these cases and affects the A, or AB blood type kitten, born from a B blood type mother by getting anti-A antibodies when it starts nursing and receiving colostrum in the critical period. A classic symptom of FNI is deep orange to brown hemoglobinuria when hand-stimulating the kitten to urinate due to intravascular breakdown. Other symptoms include lethargy, jaundice, tachycardia, and pale MM. However, those symptoms are

Table 20.1 Blood transfusion therapy for neonatal isoerythrolysis (Type A males bred to Type B females) [18, 19].

Blood type: Washed red cells from the queen OR another type B cat may be used (washed) *All future transfusions as kittens and later in life should be with Type A blood.*	**Dose:** 5–10 ml per kitten over several hours. Monitor for typical blood transfusion complications. Red cells should be suspended in saline, not plasma to reduce the exposure to anti-A-antibodies.

also typically seen in kittens that fail to thrive. Survivors of FNI may experience tail tip necrosis as it is associated with cold IgM action, hemagglutination, clot formation, and ischemic necrosis. Due to the warmth of the mother and the tail being the furthest point from the body that does not get to remain warm, such as the face and head (the ears and nose will not be affected), the tail tip withers and will simply fall off without much intervention. Treatment for FNI kittens is aggressive and begins with removing suspected kittens from the mother to prevent further transmission of A-antibodies. Blood transfusions may be necessary in cases if the kitten is severely anemic and may still not survive [15] (Table 20.1).

20.7 Postpartum Complications in the Queen

Mastitis, an inflammatory condition to the mammary tissue, may be encountered in cats that are typically kept in unsanitary conditions causing an ascending bacterial infection and can also be caused by traumatic events. The mammary tissue can become encouraged, painful, and at times severely infected that can result in abscessing and tissue death. If more than one gland is affected and there are enough teats for the kittens, many cats can be given antibiotics that are safe enough to penetrate the mammary tissue and enter the milk. Cats that have severe infections require pain management and have mammary tissue that is abscessing; the kittens should be removed, and hand raised to the care and health of the queen [16].

Kittens should not be allowed to drink septic milk as it can contribute to their mortality. Retained fetuses, retained placentas, metritis, and uterine prolapse can be experienced with these cats as well. Some cats will experience lethargy, fever, inappetence, depressed mentation, vulvar discharge, and failure to care for their kitten. Cats with uterine infections/prolapses should have their kittens removed and should be spayed and cared for accordingly to treat the infection. Her care should not be compromised simply because she needs to be present to care for her kittens. If the queen gets sick, she can easily pass her illnesses to her kittens, fail to provide proper nutrition, and do not want to care for them due to lack of energy and illness present. Queens that are pregnant and presented with illnesses either with URI or uterine infections; their care comes first. Remove the kittens from her for hand rearing while her care can be focused on.

20.8 Kitten Care

Kittens under the care of the queen should be monitored daily to ensure they are growing properly, have no illnesses, and are gaining weight. Ideally, kittens should be weighed daily; however, in circumstances where a feral mother may still be caring for her babies, it may not be possible to weigh daily if she is protective over her litter. If a kitten needs to be removed for examination if an illness is suspected, long tongs (16–24 inch in length) with rubber bumpers covering the tapered oval head, one can easily remove the kitten from the litter and replace the kitten with the same way without injuring the kitten with the teeth of the tongs. If there is a kitten that is lacking weight gain or being pushed away from the litter, remove the kitten for hand rearing or supplemental feeding.

Kittens that are with a social mother should start to be handled around 2 weeks of age regularly as this is the impressionable period of socialization. Kittens that are with a feral mom, who are weaning and not as dependent on her, should be removed for human socialization and adoption and the queen spayed/vaccinated and returned to her site of trapping. Kittens beyond the socialization period that are feral tend to become conditioned by 10–12 weeks and may not be able to be socialized. If the opportunity is provided, it may take much longer to earn trust for potential adoption. Regardless of the size of the litter, the kittens should be provided toys as they age as this provides the opportunity to learn predatory behavior and provide emotional stimulation outside of simply playing with siblings.

20.8.1 Orphaned Kitten Care

Orphaned kittens require a lot of attention and care as they are completely dependent on the person caring for them. Routine of the caregiver and kitten must be established to accommodate the necessary care possible for the next several weeks until the kitten is more self-sufficient. It is equally important that the caregiver understands and is prepared for the loss of hand-reared kittens as many of them have underlying issues that are being treated with medical support. At times, the life of the caregiver will revolve around these cases and in turn cause emotional and physical anguish preventing optimal care for the kitten. Know your limits by only accepting the number of kittens you can care for at a time as these kittens will simply suffer from poor quality care vs. humane euthanasia. Sleeping through alarms to check on kittens every few hours not only indicates limitations of the caregiver, but that kitten may be in a crisis that goes unnoticed. These kittens need to be cared for during the day as well and during busy times, may miss meals, not be given relief to urinate and defecate, and heat sources may become too cool. It is very important that technicians caring for orphaned kittens in the workplace have them on the schedule, so they get the care required and have the support of the rest of the medical team.

20.9 Bottles and Tube Feeding; What Can Be Used for Orphaned Kitten Feeding and How to Perform Tube Feeding When Necessary

Choosing a bottle and nipple system can have its pros and cons for hand-raised kittens and many can have a preference for the size, shape, and length of the nipple being used. Many commercial bottle sets come with a variety of nipple sizes for use with only 1–2 being preferred. Wildlife nipple sets that are longer, but thinner tend to be more accepted and come in 2 length sizes accommodating for the much smaller, premature kittens to their regular-sized litter mates making it easier to get them to latch for feeding vs. tube feeding. Having several on hand for the kitten to latch and become accustomed to be recommended for optimal care. The nipple should only have 1 drop of milk come out of the end when the bottle tipped on the edge; however, many of the wildlife nipple sets are easily adapted for use with a 5–12 ml syringe set allowing the user to document exact volume and the kitten has control of feeding and the user has less of a change to be tempted to squeeze the bottle flooding the kitten and potentially causing aspiration pneumonia or death.

Tube feeding is an easy and quick way to provide nutritional support to neonates and pediatrics, especially if they are not able to suckle due to a congenital defect or illness. Start small and work your way up in size as many kittens start out with a 3.5 French red rubber or nasogastric tube and then accept a 5 Fr and up as they grow. At no time should the kitten struggle with tube feeding or esophageal bulging seen. If that occurs, use a smaller tube, and gently feed the tube down the left side of the mouth to have easier access to the esophagus and less likely to tap the larynx causing the kitten to gag. Tube feeding does require the patient to be measured from the tip of its nose to the last rib to ensure no excessive tube length is being fed with the opportunity to curl around itself in the stomach or being fed too little and potentially flooding the esophagus and causing aspiration. After feeding a calculated meal and not overfeeding in volume (kcal/day should be calculated and volume distributed over multiple meals in 24 hours), the tube should be pinched and then removed to prevent any excess formula left in the tube from potential choking.

Bottle babies, at times, develop a poor emotional reputation, especially if raised as a singleton. These kittens did not have the opportunity to socialize with other cats and maybe a bit confused by the funny-looking cat that is caring for them- you. They thrive on routine, enjoy being cuddled when being fed, and need additional TLC as they do not have siblings or the ability to snuggle up to a mom around the clock for many weeks. Regardless of the use of stuffed animals to mimic mom or siblings, it is not the same and we need to ensure their emotional welfare is put into consideration. Utilizing feline pheromones on blankets and stuffed animals to cuddle into can help ease some of the stress. Grooming is also important and often forgotten. The queen does a lot of cleaning of her kittens, and we can easily mimic this with the use of a soft toothbrush that is specific to that kitten. Even when adopted out, send the kitten with their personal toothbrush, it becomes a favorite security blanket and helps create a new bond between the kitten and the new human caregiver. After feeding, use the toothbrush to gently sweep along the head and face and down the body, completely "cleaning" the kitten to mimic the natural cleaning motions of the queen.

This will also get the kitten ready to comply and potty easier. Using a gauze square, cotton round/ball, or tissue (as it will allow you to look at urine color), gently sweep the anal/genital area to stimulate a "licking" motion the queen would get the kitten to relax and urinate and defecate. Bottle babies should be allowed to urinate and defecate after each meal if not before (however, they may want to eat first) and the output should be notated if normal or abnormal.

It is essential that these kittens receive additional hands-on time and TLC from not only the caregiver but anyone who is able to provide additional hands-on attention to prevent bonding with a single person. If the kitten is being reared in a home with other cats and there is little opportunity for passing disease, and the other cats want to interact, let them participate and help this kitten learn how to cat. The orphaned kitten needs to understand that it is not a funny-shaped human that has different communication skills, it needs to understand it is a cat. The discussion for kitten kindergartens comes up frequently and is a wonderful idea; however, there is always a possibility for zoonotic disease and many of these kittens have not finished up their vaccination series so the potential for becoming ill is quite possible.

Providing plenty of toys to explore and play with depending on age helps keep kittens engaged with their environment. First-time toys (usually at 3.5–4 weeks) can easily be a crinkle ball that not only gives specific tactile stimulation but is also exposed to the noise they can make. Same for pom-pom puffs. They are excellent starter toys to provide a kitten the opportunity for prey play and natural predatory behavior. As they age, you can move up to toys that mimic prey, such as feathers and felt ribbon wands to provide stimulation to learn to hunt.

20.10 Milestones

(Table 20.2)

Kittens grow fast and will be hitting key milestones within a very short period of time. Knowing their normal values at birth and as they age can provide valuable information on proper growth and indications for illness. It is important to remember that beginning at 2 weeks of age, the kittens become impressionable, and socialization begins. While many neonates form a wonderful bond quickly with the caregiver, kittens with a queen may take a day or two to warm up to a new situation due to their instincts of being a predator and becoming possible prey.

Within the first 3–5 days of life, the umbilical cord should be dry and fall off easily. Monitor the area for redness, swelling, and discharge as this can indicate omphalitis and serious septic GI infections can occur. The dusky/bruised colored abdomen is an indication that a critical issue is present and aggressive treatment is necessary to recover the kitten. While at this point in their life, they are simply dependent on eating and being able to potty regularly, they do show satisfaction, and it is common to start hearing these kittens attempt and learn how to purr within the first few days of life responding to a comforting stimulus.

By week 2 and 3, these kittens are responsive to handling, and as their vision becomes more acute, and may be apprehensive of being picked up and held suspended in the air as they are now aware of the depth of field and may panic if not fully

Table 20.2 Week-by-week milestones: What to expect and when.

Week 1	The umbilical cord falls off, and they begin to purr, kittens able to move themselves from hot and cool spaces for thermoregulation.
Week 2	Eyes and ears open. Routine deworming can begin usually by 10–14 days.
Week 3	Walking (better motor coordination) begins, and incisors erupt. One can also easily sex kitten by week 3. These kittens are beginning to explore their surroundings.
Week 4	Social play, weaning, learning to use a potty box. The immunity gap begins with the depletion of MDAs in the body that help prevent disease but may still be too high for vaccine efficacy. You should also be able to determine what coat type the kitten will have in adulthood.
Week 5	Kittens are showing more independence and are in that adorable snuggle bug stage.
Week 6	All deciduous teeth are usually present by week 6–7. CORE vaccinations can be started
Weeks 7 and beyond	Socialization and grooming become normal as well as eyes begin to change color.

supported. This starts our critical socialization period, so it is important to expose these kittens to not only the caregiver, but other people and healthy, safe pets to be around. You should also see incisors beginning to erupt.

Weeks 3–5 we see a lot going on! These kittens are mobile, they are exploring the environment, they are beginning to play, and are weaning themselves from mom and the bottle. This is also a critical area around week 4 where we see the MDAs begin to wane yet are present enough that vaccination may not be as effective. See Chapter 9: "Feline Immunology and Current Vaccination Guidelines," for further information.

Weeks 5, 6, and 7, we have kittens that are fully engaged, and the vaccine series can be started by week 6. By now all of the deciduous teeth should have erupted, be fully mobile, and learn prey and predation behavior.

By week 10–12, these kittens should be fully weaned (with some stubborn exceptions) and are able to be adopted as they are no longer reliant on littermates or the queen. It is important that kittens have a playmate so they can continue their social behavior and not be kept solitary with no mental and emotional stimulus that cannot be provided during the day by another living being. Kittens can be spayed and neutered safely by 2 pounds or by 5 months of age. *Regarding the concern with neutering too early and the urethral size in male cats, it has been found that early neutering does not affect urethra diameter and does not contribute to urinary blockage in male cats* [17].

20.11 Kitten Nutrition

If hand or supplemental rearing, providing a commercial kitten milk replacer, and knowing how to calculate the daily MER for the kitten(s), not just the volume of food they should be intaking is important to meet their growth goals. At birth, kittens require 15 kcal ME per 100 g body weight. Depending on age, meals will vary from every 2 hours in the first week of life to expanding to every 3–4 hours in the second and third week and then onto 4–6 hours until weaned. Many kittens are underestimated for their caloric needs as many charts are simply focused on volume to make it easier for the public to care for these kittens. Kittens should be weighed daily, and one should expect anywhere from 10 to 30 g of weight gained per day. Sudden weight loss of >10 g can indicate dehydration and other issues, such as poor nutrient uptake. These kittens need to have their diet modified to prevent gastric ileus as the gastrointestinal (GI) tract will begin to slow down as the kitten begins to decompensate. Nutritional indiscretion, GI infections, and parasites are causes of diarrhea and can lead to severe dehydration in the neonate that can be difficult to correct. Utilizing a body scoring chart can help the caregiver not only assess weight but also give the body a weekly score to help aid in physical assessment and health (Figure 20.8).

If gastric ileus is suspected, clear fluids, such as oral electrolytes or Lactated Ringer's (lactate is an energy source but should not be used in kittens with pale/white/gray stool as this can indicate liver issues) may be given orally with additional dextrose to help prevent food fermentation, move food through the GI tract, and keep the kitten hydrated. However, one can also change the ratio of the diet to 1 : 3 or 1 : 4 formula to water to dilute the formula down, but still get calories in. This is not a long-term solution, but a solution that can replace a few meals in 12–24 hours to get the gut moving again.

Additional support with IV/IO or SC fluids may be necessary to prevent hypovolemic shock in these cases as GI ileus is a sign the kitten is beginning to decompensate. Kittens require fats and proteins for growth and there are currently no established ratios on carbohydrates. We do know that the only glucose source that can be digested is lactose, a carbohydrate found exclusively in mammals' milk. The pancreatic activity of amylase (the enzyme that helps to break down carbohydrates) is practically nonexistent during a kitten's first 4 weeks, which prevents kittens from being able to digest nonlactose-based carbohydrates until they are older than 4 weeks [18]. Pancreatic enzymes or digestive enzymes may need to be utilized with the commercial formulas when kittens are exhibiting a difficult time digesting the formulation if not moved to a higher quality one that is more easily digestible. Diarrhea from nutritional indiscretion needs to be taken seriously and corrected quickly as many of these kittens will lose weight rapidly and succumb to poor nutritional uptake.

20.12 Weaning the Kitten

Weaning kittens typically begin at 3.5–4 weeks of age naturally, and kittens with a queen will follow her and their siblings lead on wanting to investigate and try new food while continuing to nurse until removed from mom altogether. A high-quality Association of American Feed Control Officials-approved kitten diet in wet and dry form should be provided to allow investigation, but never forced to eat as this can cause food aversion and create a bigger issue as the kitten gets older. Kittens that are bottle fed may have more of an issue learning to eat from the floor as they are used to eating elevated

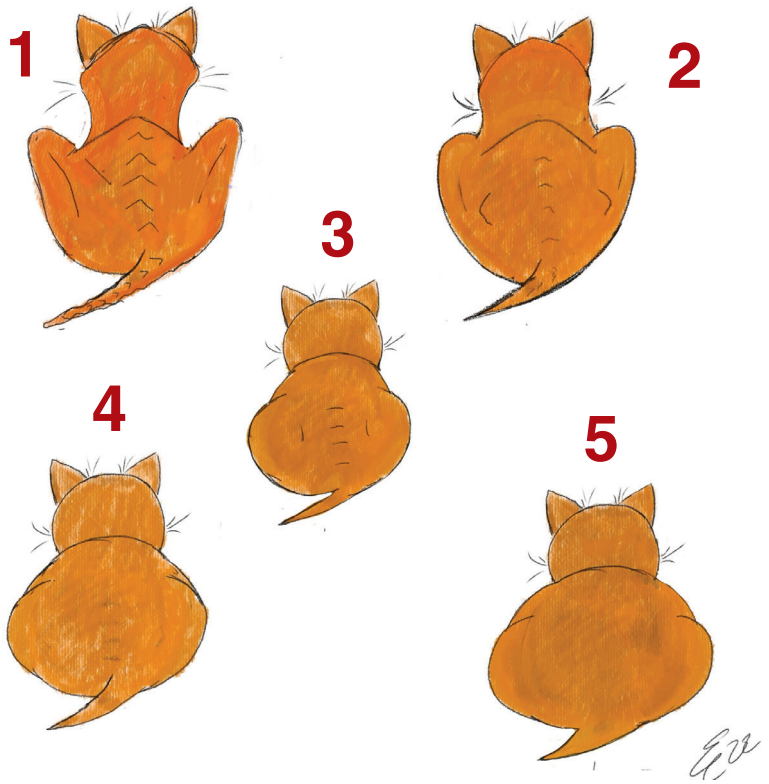


Figure 20.8 Body scoring – Body scoring compliments daily weight loss and gain. Each day you are completing a mini physical on the kitten to ensure its health status. *Source:* Drawing and scoring system is the property of Ellen Carozza, The Cat LVT LLC.

food when bottle fed. Using a spoon, you can easily hold the meal at the kitten's face level while they are sitting up or standing, allowing them to taste the food. Gradually bring the spoon to the floor or provide a tilted bowl or bowls that can be on a higher surface to allow the kittens to eat at their naturally comfortable level.

20.13 The Critical Neonate

20.13.1 Dehydration

Dehydration is common in the critical neonates (they are 80% water!) and can be difficult to assess as neonates lack skin turgor (not a reliable tool for use for any cat under 6 weeks of age) to rely upon to check the dehydration status normally used in cats [19]. Increased fat and lower water content in the skin simply make it unreliable, in comparison to the adult cat and should not be utilized. Checking urine color (normal is pale to clear yellow), tackiness of the mucous membranes, and weight loss can lead to a better assessment of their hydration status.

Feline neonates can handle subcutaneous fluid replacement when mild to moderately dehydrated (<5%) and have normal perfusion. If the kitten is stable and needs mild fluid support after a bout of diarrhea, oral fluid therapy with clear electrolyte solutions, such as Pedialyte® can be given with a feeding tube if the kitten has good mentation and is still active. When chronic diarrhea is an issue and we begin to see lethargy, dulled mentation, and isolation, then additional fluid support via SC, IV, or IO will be necessary.

Kittens with poor perfusion should be provided IV or IO fluid therapy as they will not be able to absorb fluids subcutaneously due to peripheral vasoconstriction associated with hypovolemic shock. Having 26–24 g IVC available to provide resuscitation care via cephalic, or jugular catheter placement can make a remarkable difference for these patients when seen in practice other than just offering a method of fluid therapy (SC) that could do more harm than good. While maintenance

Table 20.3 Fluid calculations/recommendations for dehydration correction in feline neonates/pediatrics [20].

Intravenous Support: 1 ml/30 g body weight	**Subcutaneous Support:** 120–180 ml/kg/day
Initial bolus: (30–45 ml/kg) is administered by slow IV push over 5–10 min. *After the initial bolus*, therapy is dropped to a rate of 80–120 ml/kg/day. Fluids are administered until the kitten has a CRT of 1 s and MM is bright pink in color	**% dehydration and body weight in kg = liters** of crystalloid fluid that can be given in a 24-h period. You do not have to give a single fluid bolus one time per day but can break it up to allow for easier absorption and comfort of the kitten. It is important to warm the fluids to 95 °F to prevent hypothermia in the kitten.
Crystalloid fluid therapy: Normosol-R with 5% dextrose added, lactated ringers are fluids of choice for resuscitation in the neonate.	**Crystalloid fluids for subcutaneous use:** Normosol-R, lactated ringers, 2.5% dextrose in NaCL in normally perfusing, mild to moderate dehydration kitten only!

requirements in the neonate are two to three times higher than the adult cat at (120–180 ml/kg/day), this amount can be divided up and administered several times during the day instead of one large fluid bolus in the interscapular space on the mild to moderately dehydrated kittens. The use of Lactated Ringers, sodium chloride (NaCl) 0.45%, or Normosol-R are appropriate for use in the subcutaneous space for fluid replacement therapy. Fluids with added dextrose can be administered at 0.45% NaCl with 2.5% dextrose with normal perfusion- not on hypoglycemic or hypothermic kittens [20]. Any percentage of dextrose above 2.5% given in the subcutaneous space has the ability to cause tissue trauma (Table 20.3).

Intraperitoneal (IP) fluid therapy can be utilized, but only for trained personnel due to the likelihood of puncturing internal organs or laceration to the intestinal tract. Crystalloids, whole blood, and even colostrum can be given IP; however, whole blood takes up to 72 hours for absorption and may not help in cases of anemia [20]. Fluids given IP should be warmed and can also help correct hypothermia in many cases. Hypertonic dextrose solutions should not be given IP.

20.13.2 Hypoglycemia and Hypothermia: Two Problems Typically Seen Together

Hypoglycemia and hypothermia in the neonate are a common issue with orphaned kittens. Ensuring the kitten is kept on a warm surface if direct heat is being used or kept in a protected and controlled environment, such as an incubator can help prevent hypothermia or be used to aid the kitten to become normothermic. Due to the immaturity of the liver and its limited glycogen stores, neonates and pediatrics are prone to hypoglycemia, and it can happen quite suddenly [19]. One moment the kitten seemed fine and an hour to two later the kitten was now in a crisis. What went wrong and how can we correct this? When hypothermic, the body uses its glucose stores to attempt to regulate body temperature, and with the limited glycogen stores the kittens have, hypoglycemia occurs rather quickly. Agitation, lethargy, and anorexia are common behaviors displayed. Some kittens may head press into corners of an incubator or bedding, others may simply fall into a comatose episode in lateral recumbency to become limp as a rag doll or paddle in place with the head arched back and vocalizing. Regardless, it is important to get the kitten normoglycemic by administering glucose. While the first go-to is generally high-fructose corn syrup as it tends to be readily available in the cabinet, in the critical neonatal and pediatric patient it can cause an issue if used straight from the bottle due to the thick viscosity and being hypertonic causing an already compromised kitten who may be decompensating have their airway become obstructed. Instead, use 5–10% dextrose solutions. One can easily make a 5% solution by adding 100 ml of 50% dextrose (50 g dextrose) to 1 L bag of fluids, same for 10% by adding 100 g of dextrose to 1 L. If the kitten is normothermic and not dehydrated, the kitten can be tube fed giving 0.25–0.5 ml of 5% dextrose solution per 100 g bodyweight until responsive and normoglycemic. It is important to wait 5–10 minutes between boluses to prevent the stomach from bloating.

20.13.3 Failure to Thrive

Pathogens and problems that can be treated and can contribute to mortality, see Chapter 9: "Feline Immunology and Current Vaccination Guidelines" and Chapter 23: "Infectious Diseases," for further breakdown of diseases. Kittens are fragile and there are a multitude of diseases that can cause death in the first few weeks of life and many of these kittens succumb very quickly once we begin to see symptoms. When the call comes into the clinic or if these kittens are presented, medical care must be initiated with the discussion of potential poor outcomes. Regardless of you and your medical team's personal opinion of the case, the client owns the pet and is requesting help. Providing the level of help that can be initiated with the discussion of the outcome at times is better than turning the patient away for another clinic to deal with. Kittens

that are labeled as "fading kittens" or the latest term used that is more appropriate, "failure to thrive," in fact die of a multitude of problems and the use of necropsy is a valuable tool for confirmation of why. There are many factors that lead to the failure to thrive and contribute to kitten mortality.

Aggressive nursing and medical care are warranted and many times the kitten still succumbs to the problem at hand due to not knowing the true contributing factors. The inability to provide the right kind of care, no appointments available, being too late to provide the care and the kitten is beyond medical assistance, not knowing how to provide the right kind of medical care (or the horrifying excuse given "we don't see neonates" is more common than you think), the caregiver does not have time, money or emotional abilities, diagnostics are unable to be run due to the limited sampling that can be provided and more are all involved in these cases. Why are we not able to provide the same level of care to these patients as their adult counterparts? Where are we uncomfortable in providing the care and how can we help? A good portion of it is knowing what common issues these kittens are put up against in turn helps us provide a better level of care. The other part is gaining the confidence and willingness to get out of your comfort zone and hone in on some new skills! After all, these are the next generation of patients that are going to be seen at the practice.

With kittens, respiratory infections, congenital defects, infectious diseases, GI diseases, such as diarrhea, omphalitis, septicemia, and systemic diseases. Bacterial infections are common in neonatal and pediatric patients and unfortunately, it is common to run into limited options for treatment either due to lack of anecdotal use through risks vs. benefits or knowing that the antibiotic option can contribute to mortality. Regardless, treatment at times is a better option than death and the clinician having the discussion of what the side effects could be with the client is better than only offering euthanasia or knowing the client (especially in rescues this is seen) is antibiotic hoarding and providing treatment at home because treatment was denied and now the wrong treatment options are being passed around. Species of *Staphylococcus, Streptococcus, E. coli, Campylobacter*, and *Salmonella* can contribute to septicemia infections in the neonate. If caught and treated early, the likelihood of mortality goes down with aggressive care. Many neonates that are exposed to queens or other cats with URI (FHV-1) can develop viral infections and secondary bacterial infections, such as neonatal ophthalmia (Table 20.4), which requires the eyelid to be teased open and the eye treated to prevent vision loss or worse, loss of the eyeball itself (Figure 20.9). It is important to treat or advocate for treatment if the kitten is symptomatic. Death is a permanent solution compared to potential issues antibiotics can cause. Monitor closely for adverse effects.

Viral infections, such as panleukopenia (a parvovirus) are highly contagious and have a high mortality rate when born and can also be a cause for early abortion in the queen. Transmitted through the fecal-oral route, having kittens that have been exposed and are quite messy, it is a disease that easily transmits quickly in entire litters either from each other or the caregiver not being able to clean appropriately and using personal protective equipment when cleaning. Postnatal infections of kittens can be characterized by fever, loss of appetite, depression, hemorrhagic diarrhea, vomiting, and dehydration. Profound leukopenia involving all white blood cell (WBC) populations is observed in these cases [21].

Table 20.4 Chapter definitions. [11–13, 15, 16, 18, 19]

APGAR scoring: a physical exam that is performed soon after birth to determine the vitality of the kitten.
Colostrum: the first form of milk excreted from the mammary glands after birth that provides antibodies to develop immunity in the kitten.
Dystocia: difficult birth that can be caused by a multitude of issues, such as fetal size, uterine disease, physical stature of the queen, and traumatic events.
Hypoglycemia: low blood sugar.
Mastitis: an inflammatory (swelling) response in mammary tissue usually caused by an infection.
Neonatal isoerythrolysis: immune destruction of red cells in the neonate due to incompatible blood typing of the queen and tom. It is activated when the kitten nurses and is exposed to allo-antibodies.
Neonatal ophthalmia: a type of conjunctivitis that occurs at birth in the neonate that still has the eyes sealed closed. This painful infection causes purulent discharge to form behind the lid and swelling is noted. This type of infection can cause corneal ulceration, perforation, blindness, and eye loss.
Superfecundation: Ova that is produced in the same heat cycle and fertilized from separate acts of mating and different toms.
Superfetation: A rare event of becoming pregnant when already pregnant. In cats, this may be seen with fetuses of different ages at birth.
Weaning: the act of slowly introducing solid foods to a kitten and removing them from nursing.



Figure 20.9 Neonatal ophthalmia – Neonatal ophthalmia is a common illness in kittens infected at birth by the queen. It is important to use a delicate touch to open the eyes early for treatment and intervention as this can cause corneal ulceration and at times loss of the eye. *Source*: Emilie Rackovan.

Regardless of a kitten having a vaccination on board, infection can still occur as vaccination failure against FPV is due to the interference of MDAs can still be present. This is why it is important for anyone in high-risk situations (shelter, rescue, hospitals) to practice good hygiene, and isolation between litters before adding more kittens into the home.

FeLV and FIV are a concern with all kittens, yet FeLV is more contagious (grooming, vertical transmission) with contact vs. FIV with direct blood contact (through deep bites that break the skin). Both can be passed via vertical transmission from the queen while in utero or nursing as high concentrations of the viruses are found in milk. There is never a wrong time (there is no declared testing age) to test for FeLV or FIV, especially in suspected cases; however, a positive test result may not be seen for weeks to months until the virus commences to replicate [22]. Both FeLV and FIV have specific diagnostic algorithms available through the American Association of Feline Practitioners (AAFP) in the retroviruses guidelines and should be utilized to properly diagnose any kittens.

Calicivirus not only can cause full body pain and fatigue but also painful oral sores that prevent the kitten from nursing. A highly contagious URI that spreads rapidly and can lead to systemic infections that cause pneumonia. These kittens do need to be treated for pain and may need nutritional assistance with tube feeding as oral lesions on the tongue may prevent suckling on a bottle or nursing on the queen.

With kittens, it is important to maintain and begin their Core vaccinations in high-risk situations as early as 4 weeks (shelter, high volume rescue) or 6 weeks for kittens, not in high-risk situations and providing boosters at their regular 3–4-week intervals as recommended by the 2020 AAFP/AAHA Feline Vaccination Guidelines.

Parasites also contribute to kitten mortality, and it is imperative that kittens begin deworming as early as 2 weeks; however, pregnant queens should also be routinely dewormed to prevent vertical transmission to the kittens. Ascarids such as roundworms and other parasites, such as coccidiosis, giardiasis, and trichomoniasis can cause severe diarrhea, fluid loss, and poor nutritional uptake. Diarrhea from parasites needs to be combated in a multimodal fashion to help alleviate symptoms and prevent the problem from worsening. Many shelters and rescues require kittens at 10 days–2 weeks of age to not only be dewormed with either fenbendazole or pyrantel pamoate but also given a course of ponazuril at intake to cover routine parasites and potential coccidia and giardia infections.

GI infections secondary to omphalitis can be seen in a large number of cases, especially if the kitten is born in a poorly maintained environment. Diarrhea is also a challenge due to GI infections and nutritional indiscretion. Before the formula is blamed, it is important to know if the kitten is being overfed or has another problem contributing to this factor. While the use of probiotics is encouraged, and many commercial formulas have probiotics in them, many are destroyed due to improper storage and reheating of the formula. Utilize a secondary probiotic with the kitten after the formula is made. Most probiotics lose efficacy starting around 110 °F, so it is important to know the temperature of the water being used for reconstitution to not destroy the fragile beneficial bacteria.

With the multitude of issues present and possibilities for loss, it is amazing to see what these fragile creatures are exposed to in such a short period of time to get to the next phase in life. By 10–12 weeks, these kittens are self-sufficient and while they are still learning about the world around them, they are able to source food, are socialized to either being used to humans or with their own community cats, and still vulnerable to disease (especially if not vaccinated or series not finished) as maternal MDAs are still present beyond 16 weeks of age. They should also be receiving their rabies vaccination and still should be receiving the feline viral rhinotracheitis, calicivirus and panleukopenia (FVRCP) series. It is advisable for kittens, that their FVRCP series are given on a regular basis up to 16 weeks of age, then a single booster at 24 weeks provided for optimal immunity against disease. The first year of life, when not cared for indoors, is precarious, and these kittens can get into a lot of trouble that is not disease-related. Demographically dependent, community kittens can be easily seen as prey for other animals, targets for human abuse, need to learn food sourcing/hunting, and more. These kittens are also constantly exposed to parasites and over-infestation can lead to mortality. Female kittens past 12 weeks of age are at the age of becoming pregnant and the cycle of life starts again unless they are part of a trap, neuter and release (TNR) program that provides desexing and vaccination to prevent zoonosis and reduce the cat population in the area. Depending on care, many of these cats live a short life of less than 5 years, usually due to disease or traumatic events. Yet, colonies that are cared for can live well into their senior years.

Our indoor kittens, on the other hand, need to learn how to function as members of the household are making bonds with the humans and perhaps other animals they reside with and learning the routine. These kittens also need to have their pillars fulfilled to provide a happy and safe life for years to come well into their senior years. While indoors, they are still prone to accidents and interpret conflicts that can lead to traumatic events including death, and improper care by the human caregivers they are depending on to thrive.

The role as the veterinary technician in practice, whether to help the queen maintain a healthy pregnancy or safe anesthesia for an abortive spay, is to take the time to ask questions, provide exemplary nursing care, educate the client, and advocate for the cats and the kittens seen in practice. Reproduction and pediatric care are rewarding experiences that help us continue learning about the feline species and evolve our level of medical care for our smallest patients.

See the companion website for further clinical references.

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21

Hematology

Camille Kelly, CVT, VTS (ECC)

TECHNICIAN TIDBITS

- To differentiate between agglutination and rouleaux when evaluating blood films, agglutination will appear as a group of red blood cells clustered, similar to grapes, whereas rouleaux appears as a stack of coins.
- Low numbers of Howell–Jolly bodies and Heinz bodies are a normal finding in healthy cats.
- Since ethylenediaminetetraacetic acid (EDTA) anticoagulant can cause Mycoplasma species to fall off the erythrocyte and increase the likelihood of stain precipitation, it is a good practice to create a blood smear directly from the patient in addition to one from an EDTA whole blood sample.
- Capillary blood taken from the ear pinna might yield a higher number of parasitized cells in cases where *Cytauxzoon felis* is suspected.
- Cats with blood type AB can receive Type A blood products.
- Since feline platelets are prone to clumping (even when the blood collection was skillfully performed) and their platelets may be incorrectly identified as canine RBCs, it is crucial to evaluate a blood smear when thrombocytopenia is reported from the complete blood count analyzer.
- Approximately 10–12 ml/kg of blood is the volume that can safely be donated in a healthy cat with normal PCV, based on lean body weight.

This chapter focuses on the study of blood in cats by examining the composition and health of the blood cells, bone marrow (where blood cells are produced), and related organs like the spleen and lymph nodes. Blood is composed of two main parts: the majority is plasma (mostly water with proteins, electrolytes, nutrients, and waste products), and blood cells (red blood cells [RBCs], white blood cells [WBCs], and platelets). The main functions of blood are the transportation of gases, nutrients, and hormones, regulating pH and volume, and protecting against the disruption of homeostasis.

Erythrocytes are the RBCs, which are biconcave-shaped discs with a large surface area for gas exchange. Their main job is to transport oxygen. Erythrocytes do not have a nucleus, which means they are not capable of repairing themselves. Inside each RBC is hemoglobin (Hb), a structure composed of globin proteins with four heme groups, surrounding an iron molecule. One oxygen molecule binds to an iron atom within each heme group. Blood becomes saturated with oxygen after passing through the lungs, which have a large alveolar surface area that allows for the rapid diffusion of gases. Oxygenated blood returns to the heart and is distributed throughout the body.

Erythropoiesis is the production of RBCs, which occurs in the bone marrow of cats. Stem cells are influenced by the hormone erythropoietin, causing them to develop into erythrocyte precursors. These precursors go through a series of maturation (erythroblast stages to reticulocyte to mature RBC) within the bone marrow before being released into the bloodstream. Conditions such as hypoxemia (low blood oxygen level) can initiate this process. The average lifespan of a mature erythrocyte is approximately 70–120 days. Expired erythrocytes are removed from circulation by the spleen and liver, and consumed by macrophages. As Hb is degraded, the protein component, globin, is hydrolyzed into amino acids, which can be reused for building new proteins. Iron, which is contained in the heme, can be stored in the liver or recycled to form new Hb molecules. Bilirubin is a byproduct of normal RBC breakdown, which the liver conjugates into bile. Bile travels to the intestines and aids in digestion, ultimately carrying bilirubin out of the body through feces. The feline spleen does not contain a sinusoidal structure, so it does not act as a large blood reservoir as it does in other species [1].

Leukocytes are the WBCs, which are part of the immune system and protect against infection. Leukopoiesis occurs in the bone marrow, starting with a hemopoietic stem cell, to colony-forming units, to precursor cells, to mature cells (Figure 21.1).

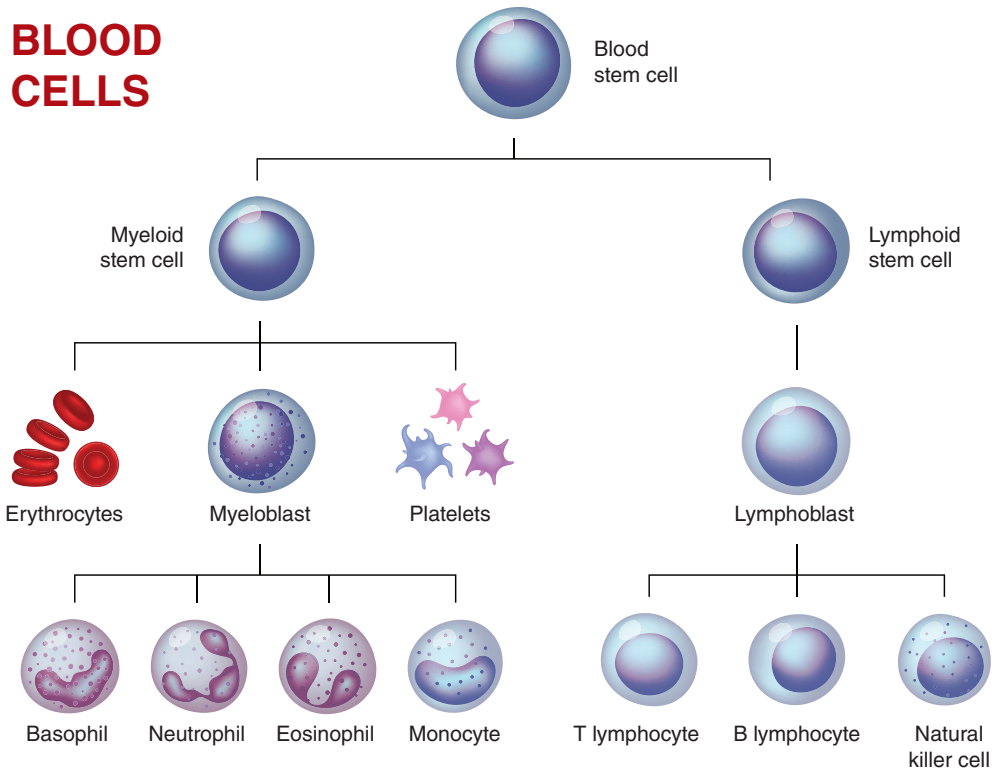


Figure 21.1 Types of blood cells.

There are two main types of leukocytes: phagocytes and lymphocytes. Phagocytes consume foreign material, cellular waste, and bacteria. Eosinophils, basophils, and neutrophils are granulocytic phagocytes, and monocytes are agranulocytic phagocytes.

The main function of the eosinophil is to kill parasites. They are also involved in modulating substances, such as histamine, that mast cells release during an allergic response. Basophils are rarely noted in healthy cats. Neutrophils are the first line of defense against pathogens, remaining in the blood for an average of 8 hours. With such a short lifespan, the concentration of neutrophils in the blood is dependent upon a steady supply from the bone marrow, which stores 5 days' worth of mature neutrophils. Band neutrophils can be observed when the bone marrow is stimulated to produce these immature phagocytes due to inflammation or infection. Monocytes are released by the bone marrow while still immature and are the largest type of leukocyte. They become macrophages, epithelioid cells or multinucleated inflammatory giant cells based upon their location and influence of chemical messengers, such as cytokines.

Lymphocytes defend against foreign invaders and cancer cells, traveling in a circuit from the peripheral blood to the lymph nodes, to the lymph, and back to the blood approximately every 12 hours. They can survive for years [2]. B cells are lymphocytes that produce antibodies which coat foreign invaders, marking them for elimination by the immune system. T cells are lymphocytes that traveled to the thymus and represent approximately 70% of all lymphocytes. They fight off viral infections and cancer cells, and release cytokines. Natural killer (NK) cells are lymphocytes that destroy foreign material. Sometimes, an inappropriate response occurs, and antibodies are produced against the body's own cells, resulting in what is termed autoimmune disease.

Thrombocytes, also known as platelets, are a necessary component for hemostasis, which is the body's response to bleeding. Platelets are formed from megakaryocytes, with an average lifespan of 3–7 days. A portion of platelets and RBCs are stored within the spleen as a reserve pool, ready to be released into circulation should the need arise. Exercise or excitement can cause a temporary increase in platelet count, which does not have clinical consequences [3]. Activated platelets release chemicals that attract and activate other platelets, causing them to clump together and form a temporary plug at the injury site. This plug helps to seal the breach and prevent excessive blood loss. Platelets also work in conjunction with clotting factors in the blood. They release signaling molecules that activate a cascade of events, ultimately leading to the formation of fibrin, a strong mesh that stabilizes the clot and promotes healing. Feline platelets can be difficult to accurately

count since they are prone to clumping, even when the blood collection was skillfully performed [4]. Thrombocytes of cats are activated more easily by precursors to aggregation (such as collagen or thrombin) than dogs. Activation of thrombocytes results in the release of serotonin, which is a potent vasoconstrictor and induces primary aggregation of platelets [5].

For effective hemostasis, there must be an adequate number of functional platelets, clotting factors, and vessels that have the ability to constrict. Primary hemostasis is the first step in normal coagulation, which involves adhesion, activation, and aggregation of platelets. Secondary hemostasis includes the formation of fibrin via the clotting cascade (Figure 21.2).

When a blood vessel is injured, the first response comes from the smooth muscle cells in the vessel wall which contract (also known as vasoconstriction), narrowing the opening and reduces blood flow. Platelets circulating in the blood encounter the exposed collagen fibers in the damaged vessel wall. This activates the platelets, causing them to change shape and release chemicals that attract and activate other platelets. Activated platelets become sticky and adhere to the injured area and to each other, forming a loose platelet plug. Blood plasma contains many proteins called clotting factors, which are produced in the liver. Activated platelets trigger a complex cascade of reactions involving these clotting factors. Calcium is an important co-factor in the clotting process. One major clotting factor, thrombin, plays a crucial role by converting fibrinogen, another clotting factor, into fibrin, an insoluble protein that forms long, thin strands. Vitamin K facilitates the production of fibrinogen; in the absence of vitamin K, abnormal bleeding will occur. The fibrin strands intertwine to form a strong mesh that traps RBCs and platelets, giving strength to the clot and sealing the wound. After the wound heals,

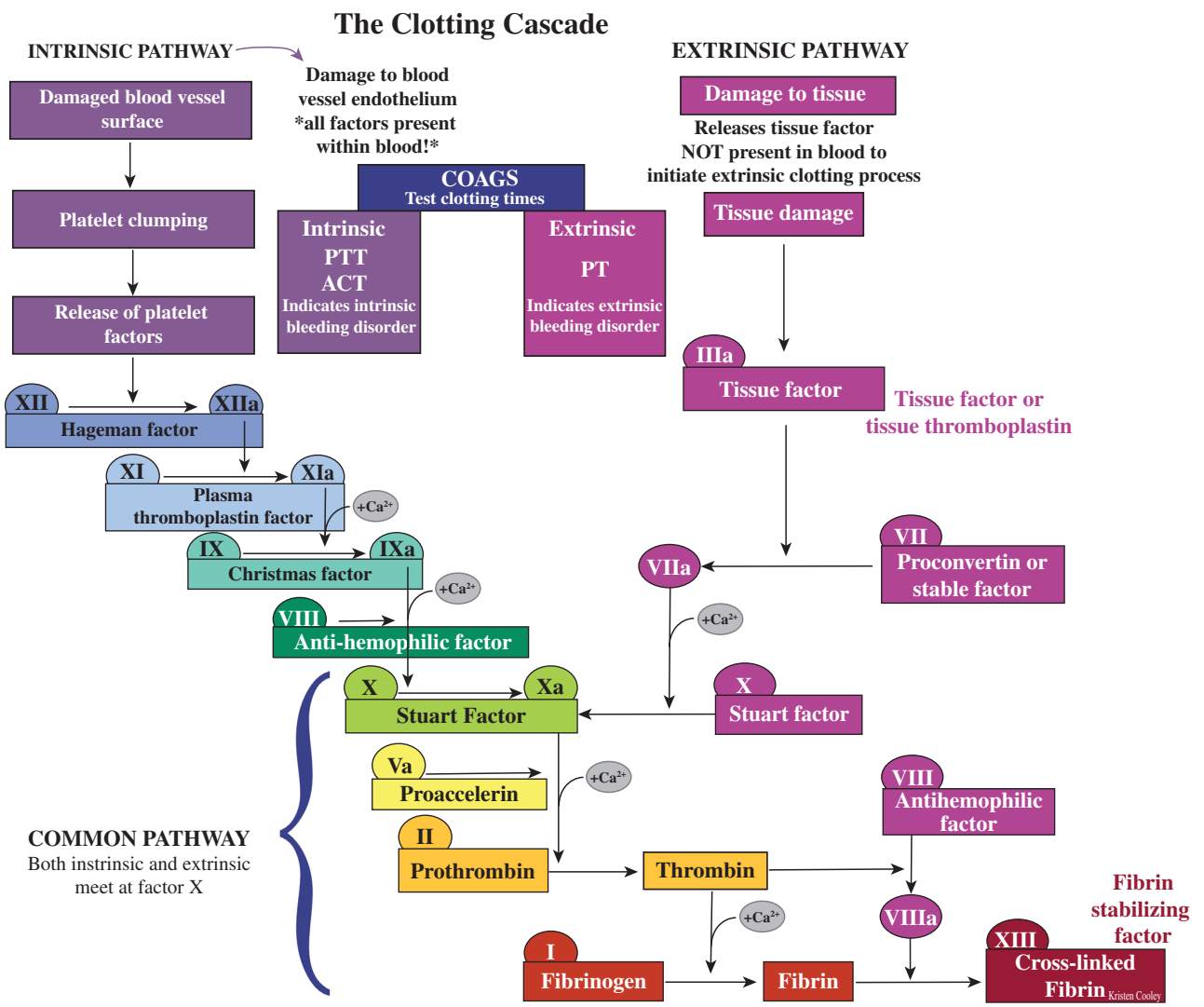


Figure 21.2 Coagulation cascade. *Source:* Kristen Cooley.

the clot is broken down (also known as fibrinolysis) by the enzyme plasmin, which gradually breaks down the fibrin mesh, allowing for normal blood flow to resume. Natural by-products of fibrinolysis include D-dimers and fibrin degradation products (FDPs). The coagulation cascade is a useful starting point to understanding laboratory tests of coagulation.

21.1 Patient History and "History Gathering Questions"

Obtaining a comprehensive history is crucial to evaluating the entire patient. It is always helpful to encourage the owner to share any other observations or concerns they might have about their cat's health. By gathering a thorough history, the veterinary technician can gain valuable insights that can help guide diagnostic tests and treatment decisions for feline hematology cases. Vaccination history, nutrition provided, and recent travel to areas with specific tick-borne or other infectious diseases can be important considerations. Some questions to ask that would be relevant to hematological concerns:

- What is the age and breed of the cat? Certain breeds may have predispositions to specific blood disorders.
- Is routine parasite prevention being administered, and what type? Internal and external parasite prevention is crucial, as some parasites can impact blood cells.
- Is there a history of recent illness or surgeries? These can influence blood cell counts temporarily.
- Is the cat taking any medications? Be sure to ask about prescribed and over-the-counter drugs.
- Does the cat have contact with other animals? This can help assess the risk of infectious diseases.
- Has the cat been spayed or neutered? If not spayed, is there a history of pregnancy? This can be relevant for certain hormonal influences on blood cell production.

21.2 Clinical Signs

The symptoms associated with hematological concerns can be vague and nonspecific, but some common presentations might offer clues. Lethargy, weakness, and pale mucus membranes can be signs of anemia or other blood cell abnormalities. Inappetence, decreased appetite, weight loss, or muscle wasting are associated with various health issues, including blood disorders. Fever can be a sign of infection, which will impact blood cell counts. Vomiting or diarrhea can lead to dehydration and electrolyte imbalances, potentially affecting blood cell function. Concern for clotting issues arises if petechiae or ecchymoses are present. Common locations for this are the pinna, gums, and inguinal region. The presence of blood in vomit or feces is a sign of gastrointestinal (GI) bleeding, which can indicate potential clotting dysfunction. Hematochezia, or bright red feces, is seen with bleeding from the lower GI system, whereas melena (dark/black feces) raises suspicion for upper GI blood loss. An increase in respiratory rate and/or effort could be related to anemia or other blood problems affecting oxygen transport.

21.3 Physical Examination Findings

A physical examination uses a systemic approach to detect abnormalities and guide diagnostic testing. This skill develops over time and experience, and it is important to know what to look for in a patient when hematological dysfunction is suspected. The general appearance of the cat, coat quality, body condition, mentation, posture/gait, and hydration status should be evaluated. Body weight and vital signs, such as temperature, heart rate, respiratory rate, mucus membrane color, and capillary refill time must be obtained.

In cats with hematological abnormalities, pay particular attention to the mucus membranes. Pallor is a common finding in the anemic patient. Icterus can indicate problems with bilirubin metabolism, which is often linked to liver issues that might affect blood cell production, or a result of hemolysis in cats with immune-mediated hemolytic anemia (IMHA) (see "Diseases" section). While not specific to hematological concerns, swollen lymph nodes can indicate an underlying infection or immune system disorder that might also affect blood cells. Tachycardia is often the body's compensatory response to anemia, as the heart tries to pump more blood to deliver oxygen despite having fewer RBCs. In states of decompensation, sometimes bradycardia is present in cats. A heart murmur may be appreciated in anemic cats (see "Anemia in the Diseases" section). Since the spleen plays a role in red blood cell breakdown and storage, splenomegaly can be associated with some blood cell disorders.

Additional points to consider are the severity of signs, which can vary depending on the underlying hematological issue. The sudden onset of clinical signs might suggest a more acute problem, while gradual changes may indicate a chronic underlying condition.

21.4 Specific Nursing Care Considerations

Cats with hematological dysfunction, such as anemia, leukemia, or thrombocytopenia, will benefit from specific nursing care to manage their condition, improve their comfort, and track changes during hospitalization.

Minimize stress by providing a quiet, comfortable environment with familiar bedding and space to hide. Depending on the degree of anemia, the patient may be tachypneic; this population requires the greatest care regarding stress. Any feline in respiratory distress should be allowed to rest with oxygen therapy while discussions take place regarding sedation to obtain intravenous (IV) catheter access for emergency stabilization and diagnostic testing. While oxygen therapy does not provide much support for anemic patients, since their oxygen-carrying capacity is diminished and must be addressed, utilizing an oxygen cage for these patients may be helpful as the design of the cage reduces noise.

Minimize unnecessary handling by bundling treatments together so the patient can rest. Using feline pheromones can help create a calm atmosphere. Maintain a clean litter box and environment to minimize the risk of infection, which is greater for cats with compromised immune systems. Infection control standards may need to be escalated, such as wearing exam gloves when handling neutropenic patients. To meet nutritional requirements, appetite stimulation or tube feedings may need to be incorporated. In patients with thrombocytopenia, handle the cat gently to avoid injuries that could cause bleeding and minimize the frequency of venipuncture. As well as avoiding jugular venipuncture and applying a temporary pressure bandage to any venipuncture site to reduce hematoma formation. If the patient is at risk of injuring itself, sedation may need to be implemented.

Some hematological conditions can be painful, specifically bone marrow diseases such as aplastic anemia, myelodysplasia, and bone marrow infiltration by cancer cells. Therefore, pain assessment and analgesic implantation should be considered.

21.5 Red Blood Cell Conditions

21.5.1 Anemia

Anemia is a condition in which the total volume of erythrocytes is reduced, and the destruction or loss of RBCs exceeds the rate at which they are produced. To make this determination, the Hb, packed cell volume (PCV), or hematocrit (HCT), and RBC count must be evaluated (Figure 21.3). Technicians should be aware of factors that might influence these results; for instance, Hb concentration will be falsely elevated in lipemic samples by spectroscopy on most hematology analyzers.

These values are affected by the total plasma volume, so this must also be taken into consideration. Cats with a normal volume of erythrocytes but who are dehydrated may appear to be hemoconcentrated, and dehydrated cats who have a decreased volume of erythrocytes may display falsely normal RBC values.

Anemia can be absolute or relative. In absolute anemia, the total red cell mass is decreased, while the plasma volume is normal. Relative anemia is characterized by normal red blood cell mass and an increased plasma volume. This is also known as dilutional anemia, which can occur after the administration of IV fluids or a result of splenic sequestration of RBCs. It is important to obtain the patient's total protein levels when evaluating the PCV, since hydration status and the level of plasma proteins will affect plasma volume.

Regenerative anemia is characterized by a low RBC count and a high reticulocyte count, indicating that the body is responding appropriately to the loss of RBCs. Nonregenerative anemia occurs when the bone marrow is no longer able to produce sufficient RBCs to replace these losses.

A new or worsening heart murmur is associated with anemia. In many cases, this would be considered a functional murmur, arising from turbulent blood flow within the heart chambers as the blood becomes thinner and less viscous. A murmur can also develop as a compensatory mechanism when the body tries to compensate for anemia by increasing cardiac output to deliver sufficient oxygen to tissues. This increased workload on the heart could cause turbulence, particularly in older cats or in those with cardiomyopathy.

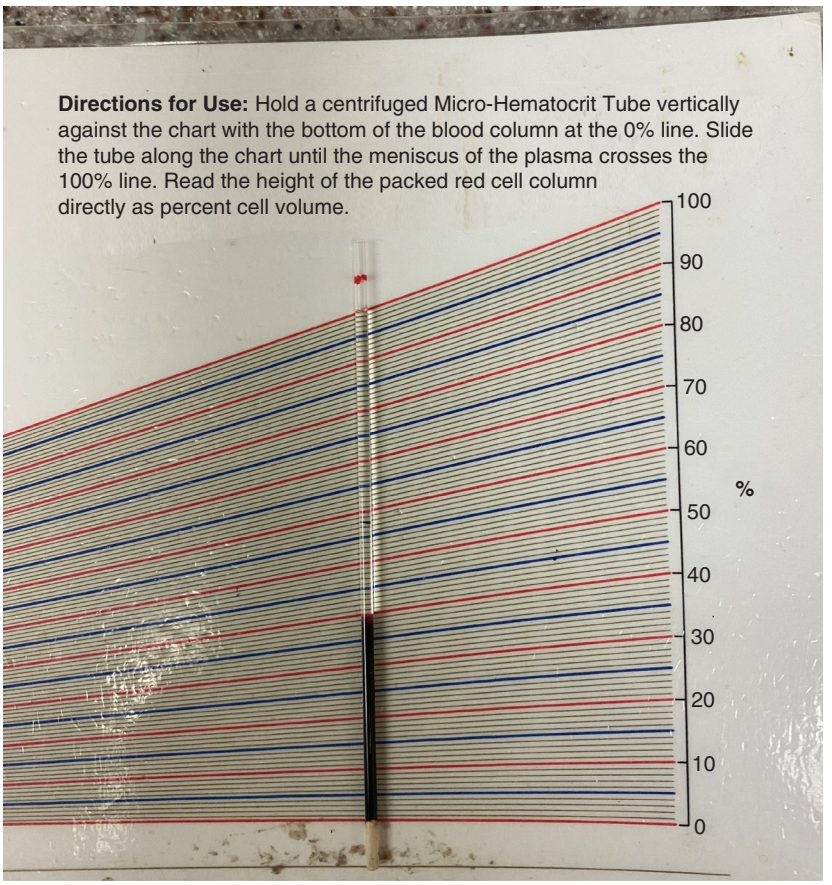


Figure 21.3 Example of spun hematocrit tube, PCV read at 40%. *Source:* Camille Kelly.

Anemia can be treated with RBC transfusions and certain medications, depending on the etiology. Therefore, a definitive diagnosis is imperative to initiate proper treatments. For example, if the anemia is caused by parasitism, such as flea anemia, the cat must receive treatment for the fleas in addition to a red blood cell transfusion, if clinically indicated. To determine if an anemic cat requires a transfusion, the whole clinical picture must be considered; the PCV is only one aspect. The severity of clinical signs, such as lethargy, tachycardia/bradycardia, and tachypnea, is what should guide therapy. Ingestion of nonedible items (known as pica) has been observed in anemic cats, particularly the eating of litter. The prognosis for anemic felines varies widely, depending on the inciting cause.

21.5.2 Iron Deficiency Anemia

Iron deficiency anemia develops due to a lack of iron during RBC production. The three main causes of this are insufficient dietary intake of iron, compromised absorption, or chronic blood loss. Neonates and juvenile kittens have a higher need for dietary iron than adults do, because of growth and increased erythropoiesis. Milk contains relatively little iron, so kittens with moderate parasitism may quickly become iron deficient. It is rare for an adult eating a commercially available diet to have an iron deficiency. If iron deficiency is suspected in a blood donor cat because of frequent blood donations, the frequency should be reduced, or oral iron supplementation can be administered.

21.5.3 Immune-mediated Hemolytic Anemia

IMHA is associated with high morbidity and mortality. It occurs when auto-antibodies target circulating erythrocytes and destroy them. It is less common in cats than dogs. The major consequences which occur from this immune dysregulation are decreased tissue perfusion due to anemia, kidney damage due to excessive Hb, which is released during hemolysis, increased

risk of thrombosis due to the antibody-covered RBCs, and liver dysfunction due to hyperbilirubinemia. Clinical signs include icterus, lethargy/weakness, bilirubinuria, fever, splenomegaly, tachycardia, and hypotension. IMHA can be peri-neoplastic, resulting from toxin exposure, infection (particularly feline leukemia virus [FeLV] or *Mycoplasma hemofelis*), a reaction to drugs/vaccines or it can be a primary disease (idiopathic).

Baseline testing for a patient presenting with these clinical signs should include complete blood count (CBC), chemistry, blood smear, prothrombin (PT), partial thromboplastin (PTT), and urinalysis (UA). While there is no gold standard criterion for the diagnosis of IMHA at the time of this publication, there are a few tests that will help make the assessment: saline agglutination test (SAT), Coomb's test, also known as the direct antiglobulin test (DAT), and/or flow cytometry (FC) [6]. Additionally, bone marrow evaluation, infectious disease testing, and imaging may also be performed when evaluating a patient with suspected IMHA. Spherocytes cannot be used as a diagnostic criterion in cats because feline erythrocytes do not consistently display central pallor [6].

Treatment for IMHA consists of addressing the inciting cause, if one has been identified or suspected, addressing the anemia with crossmatched packed red blood cell (PRBC) transfusion if clinically indicated, and suppressing the immune system with corticosteroids. Prednisone is a glucocorticoid that is metabolized into prednisolone. When cats receive oral prednisolone, higher plasma concentrations of prednisolone are achieved compared with cats who are administered oral prednisone; therefore, prednisolone is preferred for feline use [7]. Since glucocorticoid use has been associated with GI ulceration, gastroprotectants such as sucralfate, omeprazole, or famotidine may be added to the therapeutic plan.

Second-line immunosuppressives, such as cyclosporine or chlorambucil, have been used for cats, though these agents take longer to exert their effects than glucocorticoids. Anticoagulants, such as heparin products, along with platelet inhibitors, such as aspirin or clopidogrel, may be incorporated to mitigate the risk of thromboembolism in the IMHA patient.

IV immunoglobulin administration, splenectomy, or plasmapheresis are potential therapeutic strategies to manage IMHA in dogs, but there is limited literature regarding these options in cats. The prognosis for a feline patient with IMHA is more favorable than that of canines, with one study documenting a mortality rate of 23% [8].

21.5.4 Anemia of Chronic Kidney Disease

Anemia of chronic kidney disease (CKD) is a common complication affecting 30–65% of cats with CKD [9]. It occurs when the kidneys are no longer able to produce enough of the hormone Erythropoietin (EPO), which stimulates the bone marrow to produce RBCs. The kidneys produce EPO in response to low oxygen levels in the blood. When the kidneys are damaged, they can no longer produce enough EPO, which leads to a decrease in RBC production. Iron is necessary to produce RBCs. In CKD cats, iron deficiency is likely secondary to decreased erythropoiesis by diseased kidneys as well as anemia of inflammation [10]. Chronic inflammation has been shown to play a role in the pathogenesis of anemia primarily mediated by the acute phase protein hepcidin. Erythropoiesis is also inhibited by proinflammatory cytokines [10]. Cats with CKD may display a decreased appetite, which can lead to deficiencies in nutrients that are necessary for RBC production.

Treatment for anemia in CKD cats will depend on the severity of the anemia and the underlying cause. EPO-stimulating agents, such as darbepoetin, can increase the production of RBCs by the bone marrow. Iron supplements may be prescribed to treat iron deficiency. Feeding a special diet with a high-quality protein that is also low in phosphorus can help improve kidney function and reduce the progression of anemia. In severe cases of anemia, blood transfusions may be necessary to increase the number of RBCs in the bloodstream. See Chapter 26: "Urinary and Renal," for further information on CKD.

21.5.5 Anemia of Inflammation and Neoplasia

Anemia of inflammation is not a disease itself, but rather a consequence of the body's response to inflammation. The exact cause of this typically normocytic, normochromic anemia is not fully understood, but it is believed to be multifactorial. Inflammatory cytokines can interfere with the production for RBCs in the bone marrow. Iron metabolism is affected by chronic inflammation, decreasing the availability of RBC production. Additionally, inflammation may hinder the bone marrow's ability to respond to EPO effectively. Chronic gastrointestinal diseases, such as inflammatory bowel disease, and severe periodontal disease are examples of conditions that are associated with anemia of inflammation. Cancerous cells can damage healthy cells, particularly in the bone marrow. Lymphoma, a cancer of the lymphatic system, is a relatively common cause of anemia in cats. Hemangiosarcoma, which is a cancer that affects the blood vessels, and cancers of the spleen, kidneys, or other organs can also result in anemia.

21.5.6 Increased Osmotic Fragility of Erythrocytes

Increased osmotic fragility of erythrocytes is characterized by moderate to severe macrocytic and hypochromic anemia with variable regeneration and splenomegaly. It has been observed in Abyssinian and Somali cats, leading to suspicion of a novel hereditary erythrocyte defect [11], though it has also been noted in Domestic Shorthair cats [12]. The osmotic fragility test involves separating RBCs from the plasma and suspending them in a series of saline solutions with varying salt concentrations. The solutions are incubated, and the percentage of RBCs that lyse (burst) at each saline concentration is measured. Healthy RBCs are relatively resistant to lysis in weaker saline solutions. If RBCs lyse at higher saline concentrations (around 0.7% NaCl or higher), it indicates increased osmotic fragility. Since this can occur in various hemolytic anemias with different causes, the test itself does not pinpoint the underlying reason for the weakened RBC membranes. For a more comprehensive picture, CBC with blood smear examination, serum chemistry, bone marrow aspiration, and serology for infectious diseases or immune function tests might be recommended.

21.5.7 Infectious Diseases

Many infectious organisms negatively affect RBCs, which can lead to anemia. Hemotropic mycoplasmas, *Bartonella henselae, Hepatozoon*, and *Trypanosoma evansi* are some examples. Tick-borne parasites such as *Babesia* species and *Cytauxzoon felis* have also been implicated. [16, 17] Refer to Chapter 23: "Infectious Diseases," for more information.

21.5.8 Polycythemia

Polycythemia is a rare condition that occurs when there is an abnormally high number of RBCs in the bloodstream (erythrocytosis). This makes it more difficult for blood to flow through smaller veins and capillaries, leading to inadequate oxygen delivery to tissues.

Relative polycythemia arises when the plasma volume is diminished, usually a result of fluid loss, or from splenic contraction. Relative polycythemia resolves after rehydration or after addressing the cause of splenic contraction.

Absolute polycythemia can be primary, resulting from the myeloproliferative disease Polycythemia Vera, or secondary (driven by an underlying condition). The most common causes of secondary polycythemia are physiologically appropriate, as they are driven by tissue hypoxia, and can be seen with chronic pulmonary disease (such as feline allergic bronchitis) or right-to-left shunting cardiovascular disease (such as patent ductus arteriosus). Other causes of secondary polycythemia include renal neoplasia, hereditary methemoglobin reductase deficiency (which results in the erythrocytes' inability to carry oxygen) or hyperthyroidism.

Clinical signs of polycythemia are associated with hyperviscosity and the expanded blood volume and are not typically seen until the PCV is >60% [13]. They include hyperemic or cyanotic mucous membranes, hemorrhage (epistaxis and/or hyphema, due to hypertension), and neurologic signs such as lethargy and seizures. Hyperviscosity and increased vascular resistance can lead to the progression of hypertrophic cardiomyopathy and may predispose the cat to thrombus formation.

Diagnostic tests for absolute polycythemia include a CBC, absolute reticulocyte count, serum chemistry, urinalysis, blood gas, chest and abdominal radiographs, echocardiography and an abdominal ultrasound focusing on the kidneys and liver [13].

Severe absolute polycythemia may need to be treated with therapeutic phlebotomy, removing 10–20 ml/kg of blood, attempting to reduce the PCV to <60%. This strategy may need to be repeated periodically. In cases that require multiple phlebotomies in a short period of time, replacement of coagulation factors and albumin with plasma may need to be considered [13]. Cats with methemoglobin reductase deficiency experiencing severe stress may be treated with methylene blue (1 mg/kg IV over 20 minutes) [14].

Hydroxyurea, a chemotherapeutic agent, can be considered as an adjunct to phlebotomy or standalone therapy in cats who experience side effects from phlebotomy. It is important to monitor CBC when using chemotherapy drugs to identify cytopenias, and nail sloughing is a reported side effect of hydroxyurea [13].

21.6 White Blood Cell Conditions

21.6.1 Leukocytosis

Leukocytosis, an increased number of WBCs, can have many causes, such as leukemia and lymphoma. Leukemia is characterized by an abnormal increase in the number of WBC in the bloodstream, while lymphoma is a cancer of the lymphatic system. While leukemia in cats is caused by FeLV, a rare case was described in 2020 of spontaneous leukemia in a cat who tested negative [18]. The severity of leukemia is variable. Signs of acute leukemia can be vague (inappetence and lethargy) or more dramatic, resulting from cytopenias or hyperviscosity. Chronic leukemias tend to be less aggressive and are slow to progress. To reach a definitive diagnosis and assess the severity of complications arising from these conditions, testing includes CBC and bone marrow evaluation, serum biochemistry, urinalysis, coagulation testing, imaging for staging, FC, and PARR testing. See Chapter 24: "Oncology," for further information.

Stress, commonly seen in young healthy cats, is a transient cause of leukocytosis. Adrenaline release triggers splenic contraction, which leads to redistribution of lymphocytes, neutrophils, and erythrocytes into the circulating pool. Glucocorticoid-associated stress response is characterized by a moderate leukocytosis consisting of mature neutrophilia without left shift, and with or without mild monocytosis [15, 19].

Leukocytosis is most commonly driven by an inflammatory response, demonstrated by left shift, lymphopenia or lymphocytosis, and the presence of reactive lymphocytes. The prognosis depends on which organ is affected, and the cause of inflammation, and the degree of left shift, which is used as a prognostic indicator.

21.6.2 Leukopenia

Leukopenia (decreased WBCs), also seen as degenerative left shift, is unexpected with most inflammatory diseases and is a poor prognostic indicator. This is because the bone marrow in cats is very responsive and can release large numbers of neutrophils in minutes to hours.

Infectious diseases, such as feline panleukopenia, FeLV, and FIV are direct causes of decreased WBC count. [18, 20] More information can be found in Chapter 23: "Infectious Diseases." Issues impacting the bone marrow, such as toxins, aplastic anemia, bone marrow neoplasia, or nutritional deficiencies in B12 and folate, can hinder WBC production. Some medications, such as chemotherapeutic agents, certain antibiotics or antifungals, and immunosuppressive drugs, are known to cause leukopenia.

21.6.3 Neutropenia

A decrease in the number of neutrophils in the bloodstream results in a cat becoming more susceptible to infections, particularly bacterial ones. Viral infections, bone marrow disease, certain medications, and immune-mediated neutropenia (rare) are causes. Since neutropenia weakens the immune system's ability to fight infections, cats with this condition might exhibit signs of infection, such as fever, lethargy, inappetence, weight loss, skin issues, or vomiting/diarrhea. A CBC will provide diagnostic confirmation, and treatment includes addressing the underlying cause and managing symptoms.

21.6.4 Eosinophilia

An abnormally high number of eosinophils in the bloodstream is evident when there is an allergic reaction or the body is fighting off parasitic infections. Inflammatory bowel disease can sometimes lead to eosinophilia. Eosinophilic granuloma complex is a group of conditions involving eosinophils, with various presentations like skin lesions, gastrointestinal signs, or a combination of both. Rickettsial diseases, such as ehrlichiosis or anaplasmosis, cause hematological changes in dogs but these syndromes are unusual in cats. In rare cases, some feline cancers like lymphoma might be associated with eosinophilia. When eosinophilia is a feature of the CBC, further diagnostics might include fecal examination, skin cytology/biopsy, dietary trial, allergy testing, or imaging tests. Treatment options vary depending on the underlying cause.

21.7 Coagulopathies

Coagulation is the process of clot formation, and many factors influence the body's ability to perform this vital function. Coagulopathy, the inability to clot appropriately, is divided into defects of primary or secondary hemostasis, which are outlined below. Technicians must take special precautions if a feline presents with clotting concerns. Since the liver is responsible for producing clotting proteins, cats with liver dysfunction should be handled carefully, as they are at an increased risk for bleeding. Avoid jugular venipuncture in these cats, especially when signs of coagulopathy are present, such as bruising, epistaxis, gingival bleeding, or petechia. Apply a pressure bandage after peripheral venipuncture is performed to reduce bleeding and preserve the integrity of the vessel. If the cat may require hospitalization/IV medications, consider placing an IV catheter and obtaining lab samples through the catheter to avoid repeated venipuncture. Cats with coagulopathy may bleed at home, but steps can be taken to reduce these instances. Counsel owners to be conservative when clipping nails to avoid injury to the quick. Additionally, if other pets are in the home, ensure that they are respectful of each other's space (to limit the likelihood of fighting) and keep other cats' nails trimmed to avoid scratches. By using a kennel large enough to accommodate a litter box and bedding, the cat's activity can be restricted during an episode to minimize the volume of blood lost. Avoid feeding hard kibble or treats to prevent gingival bleeding. If the cause is a hereditary disorder, the cat is not suitable for breeding.

21.7.1 Disorders of Primary Hemostasis

Bleeding disorders of primary hemostasis have a direct correlation to platelets, platelet adhesion (via Von Willebrand factor [Vwf]) and vessels. Testing includes a platelet estimate via blood smear, buccal mucosal bleeding time (BMBT), vWF assay, and bone marrow sampling to evaluate megakaryocytes. It is important to distinguish between two categories of platelet disorders; one relates to the quantity of platelets (thrombocytopenia), and the other relates to the functionality of platelets (thrombocytopathia). Excessive consumption or sequestration of platelets is a cause of thrombocytopenia, which can result from disseminated intravascular coagulation (DIC), sepsis, splenic sequestration or torsion, or vasculitis. Clinical signs include bruising, epistaxis, retinal bleeding, gingival bleeding, and, in severe cases, hemorrhage, which could be life-threatening.

21.7.1.1 Chediak–Higashi Syndrome

Thrombocytopathias can be inherited, but this is rare in cats [26]. Chediak–Higashi syndrome is described in Persians as a diluted smokey blue color with yellow-green irises. The disorder arises from a mutation of the lysosomal trafficking regulator gene, which impairs the WBC function and causes a deficiency in serotonin and adenosine diphosphate-containing granules in platelets. This results in impaired platelet aggregation and prolonged bleeding time. Ocular abnormalities such as photophobia, cataracts, or rotatory nystagmus have also been described.

Diagnosing this disorder is achieved by combining breed and visual characteristics along with clinical signs, and the presence of giant granules in the neutrophils when evaluating a blood smear. Additionally, a tissue biopsy can be performed to look for giant granules within melanocytes.

There is no cure for this genetic disorder, and treatment includes supportive care and special considerations. When performing venipuncture and other medical procedures, a risk-benefit analysis should be considered due to the likelihood of bleeding in affected cats. When indicated, antifibrinolytic agents could be considered though their use in this setting has not been described, and vitamin C supplementation might improve platelet function. Owners of affected cats should be encouraged to take measures to reduce the risk of trauma and injury to their cat, such as limiting opportunities for falls or fights and maintaining good preventative healthcare. These cats should be housed indoors to reduce their exposure risk for infectious diseases and, due to their lack of normal pigmentation, to protect their eyes and skin from the sun.

21.7.1.2 Von Willebrand's Disease

Von Willebrand's disease (vWD) is rare in cats, and there is no specific breed association. It is caused by a deficiency of vWF, an adhesive glycoprotein necessary for clotting. vWF assays are available through special laboratories to achieve a definitive diagnosis. In dogs, cryoprecipitate is a plasma product rich in vWF that is used for treatment prior to surgical procedures. Since feline cryoprecipitate is not commercially available, transfusion of fresh frozen plasma (FFP) may replenish

circulating vWF to reduce hemorrhage intra-operatively, or transfusion of fresh whole blood could be considered if the patient is also experiencing anemia.

21.7.1.3 Acquired Thrombocytopenia

Acquired thrombocytopenia may occur after exposure to some drugs (aspirin, antibiotics, non-steroidal anti-inflammatory drugs), or secondary to kidney or liver disease, pancreatitis, FIP, a parasitic infection or neoplasia. Since there are no inherited thrombocytopenias reported in cats, the causes of reduced number of platelets are decreased platelet production, increased platelet destruction, and splenic sequestration. Bone marrow diseases, viral infections (FeLV), nutritional deficiencies, or some drugs can suppress the bone marrow's production of platelets.

Immune-mediated diseases or exposure to toxins or certain medications can destroy circulating platelets. In some cases, an enlarged spleen can trap platelets, leading to a decrease in the numbers in circulation. Cats who have had splenectomy may have a decreased platelet count. The most common sign of thrombocytopenia is bleeding, seen as petechiae, ecchymosis, epistaxis, bleeding within the GI tract, or oozing blood from a vessel or wound. These signs are unlikely to occur until the platelet count drops to <40 000/μl [2].

21.7.2 Disorders of Secondary Hemostasis

Bleeding disorders of secondary hemostasis are linked to problems within the coagulation cascade. Vitamin K rodenticide ingestion, liver dysfunction, and drug side effects (such as with heparin or colloid products), or hereditary clotting protein deficiencies are potential causes.

Clinical signs from disorders of secondary hemostasis tend to be more severe than disorders of primary hemostasis and include ecchymoses, hematomas, and bleeding within body cavities (hemoabdomen/hemothorax) or into joints. Testing includes activated clotting time (ACT), PT, and activated partial thromboplastin time (aPTT) measurement. Specific factor assays are available through special laboratories.

21.7.2.1 Factor Deficiencies

Hemophilia A (Factor VIII deficiency) is the most common congenital bleeding disorder in cats.

Hemophilia B (Factor IX deficiency) is diagnosed less often. Animals with extremely low Factor IX activity (less than 1%) usually die at birth or shortly thereafter. Animals with 5–10% of normal Factor IX activity may suddenly develop bleeding in the joints, oozing of blood into the body cavity, or organ bleeding. Some animals have no symptoms until injury or surgery. Often, internal bleeding into the abdomen, chest, central nervous system, or muscles occurs, and may not be noticed until a crisis happens.

Hemophilia can affect any breed of cat, with some breeds displaying a higher prevalence, such as Maine Coon, British Shorthair, Devon Rex, and Siamese-cross cats. Hemophilia should be suspected in young cats with gingival bleeding from teeth eruption sites, hematoma formation after initial vaccinations, or prolonged bleeding after surgery. However, it is prudent to wait until the cat is at least 6 months of age before testing clotting factor activity since it can take that long for the feline liver to produce enough clotting proteins. Testing of factor VIII (hemophilia A) and factor IX (hemophilia B) activity helps to achieve diagnosis.

Treatment requires transfusions of a plasma product containing factor VIII or IX (such as FFP) to replace those components, and if bleeding has become severe leading to clinical signs of anemia, transfusion of RBC products may be indicated until bleeding has been controlled.

Hemophilia can range in severity, from a mild form that does not shorten the cat's lifespan and results in intermittent signs of bleeding, to profound cases in which the cat succumbs to the condition within the first few weeks of life.

Factor XII initiates surface activation of the coagulation cascade in vitro. However, its role in vivo is not yet understood. Deficiency of factor XII, also known as the Hageman trait, is common in domestic cats of many breeds, with a geographical prevalence in the Midwestern United States. It is not associated with bleeding, but it can lead to marked prolongation in aPTT and ACT, making it difficult to distinguish from other bleeding disorders of secondary hemostasis without measuring individual factor activity. Deficiency of Factors II, VII, IX, and X has been described in Devon Rex cats that experienced bleeding postoperatively. This bleeding can be mitigated by the administration of vitamin K, and some of these cats appear to outgrow the bleeding tendency as adults.

21.8 Diagnostic Techniques

Many different tools are available for evaluating the hematological status of the cat. Typically, it is not a single test but a combination of these diagnostic techniques that allows the veterinary team to make a comprehensive assessment and identify potential blood disorders or underlying conditions. Information regarding CBC can be found in Chapter 11: "Interpretation of Common Diagnostic Test Results."

21.8.1 Blood Smear

The blood smear examination is performed to identify erythrocyte, leukocyte, and platelet abnormalities, as well as abnormal cells, which serves to confirm platelet quantification. A stained blood film should accompany every automated CBC. Since feline platelets are prone to activation and clumping, collecting blood via vacuum tube typically results in less platelet activation as opposed to collecting via syringe and transferring it to the tube [21].

The most common method requires two glass slides and a microhematocrit tube. The tube is filled with EDTA whole blood via capillary action, and a small drop of blood is released onto one end of a slide. While holding this slide in place with one hand, the second slide is held at an approximately 45° angle in front of the drop of blood. The second slide is backed into the drop of blood and held in place as the blood travels along the back side of the spreader slide, then the spreader slide is gently but quickly pushed forward to create a smear of blood (Figure 21.4a–d). The thickness of the blood, angle of the spreader slide and speed of forward spreading are factors that will influence the quality of the blood smear. A sufficient blood smear will occupy at least half the length of the slide, and a feathered edge will appear along the front portion. The slide must be dried before staining, which can be expedited by waving it in the air and should be stained within a few hours of creation using a Romanowsky-type stain such as Wright, Wright–Giemsa or Diff–Quik. A drawback to the commonly used rapid stain Diff-Quik is that it does not stain basophils, mast cells, or large granular leukocyte granules as well as methanol-based stains like Wright or Wright–Giemsa [21].

Using a standardized method to microscopically examine the stained blood film is the best way to ensure that no steps are skipped. Table 21.1 illustrates these steps, starting with a low-power survey at 10× objective along the entire slide. Then, focus on the monolayer, which is the zone between the feathered edge and the body (where the smear is thickest, near the point of blood drop application) using higher magnification, and end with the oil-immersion objective.

Leukocytes are evaluated for the presence of abnormalities, such as toxic cytoplasm in neutrophils or >5% reactive lymphocytes. The frequency of toxic neutrophils is reported as few (5–10%), moderate (11–30%), or many (>30%), and

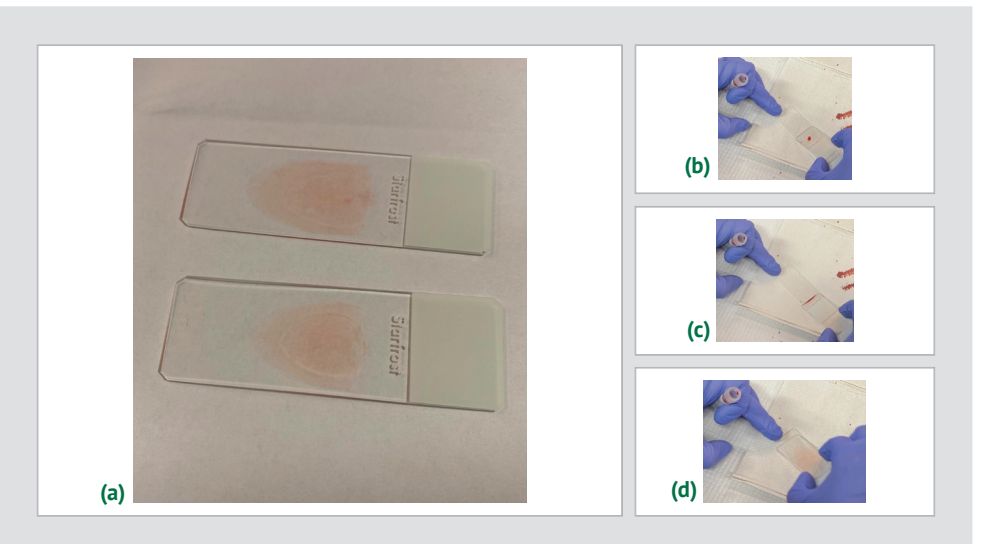


Figure 21.4 Blood smear technique. (a) Example of finished blood smear, ready for staining once dry. (b) Drop of blood on the slide. (c) Spreader slide backed into the drop of blood. (d) Spreader slide being pushed forward to create the smear. *Source:* Camille Kelly.

Table 21.1 Method to microscopically evaluate blood smears.

	Feathered edge	Monolayer	Body of blood film
10× objective	Microfilaria Aggregates of cells (especially platelets) Atypical or large cells	Scan to evaluate the relative distribution of leukocyte types. Estimate leukocyte count by calculating the average number of leukocytes per field and multiplying by 100.	Blasts Infectious agents Hypochromasia Agglutination Rouleaux
40–50× objective		Identify 200 consecutive leukocytes. Calculate the percentage of each leukocyte type and multiply by total leukocyte count. The result is the absolute number of each cell type present per microliter of blood.	
100× objective (oil immersion)		Nucleated RBCs (nRBCs): if >5 nRBC per 100 WBCs in the field, obtain count and correct with formula (100 ÷ [nRBC + 100]). Platelet Count. RBC and WBC morphology.	

the severity of toxic change (such as Döhle bodies, basophilic, dark blue-gray, and foamy cytoplasm) is recorded as 1+ to 3+.

Erythrocyte morphology is evaluated in the front half of the smear, behind the feathered edge, in the monolayer (where half of the RBCs are close enough together that they are touching). In severe anemia, a monolayer may not be present (see Tables 21.2–21.4). Information regarding how to evaluate platelet count, reticulocyte count, and slide agglutination can be found in Chapter 11: "Interpretation of Common Diagnostic Test Results."

21.8.2 Buccal Mucosal Bleeding Time

Since vessel wall disorders are quite rare, performing a BMBT in a cat with a normal platelet count is usually a test of platelet function. A BMBT is performed under sedation or general anesthesia, in lateral recumbency. Begin by folding the cat's upper lip upward and wrapping a strip of roll gauze around the maxilla to hold it, exposing the mucosal surface. Do not occlude blood flow. Tie the strip as if securing an endotracheal tube. Apply the spring-loaded BMBT device flush against the buccal mucosa in an area without visible blood vessels, using light pressure. Depress the trigger, which releases and immediately retracts the blade within, start timing, and remove the device. Allow the incision to bleed freely, blotting excessive blood with filter paper every 5 seconds, being careful not to disturb the incision site or any clot formation. Stop the timer when the bleeding stops. This technique is somewhat subjective, and its reliability is dependent on the user. Normal BMBT in cats is less than 2.5 minutes.

21.8.3 Activated Clotting Time

ACT is a test of the intrinsic coagulation pathway, though it is less sensitive than aPTT. Also, platelet phospholipid is still required for coagulation, so ACT will be prolonged in severe thrombocytopenia. When using an ACT machine, the cartridge must be prewarmed for 3 minutes first. After obtaining a small blood sample via clean and direct venipuncture, fill the cartridge to the fill line and push the actuator heat block into the closed position. When clot formation is detected, an audible tone sounds and the actuator heat block automatically rotates to the open position. Clotting factors must be <10% normal to prolong the ACT. Normal ACT in cats is <165 seconds. The i-STAT handheld analyzer can measure ACT, though the endpoint is indicated by a chemical measurement of the presence of thrombin instead of a mechanical measurement of a physical clot.

Table 21.2 Erythrocyte morphology.

Erythrocyte morphology	Shape/color	Description
Rouleaux	Stack of coins, red	Normal in healthy cats. Increased when plasma globulins are elevated (inflammation and plasma cell neoplasia). Most prominent when whole blood samples are allowed to sit undisturbed so mix the tube well before the analysis.
Agglutination	Clusters, red	Caused by immunoglobulins bound to RBC surfaces and is associated with immune-mediated hemolytic anemia.
Polychromasia	Blue, red	Immature cells containing RNA or reticulocytes. Slight presence may be normal, pronounced indicates reticulocytosis, response to hemorrhage or hemolysis.
Anisocytosis	Variable RBC diameters	Feature of regenerative anemia.
Hypochromasia	Pale pink in the center of the cell	Decreased hemoglobin concentration results in increased central pallor. The biconcave shape of feline erythrocytes is less pronounced than in canines, so there is comparatively less central pallor.
Poikilocytosis	Abnormal shape, fragments	Caused by DIC, liver disease, cardiomyopathy, myeloid neoplasms, renal failure, and doxorubicin toxicity.
Echinocytes	Evenly spiculated with spiny projections	It can be an artifact. Echinocytosis (previously referred to as crenation) has been reported in uremic felines and after pit viper envenomation.
Acanthocytes	Unevenly distributed spicules, shorter and more blunt projections than seen with echinocytes	Observed in cats with liver dysfunction (particularly hepatic lipidosis) and with disorders resulting in erythrocyte fragmentation, such as DIC and cardiomyopathy.
Keratocytes	Blister-like projection, as a single bubble or multiple smaller ones	Sometimes the bubble ruptures, leaving a notch or a bite-shaped defect in the RBC outline. Oxidative stress, liver disease, and mechanical injury are the causes.
Schistocytes	Pointed, elongated, or ragged edges	Described in cats with liver disease, DIC, hemangiosarcoma, and vasculitis.
Spherocytes	Small, spherical erythrocytes lacking central pallor	Since feline RBCs already have less central pallor and are smaller than dogs, it can be difficult to make this distinction. Immune-mediated hemolytic anemia, ingestion of zinc or onion, and transfusion of stored blood are causes.
Elliptocytes	Oval shape	May be seen with myeloid neoplasms, hepatic lipidosis, portosystemic shunts, and doxorubicin toxicity.
Dacrocytes	Tear-drop shaped	Observed in cats with portosystemic shunts and myeloid neoplasia.
Stomatocytes	Elongated, oval shape with a central slit or pinched area, resembling an open mouth	Certain breeds, like Abyssinian and Siamese cats, seem to have a higher prevalence of this anomaly. Most often, this finding is an artifact.
Eccentrocytes	Pale on one side	Oxidative damage to the erythrocyte membrane results in hemoglobin becoming eccentrically localized to one side of the cell, leaving a hemoglobin-poor area visible in the remaining space. This is characteristic of acetaminophen ingestion in cats.

Table 21.3 Erythrocyte inclusions.

Erythrocyte inclusions	Shape/color	Description
Howell–Jolly bodies	Small, intensely blue, round inclusions within the cytoplasm of an RBC	Often present in low numbers in normal cats. These inclusions are typically removed or "pitted" by the spleen, so their presence may suggest impaired splenic function (or splenectomy). Often increased when there is regenerative anemia.
Heinz bodies	Small, round, pale pink inclusions	While normal in low numbers in cats, these are composed of oxidized, precipitated hemoglobin. Increased numbers are associated with oxidative damage from acetaminophen, benzocaine, phenazopyridine, onion, or zinc ingestion, and have been reported in cats with diabetic ketoacidosis (DKA), hyperthyroidism, and lymphoma.
Basophilic stippling	Diffuse, blue punctate inclusions	Composed of aggregates of ribosomes. In cats with lead poisoning, basophilic stippling is often present, along with nucleated RBCs.

Table 21.4 Infectious organisms in blood smears.

Infectious agents	Appearance
Hemotropic mycoplasmas	*Mycoplasma hemofelis* is seen along the periphery of erythrocytes in thin areas of the blood film, appearing as small, blue-staining cocci, rings, or rods. They are smaller than Howell–Jolly bodies, and *Cytauxzoon felis* organisms and are not always present in the blood, even during acute infection. *Mycoplasma haemominutum* is rarely observed in stained blood films from infected cats. These organisms appear to stain less densely and are about half the size of *M. hemofelis*.
Cytauxzoon felis	This parasite has the appearance of a signet ring within the RBC and may not be observed on the blood film, as it has both a tissue phase and an erythrocyte phase.
Babesia species	It can appear as pear-shaped or ring-shaped structures within red blood cells.
Microfilaria	The structure appears like a worm, with a tapered end. If alive, there may be thrashing between cells. Presence confirms at least one male and one female adult heartworm is present.

21.8.4 Prothrombin Time and Activated Partial Thromboplastin Time

PT is used to evaluate the extrinsic pathway, which includes factors X, VII, V, PT, and fibrinogen. aPTT screens the intrinsic pathway, comprising of factors XII, XI, X, IX, VIII, V, PT, and fibrinogen. It is more sensitive than the ACT and results are not dependent on platelets. These tests can be performed by commercial laboratories using citrated blood (blue top tube), and you should check with their lab for specific instructions regarding sample collection and shipment. Point-of-care coagulation tests are available for in-house use (such as the SCA2000) to determine the aPTT and PT on small amounts of fresh whole blood from direct venipuncture. Normal PT in cats is 13–22 seconds, and normal aPTT is 60–115 seconds.

21.8.5 Thromboelastography

Thromboelastography (TEG) is used to evaluate the entire coagulation process, including formation of the clot, maximal strength, and fibrinolysis. Traditional coagulation testing, as described above, aims to detect cats who have an increased risk of bleeding, but it does not provide information regarding the potential for thrombosis. With many disease states

putting patients at increased risk of developing clots inappropriately (protein-losing diseases, hypertrophic cardiomyopathy, IMHA, and liver disease), its usefulness in these populations has become a subject of interest and research is ongoing [22].

21.9 Feline Blood Donors

21.9.1 Feline Blood Donor Selection

To meet the needs of feline patients requiring transfusions, blood products must be obtained by drawing from donors or by purchasing blood from a commercial supplier. While purchasing blood can be an option, there may be lengthy backorders and limited availability, so it is recommended to create a plan in advance for life-threatening emergencies.

In practices that do not perform transfusions often, it may be most sensible to purchase blood products as they are needed, and/or identify a few feline blood donors within the practice that can be called upon under short notice. In large hospital settings, where more advanced procedures are performed and critically ill cats present with regularity, the demand for blood products tends to be greater. Having access to banked blood in these instances allows for timely interventions, thereby elevating the standard of patient care.

Feline blood donor candidates can be sourced via employee pets, client-owned cats, and/or cats that are owned by the facility for the purposes of blood collection. At the author's institution, most feline blood donors are owned by the hospital and reside in sizeable living quarters where they are free to roam and socialize at will. The colony is cared for by a few select individuals who do not have exposure to patients with infectious diseases, to minimize risk of transmission. After a service period of 3 years, the blood donor cat becomes available for adoption and a replacement is identified. Regardless of the ownership status of blood donor cats, their health and well-being should be a priority (Figure 21.5).



Figure 21.5 Feline blood donor living quarters at the University of Florida, College of Veterinary Medicine. *Source:* Camille Kelly.

When selecting blood donor candidates, these are some criteria to consider:

- The cat should be healthy with a friendly temperament.
- Between 1 and 8 years old (since there are costs associated with screening, it may be prudent to narrow the enrollment window to be between 1 and 6 years of age so that cat can provide at least 2 years of service before retirement).
- At least 4.5 kg lean body weight.
- Up to date on vaccinations.
- FeLV/FIV negative (also applies to any other cats residing in the household).
- Indoor only.
- Not taking any other medications other than heartworm/flea/tick prevention.
- Never received blood product transfusion.
- No history of blood-borne illness/infection or neoplasia.

To begin screening, a physical exam should be performed by a veterinarian, evaluating all body systems. Initial lab work consists of blood typing, a CBC and chemistry panel, infectious disease testing, urinalysis, fecal test, and screening for cardiac disease. If a heart murmur is present, echocardiography can be used to determine if there is pathology associated with it. Since heart disease can be present in cats without a heart murmur [23], it is considered best practice to perform a screening echocardiogram or an NT-proBNP test.

Blood typing can be performed by sending samples to a commercial laboratory or by using an in-house kit, such as the Rapid Vet-H Feline card system (DMS Laboratories, NJ), and the Quick test A + B immunochromatographic cartridge (Alvedia, Limonest, France). The Alvedia kit has become more favorable as the results are less subjective and less likely to be influenced by auto-agglutination. More information regarding blood typing can be found in Chapter 17: "Emergency and Critical Care."

The American College of Veterinary Internal Medicine (ACVIM) and the Association of Veterinary Hematology and Transfusion Medicine issued an updated consensus statement in 2015 to provide veterinarians with standardized guidelines for canine and feline donor screening for infectious diseases in North America [24]. *Anaplasma phagocytophilum, Bartonella henselae, Cytauxzoon felis, Ehrlichia spp*., *Mycoplasma haemofelis, Candidatus Mycoplasma haemominutum, Candidatus Mycoplasma turicensis, Neorickettsia risticii*, FeLV and feline immunodeficiency virus are among the pathogens for which a feline blood donor should test negative. Major diagnostic reference laboratories have panels available which include these organisms. Since it is not yet possible to differentiate between an FIV-positive cat and an FIV-vaccinated cat, all positive cats should be excluded from consideration. Due to incubation periods for some of the organisms listed above, repeated testing after 30 days may be indicated, particularly in cases where the cat's history and exposure to infectious diseases are unknown. During this 30-day window, the owner should not allow exposure to any new animals.

21.9.2 Blood Donor Preventative Care and Maintenance

At a minimum, feline blood donors should receive an annual physical exam, core vaccinations such as rabies and FVRCP, UA, CBC, and a chemistry panel. They must also receive routine heartworm/flea/tick prevention, even if kept indoors only. A FeLV/FIV test could be incorporated annually if risk factors are present after the initial screening lab work was performed. For cats residing in a closed colony, repeated annual testing for infectious pathogens may not be necessary since they should not have exposure risk. If a flea or tick is identified on the donor at any time, repeated PCR testing should be performed and ectoparasite prophylaxis administered.

To avoid interfering with the efficacy of vaccinations, it is recommended to space blood donation 2 weeks apart from vaccination (whether prior to or following vaccination). Also, if the cat has had any change in normal habits, developed new symptoms of illness, or has undergone anesthesia recently for a surgical/dental procedure, this should delay blood donation.

Felines should be able to safely provide blood donations once every 8 weeks. If more frequent blood collection is planned to occur, such as every 4 weeks, it is sensible to incorporate oral iron supplementation to avoid causing iron deficiency anemia.

If the feline donor has received a short-term course of medication for a transient condition, a washout period prior to donation may need to be observed to ensure the blood product does not contain traces of the drug.

21.9.3 Owner Incentives

Providing incentives for clients or employees who own blood donor cats is encouraged, as they are committing time and effort to the process and acknowledging the risk, albeit low, of an adverse outcome resulting from blood donation. Complimentary physical examinations, vaccinations, and lab work are a few ways to ease the financial burden of pet ownership for the client. Providing heartworm, flea, and tick prevention free of cost is a great incentive and has the dual benefit of increasing the likelihood of compliance with use. Offering a free bag of cat food for each donation given is another idea. At the author's institution, a free blood product is provided for every unit donated if the donor cat were to need transfusion during its lifetime. Using social media to feature blood donors can help raise awareness and express gratitude. As long as recipient confidentiality is maintained, you could consider notifying the owner how the blood donation was used, since nothing creates a sense of pride and joy like hearing examples of how their cat saved a life.

21.9.4 Sedation Versus Conscious Collection

Blood donor candidates should be given the opportunity to demonstrate whether they will tolerate conscious blood collection. By giving the cat plenty of time to acclimate to the environment, providing positive reinforcement, and utilizing strategies to minimize stress, such as calming pheromone sprays or diffusers, allows the best chance of success. Keeping the area quiet and free of offensive smells (particularly of dogs) will help to keep the cat relaxed. By avoiding sedation, the feline donor is at less risk for adverse effects, and the recovery time is shortened. To desensitize the skin over the cephalic vein (ideal location for IVC placement) and the jugular vein (site of blood collection), local anesthetic cream can be applied after clipping the hair. Liposomal lidocaine cream is not systemically absorbed and therefore preferred for the feline. The cephalic vein site should be covered with a nonabsorbable dressing to prevent the cat from licking it while waiting for the numbing effect to take place, approximately 20 minutes after application.

If sedation is required, there are numerous drug combinations to achieve this. At the author's institution, the protocol which provides the most consistent sedation along with ease of administration without causing hypotension or dysphoria includes gabapentin 50–100 mg PO the night before and morning of blood donation, butorphanol 0.2–0.4 mg/kg IM, followed by a 15-minute wait, then administer alfaxalone 2–3 mg/kg IM. Waiting 15 minutes between the administration of butorphanol and alfaxalone allows both drugs to exert their peak effects at the same time [25]. It is imperative to monitor the blood donor for respiratory depression after administration of alfaxalone. The peak effect will be observed within 15 minutes of alfaxalone administration, and the steps to perform blood collection can commence. If the level of sedation is insufficient, an additional 1–2 mg/kg of alfaxalone can be administered IV, ideally through the donor's IVC if sedation was sufficient for placement.

It is important to note that splenic sequestration of erythrocytes can be a secondary effect with some anesthetic drugs. This transient change in PCV can affect the donor during donation, as their oxygen-carrying capacity may be reduced, and will result in lower PCV within the donated blood product. This change can be dose dependent, so it is prudent to utilize the lowest dose necessary to achieve the desired outcome.

21.9.5 Blood Collection

The supplies needed to facilitate blood collection will vary depending on whether or not your feline blood donor will be conscious. Open, closed, and semi-closed systems are commercially available, and can come with satellite bags for component processing. Open blood collection may be preferable in the case of the conscious blood donor, especially during the premier attempt, since it is possible that the donor moves or resists during the collection. By filling multiple syringes with an appropriate volume of anticoagulant, instead of a single syringe, as in an open system, if the total volume anticipated for collection is not able to be obtained, the syringes that were appropriately filled can still be utilized. Also, if the flow slows or stops temporarily during the procedure, which is more common in a fully alert cat, and a clot develops in one syringe, that syringe alone can be discarded while the rest are able to be used. Blood products obtained via open collection systems should be administered within 24 hours if stored at 1–6°C/33.8–42.8°F, since the risk of bacterial contamination is increased [27]. Blood donation is described below using a semi-closed system with a sedated feline (Table 21.5).

Perform a physical exam, and obtain baseline vital parameters and body weight. Calculate the volume of blood that can safely be donated, which is approximately 10–12 ml/kg, based on lean body weight. Check for notes in the donor's record

Table 21.5 Supplies for semi-closed feline blood donation.

Chlorhexidine scrub	Clippers	Refractometer
Alcohol	Gram scale	PCV clay
Heparinized PCV tube	Nonsterile gauze.	IV catheter supplies
1 ml & and 3 ml syringes	Crossmatch samples – can use tube segments if access to tube sealer, otherwise one serum separator and two plain red top tubes (add 0.2 ml of CPDA to one red top tube in preparation to fill with 1.5 ml blood).	CPDA-1 anticoagulant
Exam Gloves	60 ml syringe with 8 ml CPDA**.	
Feline blood collection bags set	Sterile eye lube.	3-way Stopcock
Butterfly catheter (19 g)	Flow by oxygen with a mask.	60 ml LRS (or other isotonic crystalloid) in syringe with extension set
20 g and 18 g needles	Supplies for warming blood donors if sedated.	Crash box with supplies for emergency intervention

*Additional supplies, such as refrigerated centrifuge, plasma press, tube stripper, etc. may be required.
**For each 1 ml of RBC collected, a volume of 0.14 ml of CPDA is required. Adjustments should be made if the volume of RBC to be collected will be less than 60 ml.

regarding previous blood collections and ensure no special adjustments in procedure or drug protocol are recommended. Ensure that the feline blood donor has not donated within the last 30 days, at minimum.

Use an aseptic technique during all aspects of the procedure. To prepare the collection set, fill a 60 ml syringe with an appropriate amount of CPDA and attach it to a stopcock. Open the feline blood collection set and attach the tubing to the stopcock. Turn the stopcock off to the bag (Figure 21.6).

Place IV catheter (ideally in the cephalic vein, alternating between right and left forelimb each donation) and obtain PCV/TP and crossmatch samples (if not planning to use aliquots from tubing). PCV must be within the normal reference interval prior to donation [27]. It is a good practice to keep a crash box, or at minimum endotracheal tubes and emergency drugs, in the room where donation takes place.

Apply sterile eye lube to both eyes, place the cat in lateral recumbency, and clip and clean the jugular site (alternating between the right and left jugular each donation). Ensure that the level of sedation is adequate and donor vitals are normal before proceeding. Using a Doppler blood pressure machine will allow for auditory confirmation of pulse rate throughout the procedure and measurement of blood pressure periodically. Administer oxygen via flow-by and use an assistant to monitor the donor's vitals and maintain positioning.



Figure 21.6 Semi-closed blood collection set from Animal Blood Resources International, with three-way stopcock and 60 ml syringe with CPDA attached. A 19 g butterfly catheter in packaging. *Source:* Camille Kelly.

In the case of conscious collection, the donor may be positioned in sternal or lateral recumbency. Ophthalmic lubrication is unnecessary since the conscious donor is able to blink and oxygen via flow-by is not necessary as respiratory depression does not occur in the absence of sedation. If easily tolerated, blood pressure measurement via Doppler or oscillometric can still be utilized to monitor changes.

The assistant will need to hold off the jugular vein at the thoracic inlet and continue holding off for the entirety of the donation. Stretch butterfly catheter tubing to relieve the coil memory that occurs from packaging. Prior to inserting the butterfly catheter into the jugular vein, it can help to create a pilot hole first, particularly in cats who have thick skin. This is accomplished by tenting the skin above the jugular vein and using an 18 g needle to penetrate the skin at a shallow angle, being very careful not to touch the vein, then removing the needle. Once the pilot hole is created, the butterfly catheter needle should be easy to insert into the vessel. Allow blood to progress through the butterfly tubing, then connect to the stopcock (which is already connected to the collection syringe and bag). Draw back on the syringe in 1–2 ml increments at a time, to avoid collapsing the vein, gently rocking the syringe every 10 ml to ensure blood is mixing with an anticoagulant. To obtain 60 ml total volume in a syringe, it should take approximately 5 minutes (drawing too quickly can cause hypotension and should be avoided) (Figure 21.7).

Once the target volume has been collected, remove the butterfly catheter and the assistant should hold firm pressure on the venipuncture site with nonsterile gauze. Ensure the stopcock is OFF to the outside world, then express blood from a syringe into the collection bag. The blood that is still in the tubing between the syringe and bag can be sectioned off in aliquots for crossmatching purposes using a tube sealer (dielectric heat devices or hand-operated metal line clips are available). Seal off the tubing that was involved in the collection and remove it, so that only the main bag and attached satellite bag remain connected. Obtain vital parameters on the donor and turn off the flow of oxygen. Clipping the nails, cleaning the ears, applying routine preventatives, or any other maintenance task should be performed now to take full advantage of the sedation. Assess the venipuncture site and clean it with peroxide if needed.

Begin recovery with the donor in a kennel, using heat support as needed. Administer crystalloid IV fluids of equal volume to replace what was collected over 1 hour via syringe pump. Write the donor's name on both bags and place them in the fridge until ready for processing (unless used as fresh whole blood). After processing, bags will be formally labeled. Remove IVC after the IV fluid bolus is complete and place a bandage over the site. Once the donor is alert and responsive,



Figure 21.7 Sedated blood donor receiving flow by oxygen, collection syringe with CPDA pictured, which will receive blood flowing from the butterfly catheter tubing. *Source:* Camille Kelly.

offer a water bowl and litter box in a kennel, and remove the IVC bandage. Depending on the manner in which donors are housed, you may want to keep the donor in a kennel with food, water, and a litter box overnight. Record notes regarding blood donation in the donor's record.

21.10 Blood Component Processing

Feline blood has a high erythrocyte sedimentation rate, meaning that the RBCs settle at the bottom with gravity alone. Therefore, if the blood will be used within 6 hours of collection and left in syringe in an upright position for about 1 hour, the plasma at the top of the syringe may be expelled to retain only the RBCs for transfusion. To reduce viscosity for ease of administration, a small volume of plasma can be left with the RBCs, aiming for a PCV of less than 80% [28].

In the blood collection bags, whole blood is spun in a refrigerated centrifuge at 3800 RPM for 8 minutes at 4°C/39.2° F with the break off (settings may vary depending on the model of the centrifuge). Start by turning on the centrifuge, and take one centrifuge holder for the blood, and one for balance to be filled with a 500 ml saline bag. To pack the holder, hold the main bag and satellite bag against each other, then place a 500 ml saline bag in the same holder. Wrap the line (including the in-line port) with a piece of bubble wrap and wedge it down into the holder. The blood bags should be on one side, 500 ml bag saline in the middle, and wrapped lines on the other side.

To balance the holders, weigh the packed holder and the holder that contains the 500 ml bag of saline. Add pieces of old unused bags to the holder that weigh less, until it is the same weight as the other holder. Place holders in the centrifuge directly across from each other, close lid and start cycle (Figure 21.8).

When the cycle is complete, remove the entire contents from the blood holder by gently lifting everything out together. Rest the blood bag on the hooks of a plasma press, then break the seal on the top of the main bag by flexing the tubing forward and backward. Release the plasma press handle from its hook to express the plasma from the top of the main bag into the plasma bag, which happens quickly. Once the PRBCs reach the line, finger clamp the line and pull the extractor handle back down and secure it to its hook. Grasp the plasma bag and squeeze so the air within is directed back into the line and



Figure 21.8 Unit packed in centrifuge (Thermo Scientific Sorvall BP 8) balanced and ready for processing. *Source:* Camille Kelly.

release your finger clamp to allow the air to be expressed into the main blood bag. Once air is relieved from the plasma bag, squeeze the bag to fill the line with just enough plasma for TP measurement, and heat seals the line in two places so you can remove the aliquot with plasma for sampling (only if blood was not collected for crossmatching when IVC was placed). Now you have a separate plasma bag.

Weigh the plasma bag on a gram scale and record the milliliters on the bag (remember to subtract the weight of the bag, which the bags depicted here are 20 g). Obtain the TP measurement by removing an aliquot of tubing from the line where plasma is visualized and cut the tubing. Squeeze a plasma drop onto the refractometer and record TP on the bag. Ensure the plasma bag has the donor's name, collection date, and expiration date. Place plasma bag into bubble wrap pouch, and place in freezer.

To begin the final processing for PRBC storage, wipe the in-line port and an additive solution bag port with sterile alcohol prep pads. Add 6 ml of additive solution (volume and storage time may vary depending on which additive solution is used) to the PRBC bag via the cleaned port on the line. Seal the tubing so that approximately two inches remain with the finished product. Gently massage and invert the bag until unit contents are homogenous, and visually ensure there is no clot present. Weigh the PRBC bag on gram scale and record the milliliters on the bag (remember to subtract the weight of the bag). Using a line stripper, strip the line to obtain a PCV aliquot, seal the tubing, and separate. To obtain PCV measurement, cut the aliquot and fill the nonheparinized hematocrit tube. Spin and record PCV on PRBC bag. PRBC bag should have the donor's name, collection and expiration date, and be stored in a dedicated refrigerator.

If crossmatch tubes are being used instead of aliquots, centrifuge the serum separator tube at 4000 rpm for 10 minutes. Transfer serum to an empty plain red top tube. Label the RBC red top and serum red top with the donor name, blood type, and date of collection and store them in a dedicated refrigerator for future crossmatching.

The study of blood and its components provides a fascinating glimpse into the inner workings of the feline body. We have explored the composition of blood, the crucial roles played by RBCs and WBCs, and the intricate mechanisms of blood clotting. Throughout this chapter, we have learned how to perform and interpret blood test results, as well as identify abnormalities. These findings can be valuable clues for veterinarians to diagnose underlying conditions affecting the blood or other organ systems. By understanding the complexities of blood, we gain a deeper appreciation for the biological processes that keep our feline companions healthy and thriving.

See the companion website for further clinical references.

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22

Hepatobiliary

Paula Plummer, LVT, VTS (ECC, SAIM, CP-fe)

TECHNICIAN TIDBITS

- "Icterus" or "jaundice" is a yellow appearance of the skin and mucous membranes caused by hyperbilirubinemia.
- Ketones are the products of fat metabolism by the liver.
- Bilirubin is a byproduct of hemoglobin metabolism (or breakdown) [1].
- Liver enzymes on most biochemistry panels consist of alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, and gamma-glutamyl transferase).
- Liver function markers on a biochemistry panel consist of albumin, globulins, cholesterol, blood glucose, and blood urea nitrogen.
- Many common drugs are hepatotoxic to cats due to their limitations in glucuronide conjugation [2].

The feline hepatobiliary system is an intricate part of the digestive system and includes (or involves) the liver, pancreas, and gallbladder. Digestion is a complex process; this chapter will provide a brief overview of the physiology of digestion in the feline patient by discussing the functions of the hepatobiliary organs in digestion. Diseases of the liver, biliary tree, and pancreas can be challenging for the veterinary team to diagnose due to nonspecific clinical signs of varying degrees. Due to the close proximity of these organs to each other and the shared vascular system of the hepatobiliary system in the feline patient, when one organ is affected by disease, others in the surrounding region are often also affected. Diseases of the feline hepatobiliary system will be discussed in this chapter, providing the reader with a general overview of each condition.

The liver is considered part of the digestive tract, defined as an extramural gland, meaning it is located outside the lumen of all other organs of the gastrointestinal (GI) tract with the exception of the pancreas, another extramural gland in the digestive tract [3]. The liver is located in the abdomen immediately caudal to the diaphragm. The feline liver is made up of six lobes: left medial, left lateral, right medial, right lateral, quadrate, and caudate lobes. The caudate lobe hugs the cranial pole of the right kidney. The gallbladder is located between the right medial and quadrate lobes. Lobes are further subdivided into microscopic lobules.

The liver receives blood from the hepatic artery and hepatic portal vein. The hepatic portal vein carries oxygen-depleted blood from the GI tract to the liver for filtration of toxins prior to the blood being returned to the general circulation. The hepatic artery is a branch off the abdominal aorta that carries oxygenated blood to the liver. The hepatic portal vein drains blood from the GI tract. These two vessels empty into sinusoids. The sinusoids are microvascular beds containing fenestrations (windows), allowing transfer of the blood nutrients to occur more easily than in other nonfenestrated capillaries in other tissues of the body. With hepatocytes on the other side of the sinusoids, large particles, such as proteins, transfer into the hepatocytes. Kupffer cells (hepatic macrophages) line the sinusoids, allowing them to easily identify and remove particulate material, such as bacteria, cellular debris, aged cells, and tumor cells in circulation.

Bile ductules are the third component of the portal triad, running within the spaces between hepatocyte lobules. When bile is secreted from the hepatocytes into the ductules, which merge into the common hepatic duct. The common hepatic duct and the cystic duct carrying bile from the gallbladder merge to form the common bile duct, which empties into the duodenum.

Table 22.1 Functions of the liver [4].

Metabolizes drugs and toxins
Metabolizes protein, fat, and carbohydrates
Metabolizes and stores vitamins
Blood glucose regulation
Bile production
Absorbing and metabolizing bilirubin
Production of coagulation factors (II, VII, IX, X, and fibrinogen)

The liver's functions aid the body in digestion, as well as in nutrient synthesis and absorption. More specifically, the liver synthesizes nutrients, regulates their release into circulation, excretes toxins (internal and external in origin), and produces plasma proteins, cholesterol, and coagulation factors. Table 22.1 summarizes the key functions of the liver [4].

Blood glucose regulation is another key function of the liver. Glucose is absorbed from the small intestine during the digestion of a meal and is carried to the liver via the portal vein. The liver metabolizes glucose into energy, and excess glucose is stored in the liver and skeletal muscles as glycogen. In the event of excess glycogen, adipose cells can take excess glucose in the bloodstream and convert it to triglycerides for additional energy storage. When glucose is needed for energy, glycogen within the liver and muscles is broken down into glucose through a process known as "*glycogenolysis*." Glucose from a noncarbohydrate substance can occur through a process called "*gluconeogenesis*" in the liver when the body requires energy. When glucose levels within the body are low, lipids can be utilized for energy. Triglycerides are first broken down to produce glycerol and free fatty acids. The liver then converts glycerol into glucose via gluconeogenesis. In situations of severely decreased glucose levels (e.g., starvation), the body can use fatty acids from adipose tissue for energy by converting them into ketones within the liver. Ketones can serve as an alternate energy source; however, an overabundance of ketones will ultimately lead to metabolic acidosis and ketosis.

Other functions of the liver include the production of blood proteins (such as plasma proteins, albumin, and blood clotting proteins) [5] conversion of amino acids into ketoacids. During the degradation process, ammonia is produced from ketoacids. Ammonia is considered a toxin to the body. Once produced, ammonia is converted to urea and excreted through the kidneys.

It is important to note the feline patient lacks certain metabolizing enzymes (UGT1A6, UGT1A9, CYP1A2) [6, 7] and conjugation enzymes (*N*-acetyltransferase and thiopurine methyltransferase) in the liver, limiting the proper clearance of drugs compared to other species. See Chapter 8: "Introduction to Feline Pharmacology," for further information.

The gallbladder concentrates and stores bile until it is needed. With animals that only eat once or twice a day, the body maintains the ability to store bile until another meal is consumed. This allows the continuation of waste product excretion from hepatocytes even when a meal is not actively being consumed. When food is not present in the intestines, the sphincter of Oddi (a muscular sphincter that controls the opening between the common bile duct and the duodenum) is closed, allowing bile to be stored in the gallbladder. During this storage period, sodium, chloride, bicarbonate, and water are absorbed from the bile, concentrating the bile and reducing the volume stored in the gallbladder. When food returns to the intestines, cholecystokinin (CCK) (a hormone released from the small intestine) is released to promote relaxation and opening of the sphincter of Oddi and contraction of the gallbladder [8]. Contraction of the gallbladder pushes bile into the small intestine to assist in digestion and lipid absorption.

Bile is made of bile salts, phospholipids, and cholesterol. Bile acids are formed from cholesterol and are either water- or fat-soluble. During the digestive process bile acids are a key factor in lipid absorption in the intestines because they emulsify the fat into smaller particles, allowing absorption to occur. Bile acids are also responsible for excreting organic compounds, specifically bilirubin.

Bilirubin is a byproduct of hemoglobin, the latter of which results from the breakdown of red blood cells (aka hemolysis) at the end of their lifespan or during disease states. Hemoglobin is converted to heme, which is then converted to biliverdin, which is ultimately converted to unconjugated bilirubin. Unconjugated bilirubin moves into circulation, where it travels to the liver and is absorbed by the liver after combining with albumin. While in the liver, unconjugated bilirubin binds to glucuronic acid, forming conjugated bilirubin. Conjugated bilirubin is released into bile, transported to the small intestine, and reduced to urobilinogen by fecal bacteria. At this point, urobilinogen can be broken down further and

Table 22.2 Summary of pancreatic digestive enzymes.

Pancreatic enzyme	Function
Lipase	Breakdown of lipids into fatty acids
Amylase	Breakdown of starch
Protease	Breakdown of protein into amino acids

excreted through fecal matter or can reenter enterohepatic circulation, by passing the liver and traveling to the kidney and be excreted through urine after further conversion to urobilin [8]. Hyperbilirubinemia can occur if any part of this process is interrupted or dysfunctional, resulting in the patient appearing yellow (icteric or jaundice).

The pancreas is a small abdominal organ that lies next to the stomach and duodenum and is surrounded by the liver. It consists of glandular tissue with two different functions. The endocrine pancreas consists of cells called the islets of Langerhans cells whose primary function is secretion of the hormone insulin to control blood glucose regulation (see Chapter 18: "Endocrinology," for further information). The exocrine pancreas is made of pancreatic acinar cells, which comprise the majority of the pancreatic parenchyma, which empty into a duct system opening into the duodenum. The primary function of the pancreatic acinar cells is to aid in digestion by producing digestive enzymes, namely lipase, amylase, and proteas. See Table 22.2 for a summary of pancreatic digestive enzymes. Proteases are synthesized as proenzymes, which require activation by the digestive enzyme, trypsin [9]. In addition to the digestive enzymes, acinar cells add bicarbonate and water to the enzymatic fluid that enters the duodenum in order to neutralize the acidity of gastric chyme in the small intestine, promoting proper nutrient breakdown and protecting the intestinal epithelial surface [10].

22.1 Patient History and "History Gathering Questions"

Gathering a history for patients with hepatobiliary disease can be extensive and require questions regarding diseases related to other body systems, due to the wide range of hepatobiliary functions within the body. The following questions can be used as a guide for these feline patients, with the understanding that this is not an all-encompassing list.

- Have you noticed abnormal coloration, specifically yellow, of mucous membranes or skin on your pet? If yes, how long has the discoloration been present?
- Please describe your pet's activity level.
- Have you noticed any abnormal behaviors at home such as hiding, or not being social? If yes, please describe them and include how long they have been occurring.
- Does your pet have any previous medical conditions? If yes, what are they? Describe the treatments they are receiving and how long they have received them.
- Have you noticed any GI upset, such as a change in appetite, nausea, vomiting, or diarrhea?
- When was the last time you saw your pet eat a normal meal?
- What is your cat's preferred brand of food?

22.2 Clinical Signs

Hepatic diseases can result in a wide range of severity of clinical signs, from asymptomatic patients with chronic diseases to severe life-threatening complications, such as seizure or hepatic encephalopathy (HE) with acute cases. Patients in crisis can present with nondescript signs that may be seem unrelated to the hepatobiliary system, such as dehydration, lethargy, or hypovolemic shock, which require immediate interventions.

Common clinical signs include vomiting, diarrhea, lethargy, anorexia, depression, or jaundice. In cases of advanced hepatobiliary disease, seizures, head pressing, coagulopathies resulting in bleeding (e.g., nosebleeds, petechiation, and ecchymoses), abdominal distension secondary to ascites, and/or dull mentation can be noted. Clinical signs noted with each disease will be reviewed in the Diseases section of this chapter.

22.3 Physical Examination Findings

In addition to the clinical signs listed in the section above, hepatobiliary disease can produce neurological disorders such as blindness. Head pressing caused by HE is commonly discussed but rarely seen clinically in hepatic disease. Initial physical examination findings indicative of coagulopathies that would warrant further investigation or diagnostics may include prolonged bleeding/hematomas at venipuncture sites, petechiae, or ecchymosis.

Jaundice (aka icterus) is defined as a medical condition characterized by yellowing of the skin and mucous membranes due to increased amounts of bilirubinemia. Jaundice is a common physical examination finding as well as a clinical sign noted by owners associated with hepatic disease. It ranges from a mild, yellow-tinged hue of the patient's skin to a bright yellow appearance, depending on the severity of the disease. In the feline patient, jaundice is most commonly noted on the oral mucous membranes; the sclera; or the skin located between the eye and the base of the pinna, or in the inguinal area. See Figure 22.1 for an example of a patient with icteric mucous membranes. When the disease is more severe, jaundice can be noticed on the skin in all areas of the body. Clinically, bilirubin can be >3 mg/dl, depending on the origin of hepatic disease before jaundice is seen on physical examination [1]. The presence or lack of jaundice is not diagnostic of liver disease. Specific physical examination findings associated with each hepatic disease will be reviewed in the Diseases section of this chapter.

22.4 Specific Nursing Care Considerations

Nursing care is an important part of any successful treatment plan. The veterinary technician plays a significant role in ensuring the prescribed treatments and therapies are carried out properly. Nursing care for a patient with a hepatobiliary disease can include basic nursing care needs, keeping the patient clean and dry, recumbency care, as well as attending to husbandry needs. These patients can be critical requiring regular physical examinations, noninvasive blood pressure monitoring, and careful monitoring of fluid intake, in addition to basic nursing care requirements. Their condition may change rapidly, and these patients can decline precipitously.

Husbandry as a whole is much more than keeping a patient in a clean cage. It encompasses everything from exercise and nutrition to animal welfare and veterinary care. Placing the patient in a cage with comfortable, warm bedding and a



Figure 22.1 A patient with icteric oral mucous membranes. Also, notice the icteric coloration of the nasal planum in this patient. *Source:* Sheila Magaw, LVT.

place to hide will help ensure their comfortable during hospitalization. Refer to Chapter 2: "Feline Friendly Interactions" and Chapter 3: "Preparing the Veterinary Hospital," for the Feline Patient for more information on how to interact with the patient in a stress-reducing environment. If the patient's medical condition allows, giving the patient time to move around and stretch outside of the cage or in a controlled environment will improve their mental well-being. Spending positive time interacting with the patient that does not involve a medical procedure, such as brushing, grooming, and talking to them in a loving manner, has proven to increase contentment and help speed the healing process [11].

Recumbency care involves rotating the body position every 2–4 hours to avoid the development of decubital sores. Physical therapy, such as passive range of motion of all limbs, will help prevent muscle atrophy if the patient is unable to move on their own. Basic eye care, such as applying eye lubricant to a patient that is not voluntarily blinking, will prevent the formation of ulcers. Regular, thorough physical examinations, along with frequent vitals (core body temperature, heart rate, pulse quality, respiratory rate, and character), should be performed to monitor the patient, as prescribed by the veterinarian. The frequency of monitoring vitals will depend on the current stability of the patient.

Feeding the patient is the basis of nutritional nursing care; however, it can be so much more than that. Many patients presenting to the hospital for hepatobiliary disease are hyporexic or anorexic at home due to nausea or underlying diseases. The veterinary technician should take extra time to properly attempt to feed the patient instead of just placing food in the cage and walking away. In the latter scenario, if the patient is nauseous, the presence of the food in the cage may make their clinical signs more prevalent and can result in food aversions. Often, cats become accustomed to certain flavors or textures of food and may only eat their "favorite" food when they are feeling well, making it a challenge to get them to eat when they are hospitalized. When obtaining a patient history, a veterinary technician can learn a patient's food preferences to offer foods the patient likes. Offering multiple types of food is common practice with the feline patient. The best nursing care practices are to take away the food they do not prefer and record those observations in the patient record, so they are not offered repeatedly. Despite the veterinary technician's best attempt to get the patient to eat, oftentimes feeding tubes must be placed for recovery. See Chapter 12: "General Feline Nutrition," for feeding tips and feeding tube care.

Patients experiencing HE will require extra nursing care measures by the veterinary technician. These patients may head-press on the side of their cage and therefore require extra padding on the sides of cages to prevent injury. Often, these patients will not ambulate normally, needing assistance to move in their cage to not knock over food/water bowls. Low-sided litter boxes are helpful, so the patient does not trip or fall over when trying to void. Some patients will be so unsteady that they will no longer urinate on their own. In this situation, urinary bladder care requires urinary bladder expression to void all contents to prevent urinary tract infections.

22.5 Diseases of the Liver

22.5.1 Hepatitis

Hepatitis by definition is inflammation within the parenchyma of the liver and can be acute or chronic by nature [12]. Prompt diagnosis through liver fine needle aspirate or biopsy will not only help determine the status of disease (acute vs. chronic) but can also determine the etiology of the pathologic disease.

The history-gathering phase of the patient's visit may reveal exposure to toxins, or travel history can lead the team to test for suspicious toxin ingestion or infectious diseases depending on geographical locations. As previously mentioned, clinical signs and physical examination findings early in disease can be general and nonspecific. Examination findings can include lethargy, hyporexia, vomiting, abdominal pain, fever, ascites, hepatomegaly, or diarrhea. These findings can vary in severity, which makes the veterinarian rely on abnormal bloodwork as an indicator of hepatic disease. Bloodwork, such as a biochemistry panel, can reveal liver enzyme abnormalities; alanine aminotransferase (ALT), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), and aspartate aminotransferase (AST) can be elevated along with total bilirubin. Refer Table 22.3 for a summary of liver enzymes on a biochemistry panel. Changes in the complete blood count (CBC) can be noted, depending on the severity of systemic inflammation as a result of hepatitis.

Etiologic agents include idiopathic, toxin exposure, or infectious agents (e.g., viral, bacterial, fungal, parasitic, or protozoal) [12, 13]. Identifying the cause will guide appropriate therapies for a successful outcome. Supportive therapy will be depend on etiology, clinical signs, and severity of disease. Treatment of the underlying cause, along with fluid therapy, will be cornerstones of treatment. The prognosis depends on the stage of the disease, complications, and the etiologic agent.

Table 22.3 Liver enzymes and their functions [14, 15].

Enzyme	Abbreviation	Functions
Alanine aminotransferase	ALT	• Liver-specific; it can be increased due to any cause of hepatocellular damage. • The half-life 24–60 hours, with expected correction over 1–2 weeks during recovery.
Aspartate aminotransferase	AST	• Not hepatic-specific, because it is present in liver, muscle, and RBC. • It has shorter half-life than ALT. • AST is present in the cell mitochondria; therefore, when increased represents a more significant disease. • Coinciding increased ALT can help determine hepatic injury with an increased AST.
Alkaline phosphatase	ALP	• It increases in association with cholestatic disease. • It has short half-life in cats. • Any increased values are significant in cats. • Cats may not have increased ALP with hepatic disease. • Hepatobiliary causes for an increased ALP: hepatic lipidosis (HL), cholangitis, and cholangiohepatitis. • Nonhepatobiliary causes for increased ALP: hyperthyroidism or diabetes mellitus.
Gamma-glutamyl Transferase	GGT	• It is useful for diagnosing cholestatic disease. • More hepatic specifically than ALP for cats. • It may not be elevated with HL.

22.5.2 Hepatic Failure

Hepatic failure is the result of acute or chronic injury to hepatocytes for any reason. Once hepatic dysfunction becomes severe, metabolic derangements may lead to HE, ulceration of the gastrointestinal system, bacterial sepsis, ascites, cardiac and respiratory dysfunction, and coagulopathy. Infectious agents, drugs, toxins, trauma, and end-stage hepatobiliary disease are common precursors to hepatic failure [15].

HE is the hallmark clinical sequelae of hepatic failure. It is understood that HE occurs when 70% or more of liver function is compromised [15]. With severe dysfunction of the liver, neurotoxins are not properly filtered, resulting in their continuous increase in circulation until reaching a point when clinical signs become evident. Clinical signs can vary depending on severity and the time of onset of hepatic failure, findings commonly associated with HE include seizures, excitability, behavior changes, ataxia, blindness, head pressing, ptyalism, ascites or circling.

Clinical signs related to hepatic failure include anorexia, vomiting, diarrhea, weight loss, icterus, polyuria, and polydipsia. Diagnosis typically involves identification of HE, marked elevations in liver enzymes, hyperbilirubinemia, and alterations in liver function markers (hypoalbuminemia, hyperbilirubinemia, hypocholesterolemia, hypoglycemia, and decreased BUN) on a biochemistry panel, along with supporting evidence noted on physical examination [15]. Alternatively, during end stage liver failure, hepatic enzyme values will decrease due to hepatic tissue being replaced by scar tissue. Additionally, electrolyte abnormalities, such as hypokalemia and hypophosphatemia, can be present secondary to the physiologic effects of hepatic failure.

Urinalysis can show ammonium biurate crystals or urate crystals in some patients. The feline patient does not have the same capacity as their canine counterpart to conjugate bilirubin within renal tubules, thereby diminishing their ability to reabsorb and eliminate excess bilirubin [16]. As a result, the presence of bilirubinuria in the feline patient should always be noted as abnormal, whereas in dogs, a small amount of bilirubin in concentrated urine can be normal.

With hepatic dysfunction or failure, a coagulopathy may be present, and diagnostics for such should be included in the patient workup. Activated partial thromboplastin time (aPTT), prothrombin time (PT), and activated clotting time (ACT) can be performed to assess coagulation status. Other diagnostics to be performed at this time include an ammonia (performed in a fasted state and 6-hours post-prandial) and serum bile acids (fasting and 2-hours post-prandial). See the "Diagnostic Techniques" section of this chapter for further information. In addition to the abnormalities above on the biochemistry panel, electrolyte abnormalities can be present secondary to physiologic effect of hepatic failure.

Diagnostic imaging, such as abdominal radiographs, ultrasound, or computed tomography (CT) can be a useful aid in this process. Depending on examination findings, the pros and cons of each imaging modality will be reviewed with the patient's status as a whole to guide the veterinarian in obtaining samples via abdominocentesis, aspirate, or biopsy methods.

Once the etiology of hepatic failure has been identified, therapies will be tailored to address the cause while simultaneously addressing complications associated with hepatic failure. Complications associated with hepatic failure, such as HE, can be life-threatening. In those cases, immediate, aggressive intervention is required. Therapies often offered to symptomatic HE patients in hepatic failure include warm water or lactulose enemas, oral lactulose therapy, or antimicrobial therapy. Antimicrobial therapy helps reduce gastrointestinal bacteria, thereby reducing ammonia production. Intravenous fluid therapy will rehydrate the patient and provide oncotic support due to the decrease in oncotic pressure. Excess fluid will accumulate in the tissue, resulting in edema. Nutritional support, when appropriate, will provide protein, fatty acids, and provide vitamins and minerals. The protein content recommendations may vary depending on the underlying cause of hepatic failure.

With time and support, the liver does have the ability to regenerate; however, patients with hepatic failure generally have a poor prognosis. Factors influencing prognosis include the etiology of failure, present complications, and comorbidities. Poor prognostic indicators include a marked hyperbilirubinemia, marked increase in PT, age (very young or old), and drug reaction as an etiology [15].

22.5.3 Hepatic Lipidosis

Hepatic lipidosis (HL) occurs when excess triglycerides accumulate within hepatocytes, resulting in impaired hepatic function and subsequent cholestasis. Known risk factors for hepatic lipidosis in feline patients include anorexia, obesity, and stress [17]. Because cats are obligate carnivores, the metabolism of lipids and proteins requires essential fatty acids, essential amino acids, and vitamins to maintain normal health. Cats do not have the ability to synthesize essential fatty acids in the same manner as other mammals. In the event of anorexia, these become deficient. The combination of these factors is instrumental in the formation of HL.

Classic clinical signs of HL include anorexia, weight loss, lethargy, vomiting, icterus, ptyalism, constipation, and diarrhea. Physical examination findings may include obesity (or a history of obesity), icterus, dehydration, mental depression, and nausea. Patients with advanced disease can become hypokalemic and experience HE with associated clinical signs. Specific clinical signs associated with hypokalemia include muscle weakness and ventroflexion of the neck.

Baseline bloodwork (CBC, biochemistry panel) should be performed to assess the patient status. Increased bilirubin, ALP, and ALT are commonly noted in HL. Blood glucose may be elevated as a result of insulin resistance, especially in obese patients; however, hypoglycemia is seen in end-stage liver function or failure. Decreased biochemistry values noted in cases of HL include albumin, BUN, potassium, magnesium, and phosphorus. See Figure 22.2 for a summary of expected changes on a biochemistry panel. A CBC can be within normal limits or reveal mild nonregenerative anemia. Additional comorbidities may result in abnormalities noted on a CBC [17]. Similar to hepatic failure, HL may result in coagulopathies; therefore, coagulation status should be confirmed. Often, patients will experience abnormalities in these diagnostics requiring interventions.

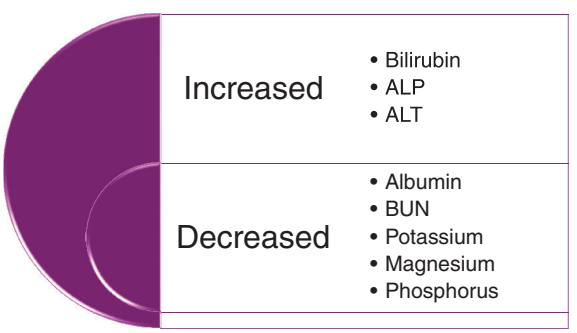


Figure 22.2 Common biochemistry panel results associated with hepatic lipidosis. *Source:* Paula Plummer.

The definitive diagnosis of HL is often made via cytologic examination of an ultrasound-guided liver aspirate or via histopathologic review of a hepatic biopsy [17]. The determination of which diagnostic is most appropriate for the individual patient by the veterinarian factors in the stability of the patient, the ability to undergo general anesthesia for a liver biopsy, and the patient's coagulation status. An ultrasound-guided aspirate of the liver may be chosen over biopsy in cases where sedation is more appropriate for the patient than general anesthesia. The sick feline patient will naturally accumulate fat in the liver; therefore, a definitive diagnosis of HL is only made once there is evidence of fat accumulation in at least 80% of hepatocytes [17].

Supportive therapy and nutritional management are the keys to the HL treatment. Many patients are dehydrated, and hypovolemia should be corrected. Intravenous fluid therapy will correct hypovolemia and electrolyte abnormalities. Supplementation of electrolytes (potassium, phosphate, and magnesium) may be required to correct deficiencies. Electrolyte correction should be initiated *before* nutritional supplementation is initiated to not further exacerbate electrolyte deficiencies. During this phase of therapy, serial physical examinations to assess hydration status, along with serial blood work to ensure electrolyte correction, are of utmost importance. The time intervals between physical examinations are dependent on patient stability but can range from hourly to every 12 hours. Time intervals between blood work are also patient-dependent but can vary from every few hours to daily once electrolyte status is more stable.

Early nutritional supplementation can be initiated via enteral or parenteral routes. Enteral feeding is preferred; however, the parenteral route can be considered in specific individuals with uncontrolled vomiting, complete/persistent anorexia, or the inability to withstand feed tube placement. Many patients will not voluntarily eat; therefore, a feeding tube can be placed for enteric nutrition supplementation. See Chapter 12: "General Feline Nutrition," for guidelines on feeding tube selection/placement and nutrition calculations. Dietary selection for the patient should consist of a high protein, low carbohydrate food, which is commonly found in veterinary recover diets.

Patients who have been anorexic for an extended period of time will require a slow reintroduction of food with a gradual caloric increase over 2–3 days to avoid refeeding syndrome. Reintroduction of calories too quickly to a patient that has been anorexic for an extended period of time will promote a rapid release of insulin due to the reversal of the body's negative catabolic state. This is called refeeding syndrome. Clinical signs of refeeding syndrome include vomiting, diarrhea, and shock. Hallmark abnormalities of refeeding syndrome on a biochemistry panel are hyperglycemia, hypophosphatemia, and hypokalemia.

Other supportive therapies should include antiemetics and/or gastroprotectants for patients that are nauseous or vomiting. Vitamin K supplementation should be included for patients with coagulopathy.

Positive prognostic indicators for HL include young age and the absence of additional complications, such as hypokalemia and anemia, at the time of diagnosis. Negative prognostic indicators include hypoalbuminemia and the presence of comorbidities [17].

22.5.4 Portosystemic Shunts

A portosystemic shunt (PSS) describes a vascular anomaly that results in a direct connection between the hepatic portal and systemic circulations. Two categories of PSS exist: intrahepatic and extrahepatic. Cats most commonly experience single extrahepatic shunts; however, intrahepatic shunts have been reported as well [18, 19].

Common clinical signs of a PSS in feline patients include copper-colored irises, ptyalism, abnormal behaviors, disorientation, or blindness [20]. However, clinical signs can range widely from anorexia, vomiting, ataxia, head pressing, lethargy, to seizures.

Ultrasonography, scintigraphy, or CT should be performed to help diagnose and determine the exact location of a PSS. A biochemistry panel will aid in identifying the severity of liver dysfunction and often reveal abnormalities in liver enzymes and liver function markers.

A combination of medical and surgical treatment is required. Preoperative stabilization is commonly required for the feline patient with a PSS due to the severity of neurologic, gastrointestinal, or urinary signs that can be present. Supportive care with intravenous fluids to correct dehydration, accompanied by targeted therapy with cathartics, antimicrobials, and nutritional modification to help decrease ammonia production. Patients experiencing HE secondary to a PSS may also require anticonvulsants or lactulose enemas, in addition to therapies previously mentioned, depending on severity. Patients with hypoalbuminemia may require intravenous albumin supplementation to correct hypoalbuminemia and associated abnormalities in serum colloid osmotic pressure. Nutritional modification should involve a low-to-medium-protein commercial diet.

Once the patient is stable, surgical intervention should occur to correct the shunting vessel using a ligature or a gradual occlusion device, such as an ameroid constrictor or cellophane band. A slow occlusion device has the benefit over immediate occlusion in that slow occlusion of the shunting vessel helps decrease the risk of portal hypertension.

Postoperative patients should be closely monitored, as they can deteriorate quickly. Small changes in the patient's visual examination can indicate significant postoperative complications. Common complications include portal hypertension, coagulopathies, and neurological dysfunction. Portal hypertension occurs due to the increased vascular pressure within portal circulation, resulting in venous congestion of the organs within and downstream of the portal system circulation. This increased vascular pressure can result in ascites, organ edema, and hemodynamic compromise. Clinical signs of portal hypertension include abdominal pain, abdominal distention, diarrhea, melena, and hypovolemia. Aggressive supportive therapy should be initiated based on the clinical signs. If a response to such supportive therapy is not observed in a timely manner, a second surgical intervention may be required to remove the occlusion device to alleviate portal hypertension and its sequelae. The feline patient has been reported to have prolonged coagulation values; therefore, clotting times should be monitored postoperatively [20].

Cats undergoing occlusion of a PSS have a higher incidence of postoperative neurological complications, such as seizures, compared to their canine counterpart. One study reported postoperative neurologic complications in 75% of the cats with neurological disorders (seizures and central blindness) being the most common complication of attenuation of a congenital extrahepatic PSS [19]. Many cats require lifelong therapies due to complications that end in euthanasia. Patients who do not develop postoperative complications have a good short term prognosis [19].

22.6 Diseases of the Gallbladder and Bile Duct

22.6.1 Cholecystitis

Inflammation of the gallbladder is termed cholecystitis and is subclassified into two categories: nonnecrotizing and necrotizing. Nonnecrotizing cholecystitis can be due to neoplasia, trauma, systemic disease, or infectious agents. Necrotizing cholecystitis can be due to trauma, extrahepatic bile duct obstruction (EHBDO), bacterial infection, gallbladder mucocele, or thromboembolism [21].

Anorexia, vomiting, diarrhea, lethargy, abdominal pain, and icterus are all reported as clinical signs of cholecystitis. On the abdominal ultrasound, the gallbladder will be enlarged with possible changes to the gallbladder wall depending on disease chronicity. Ultrasound-guided cholecystocentesis and cytologic evaluation can yield bacteria and/or inflammatory cells based on etiology. *Escherichia coli* (*E. coli*), *Streptococcus, Clostridium*, and *Salmonella* have all been identified in cases of feline bacterial cholecystitis [22]. See the "Diagnostic Techniques" section of this chapter for additional information on preparation for this procedure.

Supportive therapy is the mainstay of treatment for cholecystitis. Intravenous fluid therapy to correct dehydration and electrolytes is necessary. Nutritional support with feeding tube placement is pertinent in patients who will not voluntarily eat. The medical therapies indicated are determined by the cytologic results of a cholecystocentesis. Antimicrobials are indicated in cases secondary to bacterial infection.

In cases of gallbladder rupture or EHBDO, surgical intervention is emergently required. Postoperatively, many cats experience complications and should be monitored for anorexia, nausea, vomiting, and fever during recovery [21].

22.6.2 Extrahepatic Bile Duct Obstruction

EHBDO is commonly caused by bile sludge, cholangitis, cholecystitis, and the inability of the gallbladder to contract normally. Gastrointestinal disease, neoplasia, and pancreatitis have also been reported as potential causes of EHBDO [22]. There are no breed, age, or sex predilections associated with EHBDO; however, Siamese have been reported as being overrepresented as a result of cholangitis and pancreatitis within the breed [23].

General clinical signs of EHBDO can include icterus, lethargy, fever, weight loss, anorexia/hyporexia, vomiting, diarrhea, and abdominal pain. Elevations in liver enzymes, abnormalities in liver function markers, marked hyperbilirubinemia, hyperglobulinemia, and azotemia can be seen on the biochemistry panel. Abnormalities noted on a CBC can indicate the etiology of EHBDO. For example, eosinophilia would be seen in cases of parasitism.

Imaging diagnostics can aid in diagnosing the condition. Abdominal ultrasound is a useful diagnostic tool as the common bile duct and intrahepatic and extrahepatic bile ducts, are not seen in a normal patient. In a patient experiencing EHBDO, the common bile duct will be dilated due to the obstruction, and this dilation can be noted on ultrasound [2]. Patients may be experiencing multiple hepatobiliary diseases simultaneously; therefore, multiple disease processes may be diagnosed using this imaging modality. Additional diagnostics may include cytology of fine-needle hepatic aspirates and/or ascites, gastrointestinal function panel (feline pancreatic lipase immunoreactivity [fPLI], trypsin-like immunoreactivity [TLI], cobalamin, folate), or bacteriology [22].

Indicated treatments are multifactorial, based on the individual, the etiology of EHBDO, and comorbidities. Surgical intervention is indicated for a mucocele, cholelith, or foreign body; corticosteroids are indicated with cholangitis, or gastrointestinal disease; anthelmintics for liver flukes; and antimicrobials are indicated for suppurative cholangitis. See Figure 22.3 a patient with a dilated common bile duct and Figure 22.4 the same patient's bile duct after surgical intervention.

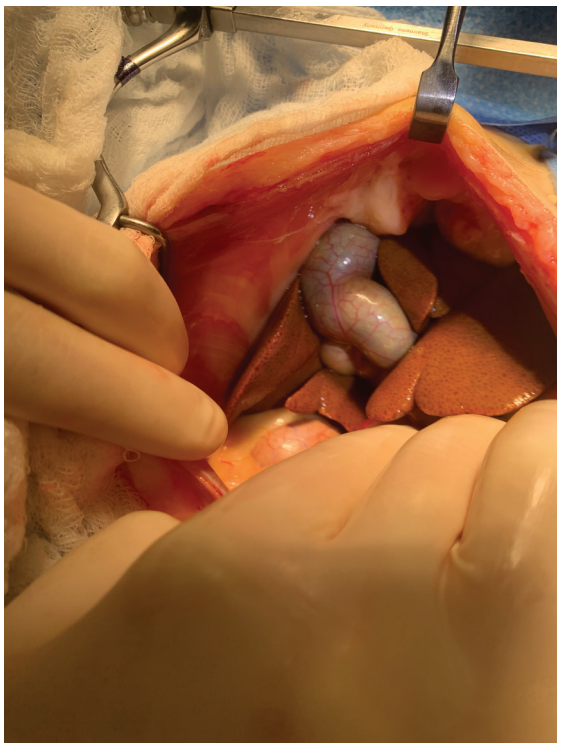


Figure 22.3 A cat with enlarged common bile duct due to an obstruction before undergoing surgical attenuation. *Source:* Vanna Dickerson, DVM, MS, DACVS (Small Animal).

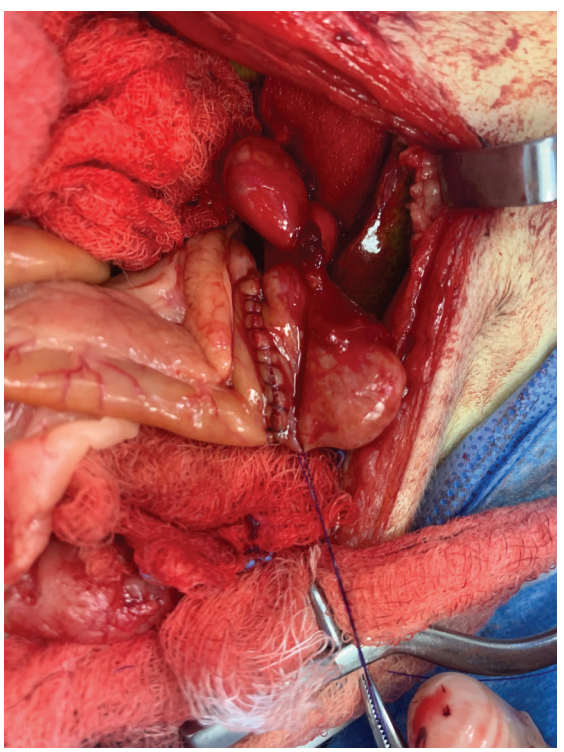


Figure 22.4 The same patient after cholycystoenterostomy. Note the reduction in size of the common bile duct. *Source:* Vanna Dickerson, DVM, MS, DACVS (Small Animal).

Supportive therapy can be time-consuming and requires great diligence to ensure the patient remains pain free, clean, and comfortable. Postoperative patients require attention to their surgical site and astute observation to prevent licking their surgical site. Bodysuits or soft E-collars are recommended, but some patients can find these aids stressful and constricting. Whether the patient has undergone surgical or medical treatment, they can easily become painful. Refer to Chapter 7: "Analgesic Considerations in the Feline Patient," for current recommendations for analgesics and feline pain scoring systems. Basic nursing care measures, including keeping the patient clean and comfortable, are important. Refer to the "Specific Nursing Care Considerations" section for further information.

Nutritional support is necessary to prevent HL from developing. If the patient is not eating voluntarily, placement of a feeding tube is required. Refer to Chapter 12: "General Feline Nutrition," for guidelines on feeding tube selection, placement, and nutrition calculations.

The prognosis for patients with EHBDO is fair to guarded. The underlying etiology, as well as comorbidities, plays a significant role in prognosis. Surgical patients can experience a myriad of complications during the perioperative period, worsening the prognosis.

22.6.3 Feline Cholangitis Complex

Feline cholangitis complex (FCC) is a common hepatobiliary disorder in cats. Studies indicate that neutrophilic cholangitis (NC) is present in 20% of feline patients with hepatobiliary disease [23, 24]. Feline cholangitis can be broken down into further categories; NC, lymphocytic cholangitis (LC), and chronic cholangitis, the latter being associated with liver fluke infestation [25]. Both NC and LC, but primarily NC, are often associated with inflammatory bowel disease (IBD) and pancreatitis [13]. This phenomenon is referred to as "*triaditis*." See the "Triaditis" section for further information.

22.6.3.1 Neutrophilic Cholangitis

NC is the most common type of FCC. It is defined as the presence of neutrophils in the bile duct and liver, which may be distributed diffusely or localized to specific areas of the organ(s). Occasionally, neutrophilic inflammation can be found in the parenchyma of the liver. NC is further classified as acute and chronic, with the difference being based on the presence of neutrophils within the organ and the severity of fibrosis. Studies have shown a higher prevalence of young versus old cats in certain geographical areas, however, any cat of any age, breed, or sex can be affected [26]. Certain breeds have been overrepresented in studies, but additional knowledge is required to determine the difference in regional geographical risk versus genetic predispositions. Potential genetically disposed breeds include British Shorthair, Burmese, Domestic Longhair, Persian, Siamese, and Sphynx [23].

The development of NC in cats depends on two different factors. The first being the presence of a complete or partial biliary obstruction which will decrease the flow of bile and increase pressure in the biliary ducts. This is important because, in this environment, biliary stasis will allow bacterial migration. The second factor affecting the development of NC is the presence of bacteria in the bile or liver. Biliary infections may be caused by bacterial migration from the duodenum via the common bile duct or develop secondary to bacterial translocation from the intestine via the hepatic portal circulation [27].

Diagnostic tests for NC include cytological evaluation and aerobic/anaerobic bacterial culture of bile collected either via ultrasound-guided cholecystocentesis or at the time of exploratory laparotomy. See the "Diagnostics Techniques" section for further information regarding ultrasound-guided cholecystocentesis. Coagulation status should be assessed prior to any invasive procedures, as these patients may have a lack of hepatic vitamin K, thus resulting in decreased activation of clotting factors necessary for coagulation.

Cytologic examination and aerobic/anaerobic culture and sensitivity of bile will guide the veterinarian's selection of antimicrobial therapies and/or aid in identifying other etiologies. E. coli is reported to be the most common enteric bacterium cultured from bile in feline patients with NC [28]. Other common bacterial species isolated include *Clostridium* spp. and *Staphylococcus* spp. [13]. Histopathologic samples of the liver obtained during an exploratory laparotomy, laparoscopic procedure, or an ultrasound-guided percutaneous needle core biopsy, i.e., Tru-Cut biopsy can also aid in providing a definitive diagnosis. Samples should be taken from multiple liver lobes to avoid a false negative in the event of only a single lobe being affected.

Although biopsies are considered a gold standard for providing a definitive diagnosis, they may not be performed due to a variety of reasons, such as instability of the patient or owner wishes. In such cases, the veterinarian must consider the patient's entire clinical picture to develop a presumptive diagnosis and initiate empirical treatment. Most patients

require hospitalization and the initiation of fluid therapy for rehydration purposes along with additional therapies, such as broad-spectrum antibiotics and nutritional support. Once culture/sensitivity and infectious disease results are concluded, treatments can be adjusted to reflect the individual patient's needs. In patients with a biliary obstruction, surgical intervention is required immediately. Once the patient recovers from the acute event and is stable, they can be discharged and managed on an outpatient basis. Prognosis varies widely and depends on the severity of disease, response to therapies, surgical complications (for the postoperative patient), and the presence of comorbidities.

22.6.3.2 Lymphocytic Cholangitis

Unlike NC, FCC secondary to LC is more chronic in nature and is characterized by an increase in small lymphocytes in the portal region, resulting in varying degrees of fibrosis and bile duct hyperplasia. Retrospective studies have shown that Persian, Siamese, Burmese, and Norwegian Forest Cats may be overrepresented [2, 23]. Interestingly, cats with LC can be subclinical in the presence of abnormal liver enzymes on routine bloodwork. The typical progression of LC occurs over months to years with waxing and waning clinical signs such as lethargy, hyporexia, vomiting or icterus.

Diagnostic testing for LC is the same as that recommended for NC, with a liver biopsy often being required for a definitive diagnosis. Special staining methods (i.e., immunohistochemistry, IHC) to identify T-lymphocytes, B-lymphocytes, and the biliary epithelium are needed for the definitive diagnosis of LC and its differentiation from small cell lymphoma.

Once histopathology confirms LC without the presence of bacteria, treatment with prednisolone can be initiated at immunosuppressive doses. If LC is diagnosed concurrently with a bacterial infection, an anti-inflammatory dose of prednisolone can be initiated with the proper antimicrobial [27]. Hospitalization is required for the unstable patient to initiate the rehydration process as well as provide supportive therapies, such as nutritional support. Once the patient is stable, they can be discharged and managed on an outpatient basis. Prognosis varies widely and depends on the severity of the disease, response to therapies, and the presence of comorbidities.

22.6.3.3 Cholangitis Due to Liver Flukes

Chronic cholangitis can be due to liver flukes, commonly of the Platynosomum species [2, 27]. Typically, cats with an outdoor lifestyle in endemic areas will remain subclinical with the severity of clinical signs being relative to the parasite burden. Anorexia, vomiting, diarrhea, lethargy, weight loss, and icterus are common clinical signs. Liver enzymes and bilirubin are commonly elevated on the biochemistry panel. A definitive diagnosis can be obtained via identification of adult nematodes on cytologic evaluation of bile (collected via a cholecystocentesis) or by detection of eggs on a fecal examination via direct smear, zinc sulfate, or double centrifugation with Sheather's sugar flotation solution [29]. Treatment with praziquantel at the time of diagnosis and 12 weeks post-initial treatment rids the patient of the parasite load. Adjunctive therapy with prednisolone, hepatoprotective agents, and antimicrobials can be considered on an individual basis for the feline patient. Prognosis depends on the severity of the parasite burden, comorbidities as well as the severity of clinical signs at diagnosis.

22.7 Diseases of the Exocrine Pancreas

22.7.1 Pancreatitis

Inflammation of the pancreas is called pancreatitis. In the feline patient, pancreatitis can be acute or chronic in nature, without an age, sex, or breed predilection. Chronic pancreatitis is associated with mild clinical signs, whereas acute pancreatitis is associated with severe clinical signs, clinically [30]. See Figure 22.5 for a summary of concurrent medical conditions associated with pancreatitis [30, 31]. Pancreatitis can be idiopathic or associated with the concurrent medical conditions mentioned, due to the anatomical differences of their canine counterparts. The cat, only having one pancreatic duct joining the bile duct before entering the duodenum, increases the risk of reflux of bile or gastrointestinal contents [32].

Common clinical signs and physical examination findings are nondescript and may vary in severity, including lethargy, anorexia/hyporexia, vomiting, dehydration, tachycardia, and hypothermia.

Abdominal ultrasound is a routine diagnostic method utilized to aid in the diagnosis of pancreatitis. A biochemistry panel, CBC and urinalysis may support the diagnosis as well. However, these diagnostics are not specific to pancreatitis; therefore, measurement of species-specific pancreatic enzyme, lipase, is specific and provides valuable information for

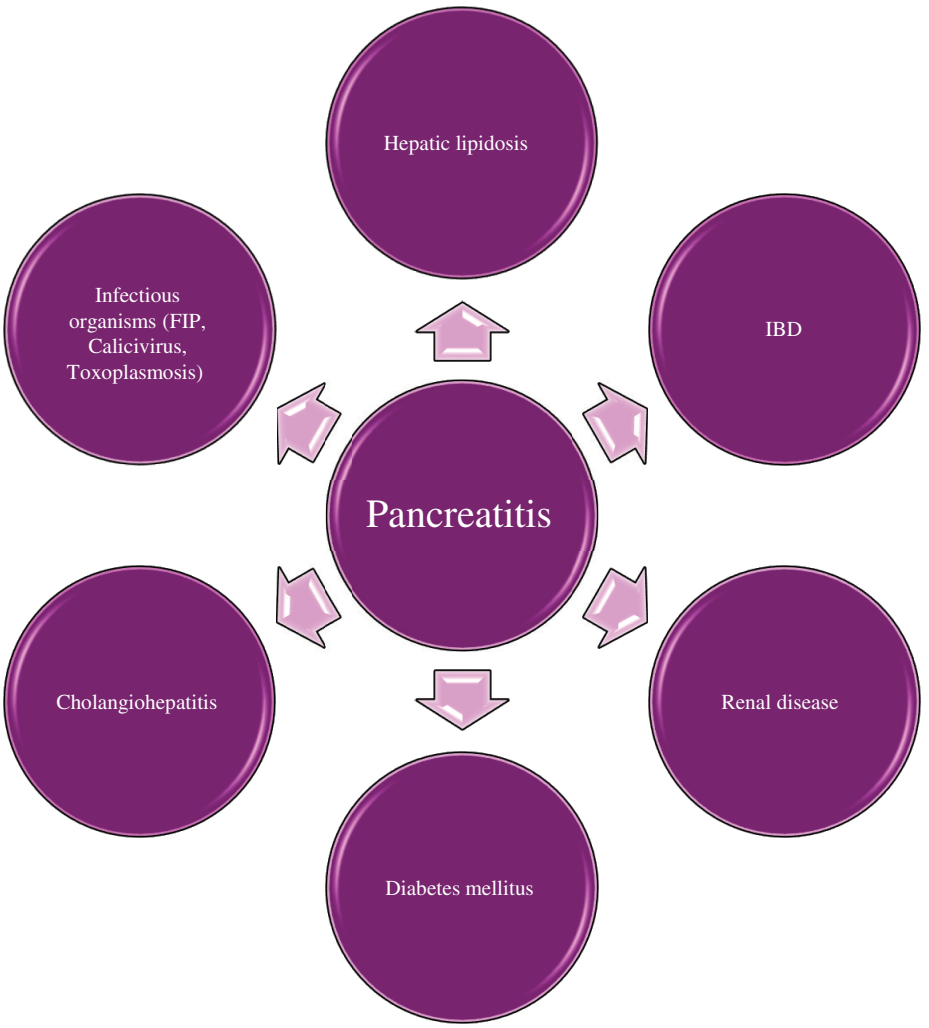


Figure 22.5 Concurrent medical conditions associated with pancreatitis [30, 31]. *Source:* Paula Plummer.

diagnosis. Due to the multiple forms of lipase existing in the body the specific serum ffPL) should be measured [31]. An elevated fPLI is supportive of pancreatitis. Other diagnostic methods include cytology of an ultrasound-guided pancreatic aspiration. The presence of inflammation would represent pancreatitis. However, it is important to remember that an aspirate only represents that localized area of tissue and is not representative of all areas of the pancreas. Diagnosis is made on a collection of supportive diagnostic tools such as bloodwork and imaging as well as patient history and clinical signs.

Treatment of pancreatitis (acute and chronic) requires supportive and symptomatic therapy. Management of an underlying condition and complications will have an impact on a successful outcome. Supportive therapies such as intravenous fluids to correct dehydration and electrolyte abnormalities, nutritional support, antiemetics, and analgesics will be the foundation of therapies. See Chapter 7: "Analgesic Considerations in the Feline Patient," for recommendations on pain assessment and analgesics. Many cats with pancreatitis will not voluntarily eat; therefore, appetite stimulants or feeding tubes must be places to provide nutritional support. The current recommendation is to restart feeding as soon as possible to counteract impaired gastrointestinal immobility, disruption of normal microbiota, and prevention of hepatic lipidosis [31]. See Chapter 12: "General Feline Nutrition," for nutritional recommendations.

Prognostic factors include the presence of comorbidities and complications associated with pancreatitis. Acute pancreatitis prognosis can range from good to grave depending on the severity of acute pancreatitis and associated complications with each individual. Chronic pancreatitis often occurs as a comorbidity of another disease; therefore, prognosis in this case will vary depending on all comorbidities and status of each individual.

22.7.2 Exocrine Pancreatic Insufficiency

Exocrine pancreatic insufficiency (EPI) is due to a decreased amount of pancreatic digestive enzymes leading to inappropriate absorption of nutrients (protein, fat, and starch) in the small intestine. Compared to the canine patient, EPI is considered rare in the feline patient. Chronic pancreatitis is considered the most common cause of EPI in the cat. However, neoplasia, pancreatic duct obstruction and parasitic infection can also be the etiology [33]. There is no age, sex, or breed predilection.

Weight loss, voluminous diarrhea, and polyphagia are commonly associated with EPI in dogs. However, weight loss is the most common clinical sign seen in cats [34]. If diarrhea is noted it can be characterized as malodorous, loose, or semi-formed, and lighter in color than normal feces. Diagnostic tests include species-specific serum feline TLI (fTLI), cobalamin, and folate. A low serum fTLI is a diagnostic of EPI in feline patients [34, 35]. Hypocobalaminemia is also commonly found in cats with EPI.

The treatment of EPI consists of cobalamin and pancreatic enzyme supplementation, and nutritional modification. Pancreatic enzyme supplementation can be done with raw pancreas or a commercially prepared supplement. Both methods of supplementation are placed on food and eaten by the cat. The raw porcine pancreas should be from a disease-free animal, be finely cut, and frozen in individual serving sizes. Of the commercially available products offered in tablets, capsules, or powder, the powder is the most effective and should be placed on fresh canned food and mixed thoroughly [34]. In cases of hypocobalaminemia, subcutaneous supplementation is superior to oral supplementation due to the body's ability to absorb cobalamin in this state. Subcutaneous supplementation requires a loading dose of a weekly injections, and then monthly thereafter. Nutritional recommendations of a commercially prepared, high-protein, or hypoallergenic diet would be appropriate if not contraindicated by a pre-existing comorbidity [36].

Response to treatment can occur due to concurrent medical conditions or by the presence of enteric microbiota dysbiosis (EMD). Therefore, control of comorbidity or antimicrobials can be considered. The majority of cats respond well to treatment giving them a good prognosis in the absence of complications [36].

22.8 Triaditis

Triaditis is the combination of simultaneous inflammatory bowel disease (IBD), pancreatitis, and cholangitis. For further information on each disease, see the "Pancreatitis and Cholangitis" sections in this chapter and Chapter 19: "Gastroenterology," for IBD. One study reports that approximately half of the cats diagnosed with pancreatitis and 32–50% of cats with cholangitis have been diagnosed with triaditis, and other studies reporting similar statistics [37, 38]. Much information is left to be discovered in regard to triaditis such as whether this condition three separate disease processes occurring simultaneously or one multi-organ disease process. Further studies are needed to fully understand the pathophysiology to improve diagnostic and treatment methods.

Clinical sign severity can vary with a portion of cases being asymptomatic. Anorexia, vomiting, lethargy, dehydration, icterus, and diarrhea are commonly reported in patients with triaditis. Diagnostic and treatment methods are demonstrated in each disease section of this textbook. Refer to those sections for further information. Supportive and nutritional therapies are crucial for the management of triaditis. Restarting nutritional supplementation as soon as possible is important to avoid development of HL.

The severity of the disease will determine the prognosis for each feline patient. For example, patients with acute, severe disease will have a poor prognosis, while patients with chronic disease that can be managed mostly at home will have a good prognosis [38].

22.9 Diagnostic Techniques

Consistently an elevated ALT indicates liver damage. An elevated ALP and total bilirubin may also be noted on a biochemistry panel as well. Other abnormalities commonly noted on a biochemistry panel that are associated with marked liver disease include decreased BUN, albumin, cholesterol, and glucose. See Table 22.3 for a summary of liver enzyme tests on a biochemistry panel.

22.9.1 Ammonia

Handling and shipping of the sample must be adhered to for accurate results because the level of ammonia will continue to rapidly increase. Consultation with the commercial laboratory performing the test before obtaining the sample is advised. Most laboratories will accept a sample from EDTA or heparin that has been separated immediately, and plasma is frozen or kept on ice if delivery of sample is within an extremely short time frame. Often commercial laboratories prefer to be notified of an incoming sample so quality control can be performed before the arrival of the sample [39]. This diagnostic test will determine the hepatic function of the patient.

22.9.2 Serum Bile Acid Test

A bile acid test should be performed on pre- and post-prandial blood sample. The patient should fast for 8–12 hours before collecting a baseline sample [40]. Once the baseline sample is drawn, the patient can be fed a small meal, and a second sample should be collected 2 hours after the patient finishes the meal. Both samples are to be placed in a red-top tube and separated immediately. Serum is to be submitted as per their recommendations to the commercial laboratory performing the test. This diagnostic test will determine hepatobiliary function and portal blood flow of the patient resulting in an increased post-prandial result with the presence of PSS [41].

22.9.3 Cholecystocentesis

This procedure can be performed percutaneously during abdominal ultrasound, laparoscopy, or abdominal exploratory surgery. This procedure has minimal complications for retrieving sterile bile samples. When choosing the percutaneous method, the patient should be under heavy sedation or general anesthesia to minimize movement, and the insertion site clipped and surgically prepped to avoid contamination. Generally, complications associated with the procedure are minimal; however, varying degrees of hemorrhage have been reported [42]. Cytology and culture and sensitivity are commonly performed on samples. An EDTA tube as well as a microscope slide should be readily available to place the sample into and perform sample preparation for cytology. Aerobic and anaerobic culturettes should be available to place the sample into for the culture and sensitivity. Shipping and handling samples should be based on the preference of the commercial laboratory performing the diagnostic test.

Hepatobiliary disease in the feline patient can be challenging to diagnose and treat due to multiple disease processes potentially occurring at the same time. The severity of clinical signs and physical examination findings varies widely with many hepatobiliary diseases. Diagnostic modalities can be invaluable in identifying the etiology and comorbidity when present. The veterinary technician will face these challenges as part of the veterinary care team during nursing care tasks and carrying out prescribed therapies as the patient advocate while on the road to recovery.

See the companion website for further clinical references.

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23

Feline Infectious Diseases

Paula Plummer, LVT, VTS (ECC, SAIM, CP-fe)

TECHNICIAN TIDBITS

- Hospital policies should include manufacturer guidelines for disinfection protocols.
- Utilize proper personal protective equipment based on transmission methods to reduce contamination and the spread of infection.
- Proper hand hygiene between each patient should be performed to control the spread of the disease.
- Premade sets of tools or instruments (stethoscope, thermometer, bandage scissors) for infectious patients will reduce the contamination of instruments and the spread of disease.
- Initiate barrier nursing to reduce contamination and spread of infection.
- When administering oral medications, giving water following each dose will reduce the incidence of esophagitis in the patient.

A veterinary technician's role in feline infectious disease patient care is vital in every step, from gathering a valuable history, proper sample collection, to patient care during hospitalization. Due to the magnitude of feline infectious diseases, this chapter will only cover common bacterial, fungal, protozoal, and viral diseases. Refer to Chapter 9: "Feline Immunology and Current Vaccination Guidelines" for suggested vaccination protocols for infectious diseases.

23.1 History-gathering Questions

Gathering information from owners can be an intricate process that helps the team gain valuable information regarding the patient. Knowing the travel history, external parasite prevention, the pet's lifestyle, vaccination status, and the health status of other pets and humans in the household is the starting point for gaining knowledge of patients potentially affected by an infectious disease. See below for an example information-gathering questions for an infectious disease patient.

- Is there a recent history of local, regional, or international travel?
- If there is a history of travel, please specify when and where.
- Is there a known exposure to a source of infection (arthropod vector, animal, or human)?
- Are there others including humans and animals in the house showing clinical signs?
- Explain the pet's lifestyle.
- What is the pet's vaccination status?
- Has this pet received any type of blood transfusion during its life?
- Has there been recent exposure to new animals of any species?

23.2 Clinical Signs

See Table 23.1 for clinical signs associated with each disease.

Table 23.1 Infectious disease, clinical signs, and physical examination findings.

Disease	Classification	Clinical signs	Physical examination findings
Aspergillosis	Fungus	Unilateral or bilateral nasal discharge, sneezing, facial swelling, epistaxis, inappetence, conjunctival discharge	Nasal discharge, sneezing, facial swelling, epistaxis, weight loss, conjunctival discharge, exophthalmos, third eyelid prolapse, keratitis, corneal ulcer, absent pupillary light response (PLR), absent menace
Bartonellosis	Bacteria	Vary widely, asymptomatic, lethargy, ataxia	Vary widely, fever, lymphadenopathy, respiratory distress, endocarditis, heart murmur or arrhythmia, neurological disease
Bordetella	Bacteria	Vary widely, asymptomatic, coughing, sneezing, ocular discharge, dyspnea, lethargy	Vary widely, fever, coughing, sneezing, ocular discharge, lymphadenopathy, pneumonia, dyspnea, cyanosis, death
Calicivirus	Virus	Sneezing, tongue/oral ulcers, nasal discharge, inappetence, lameness, ulceration of nasal planum	Sneezing, tongue/oral ulcers, fever, nasal discharge, chronic gingivostomatitis, conjunctivitis, polyarthritis, ulceration of nasal planum, pneumonia
Chlamydiosis	Bacteria	Conjunctivitis, sneezing, cough, nasal discharge, reproductive disorders, lameness	Conjunctivitis, rhinitis, cough, sneezing, blepharospasm, nasal discharge, stertorous respirations, reproductive disorders, arthritis
Cryptococcosis	Fungus	Inappetence, sneezing, coughing, nasal discharge, facial mass (ulcerated or nonulcerated) over the bridge of the nose, ataxia, blindness, behavior changes	Regional lymphadenopathy, stertor, dyspnea, oral lesion, otitis externa, cutaneous lesion over the bridge of the nose, behavior changes, optic neuritis, blindness, ataxia
Cytauxzoonosis	Protozoa	Anorexia, lethargy, pyrexia, respiratory distress, vocalization, weakness, icterus or pale mucous membranes, obtunded, coma, seizures	Tachypnea, tachycardia, dyspnea, vocalization, weakness, icterus or pale mucous membranes, lymphadenopathy, splenomegaly, hepatomegaly, ataxia, seizures, coma, sudden death
Dermatophytosis	Fungus	Localized to general circular lesions +/– scaling/crusting in alopecic areas, +/– pruritis	Localized to general circular lesions +/– scaling/crusting in alopecic areas, +/– pruritis
Feline immunodeficiency virus	Retrovirus	Inappetence, depression, lymphadenopathy, fever	Weight loss, fever, lymphadenopathy, depression, chronic gingivostomatitis, chronic rhinitis, underconditioned
Feline leukemia virus	Retrovirus	Vary widely, reproductive disorders, lethargy, pale mucous membranes, failure to thrive, vocalization, elevation of third eyelid, blindness, paresis, abortion, sudden death, tumors, clinical signs of other opportunistic infections	Vary widely, immunosuppression, tumors, reproductive disorders, neuropathy, upper respiratory tract disease, pale mucous membranes, dermatitis, gingivostomatitis, petechiation, blindness, paresis, anisocoria, underconditioned, weight loss, Horner's syndrome, sudden death. Kittens progress rapidly: severe dehydration, failure to nurse, failure to thrive, sudden death.
Giardia	Protozoa	Asymptomatic, intermittent diarrhea, chronic weight loss, malodorous feces	Asymptomatic, dehydration, weight loss, diarrhea

Disease	Classification	Clinical signs	Physical examination findings
Herpesvirus	Virus	Sneezing, nasal discharge, ocular discharge, respiratory distress, blindness	Rhinitis, conjunctivitis, corneal ulcers, dyspnea, stromal keratitis, rhinosinusitis, corneal edema, blindness, sneezing, nasal discharge, ulcerative facial dermatitis, third eyelid protrusion, ocular discharge
Histoplasmosis	Fungus	Depression, lethargy, inappetence, weakness, respiratory distress, lameness, coughing, diarrhea, vomiting, skin lesions	Weight loss, lethargy, dyspnea, pale mucous membranes, lameness, conjunctivitis, retinal detachment, coughing, facial abnormalities, organomegaly on palpation, lymphadenopathy
Mycoplasma	Bacteria	Weakness, depression, anorexia, weight loss, lethargy, sudden death	Weakness, depression, pale mucous membranes, underconditioned, dehydration, weak pulses, tachycardia, sudden death
Panleukopenia		(Rapid decline in kittens) inappetence, hypothermia, comatose, vomiting, diarrhea, oral ulceration, icterus, ataxia, tremors, seizures	Septic shock, extreme dehydration, icterus, hypothermia, comatose, lymphadenopathy, oral ulceration, retinal lesions, retinal degeneration, ataxia, tremors, seizures
Rabies	Virus	Change in behavior, unexplained aggression, weight loss, anorexia, agitation, hyperexcitability, paralysis, or seizures, exposure to a rabid animal	Change in behavior, unexplained aggression, weight loss, anorexia, agitation, hyperexcitability, paralysis, or seizures
SARS-CoV-2	Virus	Fever, cough, lethargy, increased respiratory effort, gastrointestinal and respiratory system involvement	Fever, cough, lethargy, increased respiratory effort, gastrointestinal and respiratory system involvement
Toxoplasmosis	Protozoa	Asymptomatic, diarrhea, lethargy, inappetence, personality changes, ataxia, seizures	Asymptomatic, weight loss, fever, lethargy, seizures, hyperesthesia, ataxia, opisthotonos, respiratory distress
Tritrichomoniasis	Protozoa	Asymptomatic, waxing and waning malodorous diarrhea upon completion of treatment	Asymptomatic, large bowel malodorous diarrhea

23.3 Physical Examination Findings

See Table 23.1 for physical examination findings associated with each disease.

23.4 Nursing Care Considerations

Nursing care for the infectious patient will require a wide variety of critical thinking skills due to the variety of an infectious patient's needs. However, the utilization of barrier nursing will limit transmission to other patients as well as humans, with proper protocols for personal protective equipment (PPE) and disinfection. These techniques should always be at the forefront of the veterinary technician's patient care. Proper hand hygiene, in addition to the utilization of examination gloves, is key to reducing cross-contamination. General patient care, such as keeping the patient clean and dry, maintaining dry bandages over wounds, and intravenous catheter maintenance, will be ongoing tasks.

Attending to the patient's well-being with low-stress techniques, comfortable beds during recovery, and positive, non-medical interactions, in addition to medical therapies, with the patient will improve the patient's hospital experience. The specific needs of each patient should be tailored to each patient. For example, gently cleaning the nostrils and eyes of congested patient with a warm compress will soften hardened debris and allowing for continued drainage to clear the passages and potentially entice them to eat.

23.5 Bacterial Infectious Diseases

23.5.1 Bartonellosis

Feline Bartonellosis is a zoonotic and vector-borne disease caused by *Bartonella henselae*. The Bartonella species are a gram-negative hemotropic bacteria found worldwide, with higher rates geographically in flea-endemic areas [1]. Fleas (*Ctenocephalides felis*), as well as ticks, mice, mites, and flies, are all considered vectors for Bordetellosis. Once transmission occurs, the erythrocyte is infected, becoming the site of replication. The infection is typically chronic with subclinical periods and recrudescence lasting for years. Clinical signs and physical examination findings can vary widely in severity.

The bacteria have been identified in peripheral blood samples using the immunocytochemical and immunohistochemical methods; however, blood and tissue cultures are the most reliable diagnostic methods for active Bartonellosis infection. Other diagnostic methods utilized for diagnosis include polymerase chain reaction (PCR), culture, histopathology, serology (including indirect fluorescent antibody [IFA], enzyme-linked immunosorbent assay [ELISA], and Western immunoblot) on whole blood, fine needle aspirates (FNA), or tissue samples when patient history and clinical signs correlate with active infection or exposure.

Treatment of Bartonellosis in stable patients includes doxycycline in conjunction with a fluoroquinolone. The use of antibiotics should be reserved for confirmed-positive cats to reduce the incidence of microbial resistance. To reduce the incidence of a sudden release of bacterial endotoxins, multimodal antimicrobial therapies should be prescribed to combat resistant strains of Bartonella. With this therapy design, the second antimicrobial should be started seven days after the first to reduce the sudden release of large numbers of toxins into the body at the same time [2]. Treatment for positive patients with endocarditis includes supportive medication and therapies during congestive heart failure. The prognosis is poor in patients with endocarditis.

23.5.2 Bordetella

Bordetella bronchiseptica is gram-negative coccobacillus that colonizes the respiratory tract causing rhinitis, tracheobronchitis, and bronchopneumonia in mammals. Direct and indirect transmissions occur from oral and nasal secretions, as well as communal water sources. Overcrowding and poor disease management predispose infection of feline populations. *B. bronchiseptica* is stable in the environment for 10 days and is susceptible to most disinfectants [3].

Severe infections can include pneumonia, dyspnea, cyanosis, and even death, with young kittens being reported to be at a higher risk of severe infection [4]. Identification of the bacteria in tracheal or bronchoalveolar lavage (BAL) samples, bacterial culture, and a real-time PCR are the diagnostics of choice. Samples for bacterial culture can be obtained from an oropharyngeal swab or trans-tracheal wash. Studies show that PCR is a reliable diagnostic tool for the identification of *B. bronchiseptica* in feline patients [5].

Disease management includes proper disinfection protocols, antimicrobial therapy, supportive treatment, and vaccination protocols. Antimicrobial therapy is recommended based on the results of susceptibility and sensitivity results. Symptomatic treatment may include intravenous fluids, oxygen therapy, or nutritional support depending on clinical signs.

23.5.3 Chlamydiosis

Worldwide, feline chlamydial infections are caused by the intracellular bacterial organism Chlamydia felis. Due to transmission methods requiring close contact, the prevalence is higher with overpopulation in shelters, breeders, or households. Venereal transmission has been noted due to shedding of the organism through vaginal and rectal discharge, in addition to ocular discharge.

Once transmission occurs, the organism reproduces in the epithelial cells of the conjunctiva and then moves into circulation via the tonsils, lungs, liver, spleen, gastrointestinal tract, and kidneys taking 2–5 days for a pathogenic infection to occur. However, some infected populations will remain asymptomatic [6]. Diagnosis can be achieved with a PCR of oropharyngeal and conjunctival epithelial cell collections via swab with a cotton tip applicator. See the Diagnostic Tools section below for a full description of the sample collection. The PCR can be used as a monitoring tool throughout treatment to ensure the infection is resolved [7].

Treatment with tetracycline or doxycycline for a minimum of three to four weeks will resolve the infection. However, clavulanic acid and fluoroquinolones have been proven to be effective in those patients whose doxycycline is not indicated. Treatment should continue for two weeks beyond the resolution of clinical signs.

23.5.4 Mycoplasma Infections

Mycoplasmic organisms are the smallest living organisms and are classified into nonhemotropic or hemotropic species. Hemotropic mycoplasmas are parasitic organisms that attach to the wall of erythrocytes causing the destruction of the cell wall and resulting in immune-mediated hemolytic anemia (IMHA). Multiple strains of hemotropic mycoplasmas affect cats, with *Mycoplasma haemofelis* considered as the most pathogenic, not requiring an altered immune status of the host to become pathogenic from the organism [8].

This infectious disease is reported worldwide with higher rates of infection noted in certain geographical locations with arthropod vectors, such as the cat flea (*Ctenocephalides felis*) or ticks. Because of this, it is assumed that arthropod vectors may play a role in transmission. Transmission can also occur via bite wounds or saliva as well as indirect methods, such as blood transfusions and contaminated instruments.

Once transmission occurs, the acute phase of the disease occurs in a month or more thereafter causing a rapid decline in health status due to acute anemia. The number of bacteria present on erythrocytes is of a cyclic manner, taking 1–5 days for bacterial levels to decrease. When diagnostic samples are collected during lower-level periods, diagnostics can be inconclusive. Bacterial numbers are associated with splenic sequestration, which releases infected or noninfected erythrocytes into circulation, altering the appearance of the bacteremia load. This cycle causes progressive erythrocyte damage and shortens their life cycle causing immune-mediated injury. The splenic activity of the patient will eliminate the bacteremia over time.

Clinical signs and physical examination findings will vary depending on the stage of infection, immune response, and health status of the cat. Abnormalities, such as regenerative or nonregenerative anemia or splenomegaly, are noted in laboratory testing and diagnostic imaging, respectively. A definitive diagnosis can be achieved with a positive cytology from an FNA using a Romanowsky stain; however, PCR testing is considered the gold standard. Cytology has a low sensitivity and cannot differentiate between species.

Treatment protocols include tetracyclines (e.g., doxycycline), or fluroquinolones (e.g., pradofloxacin or marbofloxacin). First-line treatment is doxycycline for a minimum of 2–4 weeks. PCR can be repeated for monitoring purposes throughout treatment to ensure the reduction in bacteremia. Supportive therapy can include intravenous fluids to correct hydration status or blood transfusions and oxygen therapy to support severe anemia. Prognosis is favorable when infections are treated early. Some cats can become carriers, with recrudescence occurring thereafter.

23.6 Systemic Fungal Infectious Diseases

23.6.1 Aspergillosis

Aspergillosis is a pathogenic fungal disease caused by *Aspergillus sp.*, containing hundreds of species with six subgenera. The subgenera affecting feline patients are commonly *Fumigati, Circumdari*, and *Nidulantes* [9]. The spores (conidia) naturally live in an environment, including soil, water, and air. *Aspergillus* is an opportunistic pathogen; therefore, host immunity is a key factor in the development of disease [10]. Infection typically resides in the nasal cavity extending to the extra-nasal, plate and cribriform plate or orbital tissue; this is termed fungal rhinosinusitis.

The definitive diagnosis of aspergillosis is achieved through positive identification on cytologic examination or histopathology, advanced imaging, and visualization of the fungus in the affected tissue via rhinoscopy. Advanced imaging can identify bone erosion of the cribriform plate or nasal turbinate destruction before nasal cultures or biopsies are

obtained to avoid the incidence of sampling normal brain tissue. Nasopharyngoscopy can identify the presence of fungal plaques in sino-nasal infections. However, endoscopy can be unfruitful in sino-orbital infections due to the deep tissue invasion of the fungus. In addition to positive identification on cytology or histopathology, serology and PCR can be utilized to identify the presence of aspergillosis.

Treatment methods for feline aspergillosis depend on the classification of infection: invasive versus noninvasive. Invasive infections include antifungal drugs, such as itraconazole. Noninvasive sino-nasal infections include endoscopic debridement of fungal plaques and the application of topical therapy. Clotrimazole (1%) intranasal infusions require general anesthesia of the patient, with a contact time of 15 minutes in each recumbency [9] (Figure 23.1).

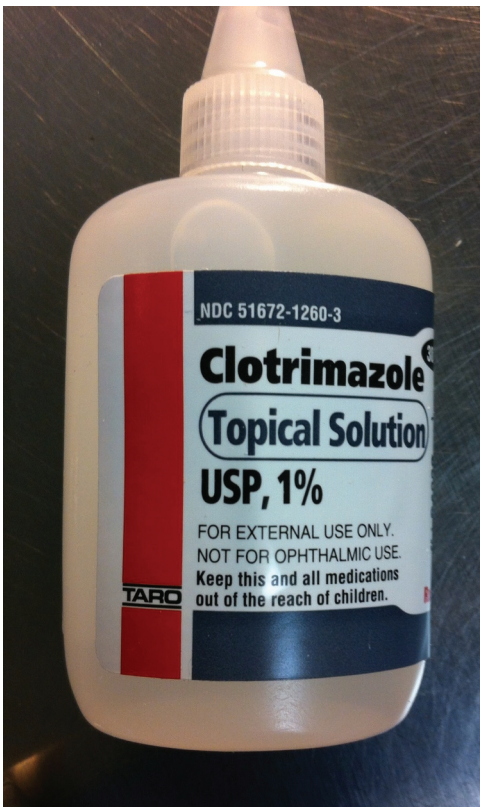


Figure 23.1 Clotrimazole 1% for intranasal infusion. *Source:* Paula Plummer.

23.6.2 Cryptococcosis

Cryptococcosis is a common systemic fungal infection in cats caused by *Cryptococcus gattii* and *Cryptococcus neoformans* species complexes, respectively. The infection can be acquired worldwide and is believed to result from inhalation through the environment. In feline patients, the most common site of infection is the nasal cavity due to the transmission method and the size of the organism [11]. There is no gender or age predilection. Once the infection becomes disseminated, multiple body systems are infected complicating physical examination findings and their severity.

Positive identification can be obtained through cytology, fungal culture, or histopathology of a tissue sample via nasal swab, nasal wash, FNA, impression smear, or BAL. Abnormalities observed on a complete blood count (CBC), biochemistry profile, or urinalysis will be nonspecific to cryptococcosis. Advanced diagnostic imaging can be support the diagnosis of fungal infection and aid in choosing the sample collection site.

Fluconazole is the treatment of choice for localized cryptococcosis due to its low cost and capability of penetrating the brain, eye, and urinary tract [12]. Patients who are resistant to fluconazole can undergo treatment with other antifungals. Therapy should continue until the antigen titer is zero and complete healing of a lesion when present. Antigen titer monitoring should occur every 2–3 months during therapy and every 3–6 months after titers are zero, to monitor for recurrence according to the Miravista Veterinary Diagnostics guidelines at the time of publication (www.miravistavets.com). Hepatoxicity is a common side effect of azole antifungals; therefore, liver enzymes should be monitored frequently during treatment.

As with other systemic fungal infections, supportive therapy would include nutritional support via feeding tube placement until the patient is voluntarily eating. Stabilization such as intravenous fluid therapy, patient monitoring during hospitalization, and antiseizure medication for the patient experiencing neurologic instability. The prognosis for the cutaneous form is good; however, those with the disseminated form of infection may have a poor prognosis, depending on the severity of the infection and complications.

23.6.3 Dermatophytosis

Dermatophytosis is the most contagious and zoonotic skin disease diagnosed in high-density cat-populated areas, such as households, shelters, and catteries. Outbreaks can be avoided or reduced if proper identification, treatment, and isolation protocols are strictly followed. The most common dermatophytes in cats is *Microsporum canis* or *Trichophyton sp.* Transmission occurs by direct contact with an infected cat or indirectly through contact with a contaminated environment. The incubation period is 1–3 weeks, and cats can remain infectious for several weeks after the resolution of clinical signs if not appropriately treated.

Clinical signs include localized to generalized circular lesions of alopecia, often with scaling or crusting in the center. The degree of pruritus can vary from absent to severe. Typical locations for the lesions are the face, pinnae, feet, and tail, but they have been identified in all anatomical locations.

Diagnosis cannot be made by examination alone. A Wood's lamp examination can aid in the diagnosis of dermatophytosis; however, it is important to note that not all genera and species will test positive with a Wood's lamp examination, so a culture must be performed for a definitive diagnosis. See Figure 23.2 for a demonstration of a positive Wood's lamp examination on a kitten's face, and Figure 23.3 for a demonstration of a positive Wood's lamp examination on a kitten's paw. The toothbrush technique is the most effective method for obtaining a dermatophyte culture [13]. Dermatophyte test medium (DTM) can be commercially purchased, and cultures can be performed as in-clinic diagnostic or sent to a commercial laboratory. See the Diagnostic Technique section at the end of the chapter for an explanation of the technique and diagnostic interpretation. Treatment of ringworm includes decontamination of the environment, and systemic and topical treatments. First, the patient must be topically decontaminated with diluted lime sulfur dips or antifungal shampoo, started immediately to help decontaminate the patient and prevent recontamination of the environment, and applied twice weekly. Clipping of hair should only be done when medically indicated for specific cases, due to the aerosolization of the spores in the environment and the spread of clinical signs. In cases with lesions in locations that are unable to be reached by dips, such as the face or around the eyes, topical antifungal medications can be applied as an adjunct therapy. Systemic antifungal medication, itraconazole, should be administered in conjunction with topical therapies and disinfection [14]. Therapies should continue until diagnostic measures are negative.

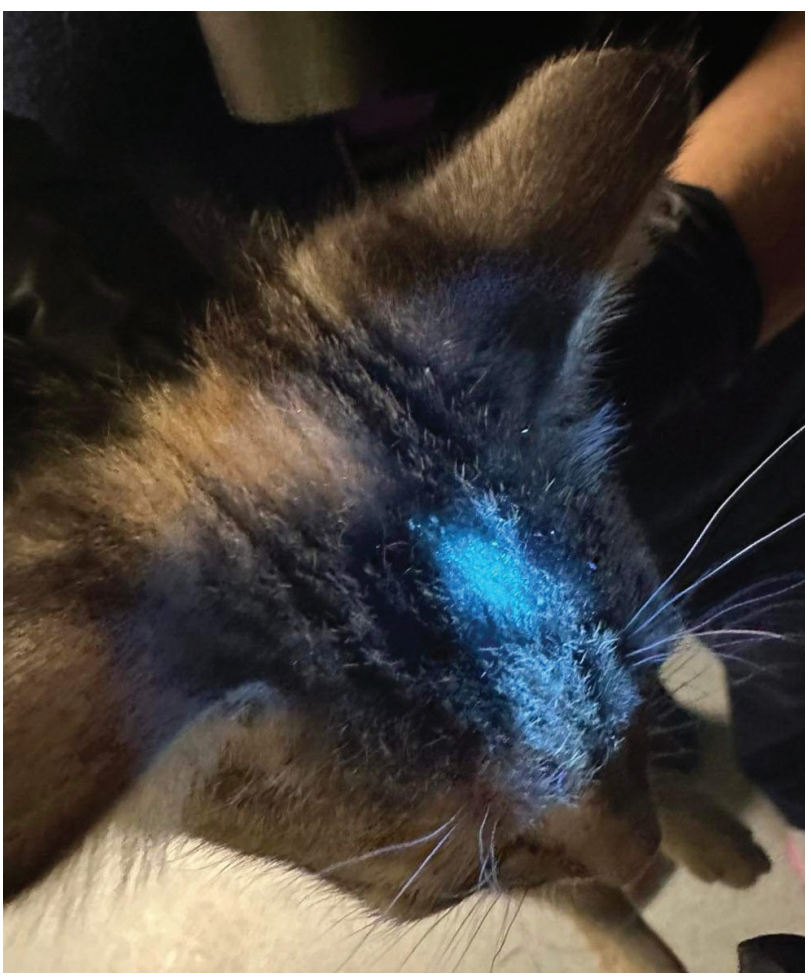


Figure 23.2 Positive Wood's lamp examination of dermatophytosis on a kitten's face. *Source:* Christine Prior, DVM.

Disinfection with agents that target fungal infections specific to species of dermatophytes will be effective. Any surface the patient encounters should be regularly disinfected. All soft surfaces, such as bedding, furniture, clothing, carpet, and upholstery should be cleaned twice weekly with a disinfectant that is labeled to kill this organism. Hard surfaces such as food and water bowls, litter boxes, and flooring, should also be cleaned twice weekly. Isolation of positive cats in areas with a different ventilation system will help control contamination as well.



Figure 23.3 Positive Wood's lamp examination of dermatophytosis on a kitten's paw. *Source:* Christine Prior, DVM.

23.6.4 Histoplasmosis

Histoplasmosis infection derives from the fungal organism *Histoplasma capsulatum*, a fungus living in soil worldwide. It can survive in almost any environment; however, it thrives in warm, humid climates. Histoplasmosis is transmitted by inhalation of the microconidia, which are small enough to reach the lower respiratory tract on inhalation, with an incubation period of approximately 2 weeks or faster, depending on the immune status of the host. After inhalation, the microconidia convert to the yeast phase and buds (reproduce). The yeast is then taken up by phagocytosis and undergoes further replication and migrates to regional lymph nodes, then to the liver and spleen. Histoplasmosis can become disseminated, taking on an acute or chronic form of disease. Common sites for disseminated histoplasmosis include bone marrow, the small or large intestinal tract, skin, bone, and eye, in addition to the sites previously mentioned [15].

There are no age, breed, or sex predilections. Clinical signs are dependent on the infection site; however, they can be nondescript. A diagnosis can be obtained by positive cytologic identification of the organism from aspirates, fungal culture, antibody serology, PCR, or antigen assay. Aspirates of the organism can be obtained from affected locations such as bone marrow, lung, spleen, urinary bladder, liver, or lymph node. Antigen assay (Histoplasma Quantitative EIA Test) detection can be identified in serum, or urine for initial diagnosis, as well as determining relapse or remission when submitted to Mira Vista Diagnostics in Indianapolis, IN [16]. Diagnosis of histoplasmosis can be challenging, therefore, multiple diagnostics as well as a supporting patient history and clinical signs can be used to obtain a definitive diagnosis.

Hematologic abnormalities vary depending on the chronicity and severity of the disease in the individual. Abnormalities noted are normocytic, normochromic, nonregenerative anemia, thrombocytopenia, neutrophilic leukocytosis with monocytosis, and eosinopenia. Biochemistry panels commonly show hypoalbuminemia, hyperbilirubinemia, increased ALP, and hyperglobulinemia depending on the organ(s) affected.

Diagnostic imaging provides supportive information for a histoplasmosis infection. Radiographic abnormalities consist of diffuse, linear, or nodular interstitial patterns, mixed interstitial-alveolar-bronchial patterns of lung lobe consolidation on pulmonary radiographs. See Figure 23.4 for an example of a thoracic radiograph of a patient with Histoplasmosis. Splenomegaly, hepatomegaly, or ascites can be present on abdominal radiographs. Joint involvement including extracapsular or intracapsular swelling, osteomyelitis, or pathologic fractures, can be seen on distal limb radiographs. Abnormal ultrasound includes enlargement or hypoechogenicity of regional lymph nodes or abdominal organs, such as spleen, liver, adrenal gland(s), intestinal wall, or kidney(s).

Azole antifungal medications are the treatment of choice for Histoplasmosis. Itraconazole also comes in compounded formulations, liquid, and capsules; however, studies show that the oral suspension is more consistently absorbed, whereas compounded formulations are poorly absorbed. Capsules show lower absorption rates on an empty stomach and provide administration challenges to the owner [17, 18]. Fluconazole is another antifungal used to treat histoplasmosis in cats that cannot tolerate itraconazole. Most patients undergo long-term therapy of four months or more depending on response and severity of infection, with antifungal drugs before they are negative. Response to therapy

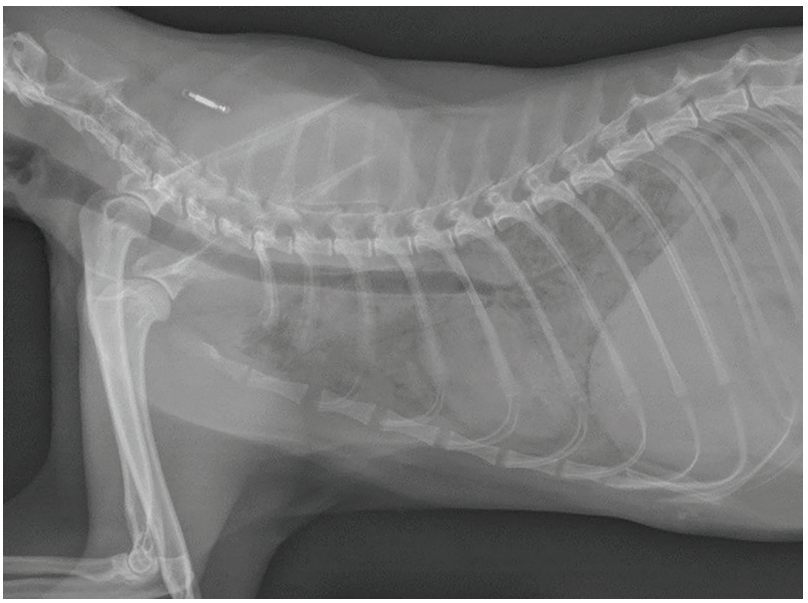


Figure 23.4 A thoracic radiograph of a feline patient with Histoplasmosis. *Source:* Paula Plummer.

should be monitored routinely with monthly biochemistry panels to assess liver values. Reevaluation of therapeutic drug monitoring for itraconazole to ensure proper levels are reached, should be performed 21 days after initial therapy or a dose change occurs. In the acute phase of the disease, supportive therapy is necessary for successful treatment. Patients who are dehydrated, anorexic, or dyspnea will require fluid therapy, nutritional support with feeding tubes, and oxygen therapy, respectively. A sizable percentage of cats will survive for months following diagnosis. However, complications such as relapse, drug toxicity, and severe infections affecting respiratory, hepatic, or neurologic systems will reduce the survival rate [19].

23.7 Protozoal Infectious Diseases

23.7.1 Cytauxzoonosis

Cytauxzoonosis is caused by the hematoprotozoal parasite *Cytauxzoon felis*. Cytauxzoonosis is transmitted only by the American Dog Tick (*Amblyomma americanum*). This tick must feed off a reservoir host, become infected, and then feed on a domestic cat. There is no breed, age, or sex predilection for cytauxzoonosis. Clinical signs, such as anorexia, lethargy, and pyrexia are commonly noted. The disease will progress very quickly, and within hours to days, the cat will be severely affected.

Diagnosis is achieved by identification of the piroplasm on a peripheral blood smear. Infected tissue can be obtained by FNA from the lymph node, liver, or spleen for a diagnosis as well. Hemolytic anemia and thrombocytopenia will be noted on CBC. Coagulation factors, such as activated partial prothrombin time and prothrombin time, will be prolonged as a common finding in disseminated intravascular coagulation (DIC) as a secondary condition to cytauxzoonosis. Other laboratory abnormalities noted on the biochemistry profile include hypoalbuminemia, hypocholesterolemia, hypokalemia, and an elevated alanine aminotransferase (ALT). PCR can confirm the presence of cytauxzoonosis even in early disease.

Treatment with atovaquone and azithromycin should be started immediately [20]. This treatment regimen shows a higher success rate than previous therapies. Aggressive supportive care, such as blood transfusions, intravenous fluids, and medications are necessary to combat the heavy parasite load, DIC, and multiple organ dysfunction syndrome during the acute phase. In recent years, cytauxzoonosis has been a disease that felines can survive, rather than historically being viewed as a fatal only infectious disease. Ectoparasite prevention and an indoor lifestyle in endemic areas are the best prevention strategies.

23.7.2 Giardiasis

Giardiasis is a disease caused by a protozoan parasite of the *Giardia* spp., which occurs worldwide. Animals who are immunocompromised or in overcrowded situations have an increased prevalence of clinical infection [21].

Diagnosis of giardiasis in the feline patient is typically obtained via a direct fecal smear using light microscopy. However, antigen, fecal culture, or PCR can be performed for identification on a fresh, unrefrigerated sample. The recommended treatment for giardiasis is metronidazole. Utilizing lower doses in kittens will reduce the incidence of central nervous system and gastrointestinal toxicity. In the feline patient, fenbendazole is another safe treatment option for nonpregnant, adult cats.

23.7.3 Toxoplasmosis

Toxoplasmosis is caused by the protozoan parasite *Toxoplasma gondii*. Only cats can complete the life cycle and pass oocytes in the feces for *T gondii*. Toxoplasmosis can infect many warm-blooded vertebrates and is found in warm, humid climates worldwide. This parasite is considered highly contagious and zoonotic. See Figure 23.5 for the *T. gondii* life cycle. The definitive host (cat) ingests a tissue cyst or oocyst. The organism then undergoes asexual reproduction in the intestine and unsporulated oocyst is shed in the feces for approximately 14 days. Once in the environment, the oocyst becomes sporulated, lying dormant waiting for a new host. Intermediate host (e.g., rodents, birds, and dogs) ingests sporulated oocyst. The sporozoite spreads and transforms into a tachyzoite, then a bradyzoite. End-stage host (e.g., human, cow, and pig) ingests sporozoite from tissue cyst, soil, or contaminated food or water [22].

Transmission of toxoplasmosis occurs in carnivores and omnivores by ingesting the sporozoites (tachyzoite or bradyzoite), oocyst, or tissue cyst in contaminated food or water, fecal to oral or working in contaminated soil.

Infected cats can remain asymptomatic depending on the strain of *T. gondii* and the occurrence of an immunosuppressive event, such as a secondary medical condition or the administration of immunosuppressive medications. When cats become symptomatic, the clinical signs can vary depending on the location of infection. During respiratory infections, pleural effusion

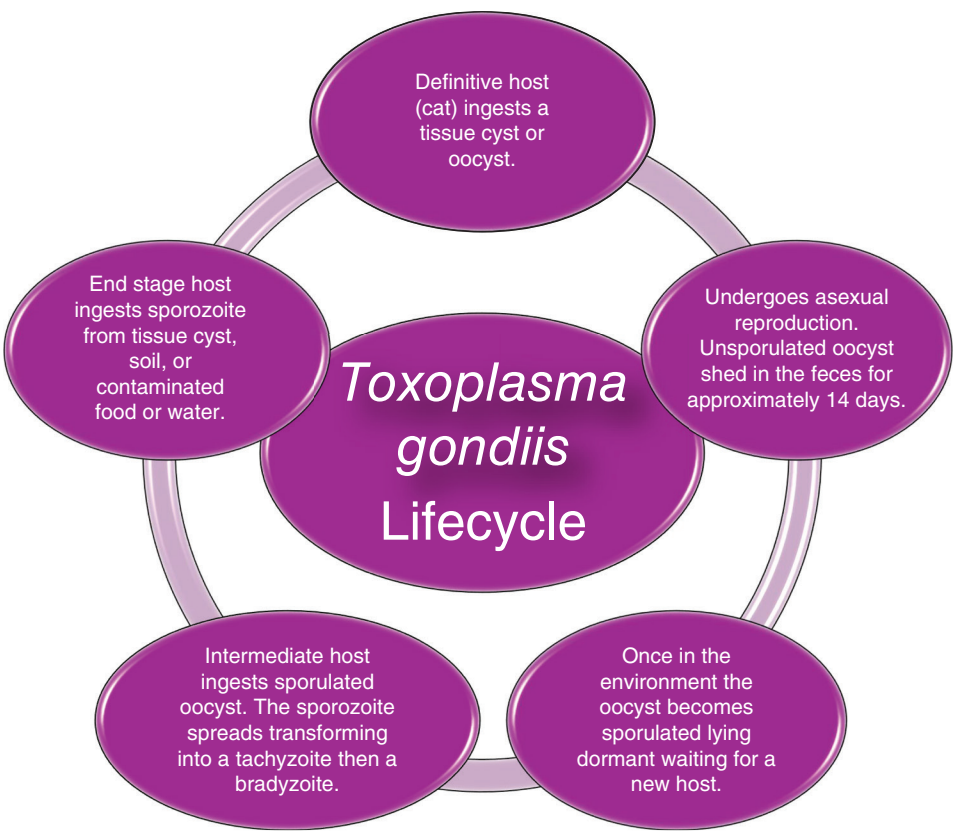


Figure 23.5 *Toxoplasma gondii* life cycle. *Source:* Paula Plummer.

and diffuse interstitial to alveolar patterns can be seen on advanced imaging. Kittens can develop more severe clinical signs, with the disease becoming fatal quickly when an infection is transmitted via transplacental or queen's milk.

Diagnosis is obtained with a variety of diagnostic methods in conjunction with the presence of correlating clinical signs. These include fecal flotation, PCR, cytology, histopathology, serology, IgG, IgM, ELISA®, or agglutination assays. Oocysts can be identified on fecal flotation; however, it requires active shedding of oocysts. Therefore, it can be a difficult diagnostic test to determine the presence of active disease. Positive identification on cytology, BAL, or histopathology of samples will result in a diagnosis of active infection. Serological diagnostic tests can be challenging to interpret, as both active infection and a history of exposure will test positive. IgM and IgG-positive titers can aid in diagnosis in cats with supportive client history, clinical signs, and the presence of inflammation [22]. A negative IgM and IgG antibody titer would indicate a naive cat that is susceptible to infection when exposed.

Abnormalities in other laboratory tests will depend on the affected organ. CBC and biochemistry abnormalities can include nonregenerative anemia, as well as affecting neutrophils, lymphocytes or eosinophils, increased protein, bilirubin, ALT, ALP, and lipase based on the severity of infection. Diagnostic imaging may be unremarkable or show abnormalities specific to the affected organ.

Treatment for toxoplasmosis includes clindamycin, azithromycin, ponazuril, or trimethoprim-sulfa. Cats with uveitis due to toxoplasmosis require topical glucocorticoids in addition to avoid lens luxation or glaucoma. Alternate therapy can be prescribed by the attending clinician if the owner notes a negative response after seven days. Therapy should be continued for a total of four weeks. In cases with hepatic, CNS, or pulmonary involvement, the prognosis is poor.

Humans contract toxoplasmosis by eating undercooked meat, eating with utensils that touched infected raw meat, ingestion of infected water, ingestion of infected feces (occurs accidentally when cleaning litter boxes of infected animals, ingesting contaminated soil), or transplacental transmission or blood transfusion. Individuals who are most at risk include those who are pregnant or immunocompromised. Proper hand hygiene, cleaning litter boxes daily, and eating fully cooked meat will reduce the risk of human infection. It is recommended to consult a human physician and the Centers for Disease Control and Prevention for high-risk situations.

23.7.4 Trichomoniasis

Trichomoniasis is caused by the protozoan parasite *Tritrichomonas blagburni*, also known as *Tritrichomonas foetus* in cats. The parasite is found worldwide in cats, with the prevalence dependent upon geographical location and housing situation. Cats living in higher population environments without disinfection protocols are at risk for infection.

Transmission commonly occurs indirectly through feces-to-mouth ingestion of the parasite. The parasite can survive for several hours in moist food and several days in moist feces. *T. blagburni* lives in the large intestine, specifically the distal ileum and colon, causing colitis and foul-smelling diarrhea.

Laboratory abnormalities noted on a CBC and biochemistry profile are nonspecific to trichomoniasis. In cases with severe diarrhea, electrolyte derangements (potassium, chloride, and sodium) may be noted secondary to dehydration from the diarrhea. Fecal PCR and cultures can provide a diagnosis through direct wet mount fecal on fresh, nonrefrigerated samples. False negatives occur with decreasing numbers of the organism or with inappropriate samples. Samples must be handled based on commercial laboratory recommendations, knowing false negatives can result in mishandling.

Treatment should include supportive care when a patient is dehydrated from diarrhea, in addition to the azole drugs (ronidazole or tinidazole) for a minimum of 14 days. If clinical signs reappear, repeating the course of therapy is recommended. Neurological signs, such as ataxia and seizures are side effects of this drug class in the feline patient. Close monitoring for the presence of these clinical signs should also occur at home.

23.8 Viral Infectious Diseases

23.8.1 Calicivirus

Feline calicivirus is highly contagious with widespread distribution in the feline population. This virus is shed in oral and nasal secretions in the acute form of the disease. Calicivirus is widespread in densely populated areas. This virus can remain stable in the environment and can be considered infectious for up to thirty days. On dry surfaces, at room temperature, or

in colder environments, the virus can remain active for much longer. Calicivirus causes necrosis of the epithelial cells of the upper respiratory system. Commonly the patient will frequently sneeze.

Diagnosis of calicivirus can be challenging. Conjunctival and oropharyngeal swabs for PCR testing can be collected. False negatives can be present if the panel of strains of the virus is limited. Using clinical signs, contagiousness, mortality rate, and the presence of other positive cats within the same household can help lead to a definitive diagnosis.

Affected cats may require intensive nursing care and supportive therapy during the acute phase of the disease. The goal of supportive therapy is to rehydrate, and restore electrolyte imbalances with intravenous fluids, and restoration of nutritional requirements. Due to the high volume of nasal discharge and lingual ulcers, many of these cats will become anorexic. Frequently cleaning away nasal discharge and feeding increasingly odiferous cat food with a variety of flavors can help entice the patient to eat.

Disease control includes limiting transmission through a proper vaccination protocol for shelters and catteries. Keeping new additions separate until vaccinated and infectious diseases are negative is essential to prevent the spread of the virus. Vigilant cleaning and disinfection with commercially approved products are key to limiting the spread of the disease.

23.8.2 Feline Immunodeficiency Virus

Feline immunodeficiency virus (FIV) is a retrovirus from the Lentivirus genus that infects domestic and wild cats worldwide. Transmission of the disease occurs through saliva or blood. Other modes of transmission include queen-to-kitten, however, this occurs infrequently or through a blood transfusion.

Common clinical signs during the first few weeks of infections, also termed transient primary stage, include anorexia, depression, lymphadenopathy, and fever. A decrease in the viral plasma load begins at the onset of the chronic subclinical stage, during the individual's natural immune response. This phase of the disease can last for years and potentially lifelong. During the chronic subclinical phase, the viral load stays stable, but a decrease in T lymphocytes occurs, leading to an unnatural immune response to a secondary medical condition. In some cats, over time, this leads to a functional immunodeficiency with advanced clinical signs of immunodeficiency that can lead to severe systemic disease.

Because the virus causes the breakdown of the immune system, most clinical signs are not related to the retrovirus. Once past the acute phase of infection, immunodeficiency and immune stimulation commonly appear in the form of chronic gingivostomatitis (Figure 23.6), chronic rhinitis, lymphadenopathy, immune-mediated glomerulonephritis, weight loss, and other secondary medical conditions.

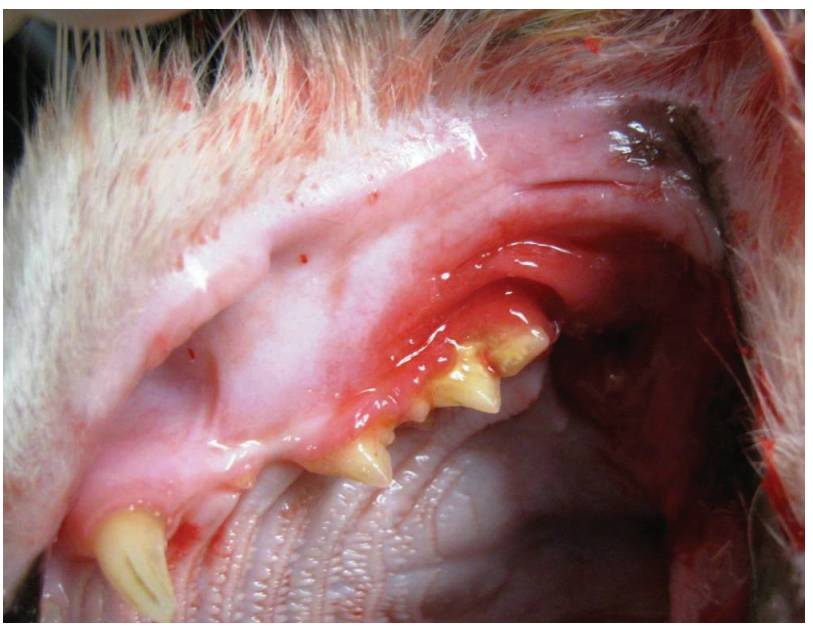


Figure 23.6 Gingivostomatitis in a feline patient. *Source:* Tommy Koenig, LVT, VTS (Dentistry).

A common diagnostic method is via antibody detection with a point-of-care test, ELISA, or rapid immunomigration (RIM) on whole blood or serum. Additional testing can be indicated with known exposures or inconclusive antibody results. The PCR method can be used but may lead to discrepant results due to strain variation of the virus when PCR and serology results are compared. The gold standard for FIV diagnosis and used to confirm inconclusive results is done traditionally via the Western blot analysis. However, studies have shown that both diagnostic modalities, the western blot and serology can provide conclusive results [23]. Due to the impact a positive result would have on the patient and the client, confirmation with a second testing method is often pursued by the veterinarian. In situations of early infection when at risk or known exposure, cats can test antibody negative; therefore, it is recommended to retest 60 days after the last known exposure to determine the presence of infection. Multiple diagnostic methods over time may be necessary to obtain a definitive diagnosis.

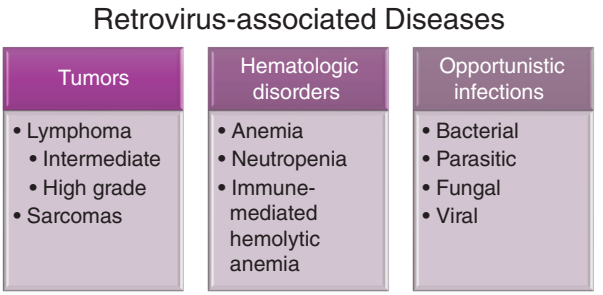


Figure 23.7 Retrovirus-associated diseases. *Source:* Paula Plummer.

Treatment with antivirals, immunomodulators, or alternative therapies in the FIV patient has been done with limited success. Currently, at the time of publication, no cure exists. Feline interferons and the antiviral drug, zidovudine (AZT) have been used with some success, with reports of viral load reduction. Many cats do not receive antiviral therapy and do well on supportive therapies, without the additional expense of these medications. With proper disease management and lifestyle, the life expectancy of a FIV-positive cats can be equal to negative individuals; therefore, the decision to euthanize should never be completely based on the presence of a positive test result.

Supportive care for the sick FIV-positive cat must be prompt and requires an accurate diagnosis to treat them successfully. They typically respond to treatment appropriately; however, due to immune status, they may require a longer course of medications than an FIV-negative cat. The use of immunosuppressive drugs should be avoided due to the exacerbation of side effects and an already immune-suppressed patient. Further investigation of FIV-associated diseases should be prompted to ensure the best possible outcome. See Figure 23.7 for retrovirus-associated diseases.

Preventative healthcare is of the utmost importance in FIV-infected cats to prevent the progression of the retrovirus or early detection of other feline diseases. Minimizing the risk of exposure as well as keeping positive cats protected from secondary exposure risks due to immune compromise will include a lifestyle change. These individuals should have physical examinations and bloodwork performed regularly by a veterinarian. Maintaining proper preventative care with the proper commercial feline diet will optimize their health and reduce the risk of secondary infections.

23.8.3 Feline Infectious Peritonitis

Feline infectious peritonitis (FIP) is caused by the virulent form of feline coronavirus, while the nonvirulent form is classified as feline enteric coronavirus (FECV). This virus belongs to the Coronviridae family in the Nidovirales order. FECV is very common in high feline-populated areas, typically causing a mild case of diarrhea. In certain cats, a virulent strain of FIP virus will mutate from FECV causing FIP. Some risk factors, such as overcrowding, stress, age, genetic predisposition, or a decreased immune response, are known; however, some cats will not exhibit any risk factors and still contract this infectious disease [24]. This continues to prove that there is more to learn about the genetic factors and other aspects of FIP. Commonly kittens usually develop FIP at 5–6 weeks of age, when the efficacy of maternal antibodies has subsided; however, cats of all ages have been reported to have FIP.

Transmission occurs through feces. Typically, seropositive cats will shed the virus in the feces and a naive will ingest the virus. After infection, the cat will shed the virus in approximately 1 week and continues to shed it for weeks or months.

FIP is classified into two forms: effusive (wet) or noneffusive (dry). The effusive form is characterized by the presence of cavitary effusion in either (or both) the abdomen or thoracic cavities, consistent with both modified and pure transudate. Cytologic evaluation of effusion consistent with FIP is viscous, a straw or light-yellow color. It will string or feel tacky when between fingers and pulled apart due to elevated levels of protein. Common findings are high protein, low A:G and cell count. These findings are not specific to FIP, and pursuing other diagnostic tests is required for a diagnosis of FIP [24]. The noneffusive form is characterized by granulomatous lesions in organs. Pyogranulomatous and vasculitis lesions often develop in the kidneys, lymph nodes, lungs, liver, spleen, omentum, and brain.

Clinical signs and physical examination findings can vary widely. Obtaining a diagnosis can be challenging due to the lack of a single available diagnostic test. A patient living in a high-population situation with supportive clinical signs can be an indicator to pursue FIP diagnostics. Supportive findings from advanced imaging and the presence of fluid accumulation with cytological examinations containing transudate or modified transudate are all suggestive of viral infection. Bloodwork abnormalities, such as lymphopenia, neutrophilia, anemia, hyperglobulinemia, elevated liver enzymes, and hyperbilirubinemia, also suggestive of FIP, accompanied by other supportive factors of the disease. Immunohistochemistry, immunocytochemistry, or PCR can be performed on FNA, fluids, aqueous humor, cerebrospinal fluid, or biopsies to detect the presence of the virus. In effusive forms of FIP, a Rivalta's test can be performed, providing a reliable result for FIP [24]. See the Diagnostic Techniques section below to review the diagnostic test procedure. A positive Rivalta's test is indicative of FIP, with further diagnostics being indicated for a definitive diagnosis.

For many years, FIP has had a high mortality rate. However, the release of a new drug has shown evidence to change the outcome of clinically affected FIP cases. At the time of publication of this text, the drugs GS-441524 (GS) and GC376 (GC) were FDA-licensed for use in cats in certain countries only making owners search for the drug on their own if they are located in countries where the drug was unobtainable through a veterinarian [25].

23.8.4 Feline Leukemia Virus

Feline leukemia (FeLV) is a retrovirus that is a member of the Oncornavirus subfamily and affects domestic cats worldwide. Due to the retrovirus becoming part of the host's DNA, it continues to destroy hematologic and immune stem cells after the bone marrow is destroyed. It is because of this that finding a cure has proven difficult.

The virus is shed in saliva, blood, nasal secretions, feces, urine, and milk. However, saliva contains the highest number of viral particles and is the most common method of transmission. It is less likely for the retrovirus to be transmitted through feces or urine. Transmission from mother to kittens can occur transplacentally, during routine grooming, or nursing. Kittens with a positive mother can be negative at birth, but in weeks to months, can test positive once the retrovirus starts to replicate.

Once transmission occurs through the oropharynx, viral particles quickly travel through the lymphatics and circulation, making the cat viremic in as little as 2–3 weeks. During this early phase of infection, if the virus is not contained by the individual's immune system, replication will occur, this is termed "Progressive Infection." Due to the nature of this infection, these cats will have a shorter life expectancy. A "Regressive Infection" is when the virus is present in the body, but the immune response stops replication of the virus. These cats will test positive for FeLV and are at risk for developing FeLV-associated diseases (see Figure 23.7 for retrovirus-associated diseases). The last type of infection is "Abortive Infection." This group of cats does not have clinical signs but shows positive antibody results on diagnostic tests [26].

Clinical signs during progressive infection are supportive of immunosuppression, tumors, secondary FeLV-related diseases, opportunistic infections, leukemia, anemia, thrombocytopenia, reproductive disorders, neuropathy, or sudden death.

Diagnosis of FeLV is typically achieved by detecting the FeLV p27 antigen on a point-of-care test using serum or plasma samples. See Figure 23.8 for an example of a positive FeLV ELISA test. Antigen detection can be achieved approximately 30 days after exposure. If an antigen test is negative after exposure, the recommendation is to wait and retest. A quantitative PCR can be performed in a commercial laboratory, as it is the most sensitive diagnostic method for FeLV, a PCR can be used to determine a suspicious ELISA test and determine the type of infection. An IFA test can be performed on blood or bone marrow to detect secondary viremia. It is not recommended for screening purposes as viremia will not be detected for 3 weeks, resulting in the possibility of the individual shedding the virus unknowingly to naive cats. However, IFA can be used to confirm a suspicious ELISA result. Other laboratory abnormalities that support diagnosis include nonregenerative anemia, neutropenia, thrombocytopenia, or lymphocytosis with the presence of Howell–Jolly bodies. Bone marrow cytology results can include severe nonregenerative anemia or pancytopenia, with the possibility of neoplastic cells as well. Diagnostic imaging can reveal findings supportive of secondary disease with nonspecific findings directly associated with FeLV.

Infected cats will often show clinical signs requiring hospitalization and supportive care, such as rehydration or blood transfusions. The treatment prescribed will often be related to a secondary disease or opportunistic infection. Antiviral and interferon medications specifically for FeLV have been used with limited success. Lifestyle changes may be recommended by the attending clinician, depending on the individual's lifestyle and exposure to other cats. Currently, there is no cure for FeLV. The life expectancy of a FeLV-positive cat is typically 2–5 years, depending on the type and strain of viral infection.



Figure 23.8 Example of a positive FeLV ELISA test. *Source:* Christine Prior.

Preventative healthcare is of the utmost importance in FeLV-infected cats to prevent progression of the retrovirus or early detection of other secondary diseases. These individuals should have thorough physical examinations and laboratory bloodwork (CBC and biochemistry profile) as recommended biannually. Prevention for uninfected cats includes an indoor lifestyle with preventative veterinary wellness visits. FeLV vaccination will not reduce the exposure risk; however, can be pursued for those individuals in high-risk situations.

23.8.5 Herpes Virus

Feline herpesvirus affects domestic and wild cats worldwide. Transmission occurs through nasal, oral, and conjunctival droplets that are aerosolized and highly contagious. Shedding of the virus starts approximately 24 hours after infection and lasts up to 3 weeks. The acute phase of the disease usually resolves within 10–14 days. Frequently infected cats become lifelong carriers of the virus once recovered, becoming latent carriers with periods of reactivation of the disease caused by stressors in the cat's environment or illness. Proper PPE such as gowns and gloves should be worn and isolated from healthy cats to reduce spread. Common disinfectants will kill this virus. Diagnostics performed for this virus include PCR testing and viral isolation. Conjunctival and oropharyngeal swabs can be obtained and preserved by placing the swabs in a sampling tube and submitting them to a commercial laboratory [27]. See the Diagnostic Techniques section of this chapter for guidelines for obtaining samples.

Cats with severe clinical signs may require supportive treatment such as rehydration with intravenous fluids. As always, nutrition is extremely important. The placement of a short-term feeding tube may be necessary until the patient is willing to voluntarily eat. Before placement of a feeding tube appetite stimulants or odiferous canned food can be offered.

Therapeutics for acute and chronic infections include systemic antivirals such as famciclovir. Other therapeutics such as antibiotics (systemic and ophthalmic), interferon, lysine, and probiotics, have been successfully used as therapies. In cases with secondary bacterial infections, clavulanic acid or amoxicillin has shown successful outcomes. Individuals with conjunctivitis will benefit from ophthalmic antibiotics without steroids (Figure 23.9). Feline interferons have been used as ophthalmic treatment when diluted or as oral therapy. Accessibility to the medication can be dependent on geographical location. Lysine has been used in acute and chronic infections with variable results. A positive response has been noted with the use of probiotics in chronic infections.

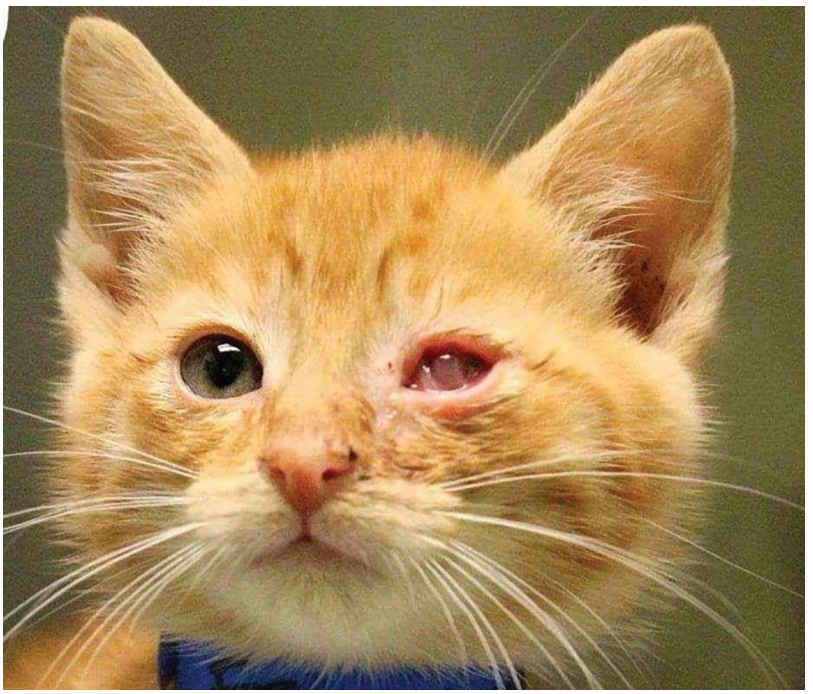


Figure 23.9 An example of ocular clinical signs in a patient with herpesvirus. *Source:* Christine Prior, DVM.

23.8.6 Rabies

Rabies is a virus from the Rhabdoviridae family, which includes over 175 viruses. The virus is transmitted through a wound or break in the skin or absorption through the mucous membranes. The incubation period can vary, with an average of 4–6 weeks after exposure before clinical signs appear. Once clinical signs are present, disease progression occurs rapidly.

There are two forms of rabies: the furious (aggressive) form and the paralytic form [28]. The furious form of rabies has three distinct stages: prodromal, mad (or psychotic), and paralytic. The prodromal phase of the disease lasts 12–48 hours. Clinical signs such as fever, anorexia, vomiting, and diarrhea occur, and occasionally behavior changes, such as being unusually friendly. During the psychotic phase, the cat can become aggressive, biting anything. The paralytic phase is the last phase, beginning only a few days after initial clinical signs are noted. During the paralytic phase, clinical signs include paresis, ataxia, paralysis, seizures, status epilepticus, and coma.

A definitive rabies diagnosis can only be obtained from a post-mortem laboratory investigation of the pons, thalamus, and medulla portions of the brain. Samples should be shipped only to commercial laboratories that regularly perform this diagnostic. The sample must be harvested and shipped according to the laboratory and state regulations. Supportive therapy for patients with a confirmed diagnosis of rabies is not recommended due to public health risks. No therapies have been proven to help affected patients. In cases with clinical signs and exposure, euthanasia is appropriate. In situations where an asymptomatic patient has bitten someone, local and state regulations should be followed by conducting a rabies quarantine for 10 days.

23.8.7 SARS-CoV-2

SARS-CoV-2, the virus causing COVID-19, has been reported to naturally infect cats. However, there is still much to learn about the effects of the virus on the feline species. At the time of publication, the Centers for Disease Control indicates that the risk of animals transmitting COVID-19 to humans is low. Reports of humans spreading the virus to animals through close contact with humans have occurred in cats. Supporting evidence that animals impose a risk in the spread of the virus is absent; therefore, pets are not considered a risk for spreading the disease at this time [29]. Studies report that clinical signs of cats with SARS-CoV-2 are like those of humans with fever, cough, lethargy, and increased respiratory effort being reported in experimentally intra-tracheal inoculated cats. Other studies report that

naturally infected cats are asymptomatic or exhibiting mild symptoms involving the gastrointestinal or respiratory tract, dependent upon the variant [30, 31]. At the time of publication, there is still much to learn about SARS-CoV-2 infections in feline patients.

23.9 Diagnostic Techniques

23.9.1 Obtaining Diagnostic Samples for Respiratory Pathogens

The PCR and culture diagnostics are sensitive tests; therefore, care should be taken to obtain samples according to the commercial laboratory's preferences. To ensure the sample is viable upon arrival, see the preferred shipping methods for each laboratory. Collecting swabs for respiratory pathogens should be performed during the acute phase of the disease to obtain the highest number of pathogens. Conjunctival and deep pharyngeal swabs should be obtained for each patient.

Supply list: Sterile cotton tip applicators (2), examination gloves, new red top tubes (1–2).

Obtaining conjunctival swabs

1. New examination gloves should be worn for each patient.
2. While an assistant is handling the cat, gently lower the lower eyelid, separating it from the eye to expose the conjunctiva.
3. Gently place the cotton tip applicator in the opened area between the eyelid and the eye, and rotate the swab.
4. Place the cotton tip applicator directly into the clean red top tube. Snap the excess portion of the applicator off to completely close the red top tube.
5. Label the container with patient and sample information as required, prepare and ship sample based on commercial laboratory requirements.

Obtaining deep pharyngeal swabs

1. New examination gloves should be worn for each patient.
2. While an assistant is handling the cat, they will gently open the mouth.
3. Gently place the cotton tip applicator on the oropharynx, avoiding saliva and the tonsils. Rotate the swab to obtain a sample.
4. Place the cotton tip applicator directly into the same red top tube. Snap the excess portion of the applicator off to completely close the red top tube.
5. Label the container with patient and sample information as required, prepare and ship sample based on commercial laboratory requirements.

23.9.2 Rivalta's Test

The Rivalta's test is a fast, low-cost, in-house diagnostic tool used to examine effusions with suspected FIP patients. The effusion can be obtained via ultrasound-guided centesis from the affected patient. Effusions containing an elevated amount of protein will cause the drop of effusion to fall to the bottom of the tube. Alternatively, a portion of the drop can move to the bottom of the tube while the other portion of the drop remains at the top, which is termed precipitate, and indicative of a positive result. Effusions containing a reduced amount of proteins will mix with the saline so the drop of effusion can no longer be identified, which is termed dissipate, and indicative of a negative result.

Supply list: 8 ml of distilled water mixed with one drop of 100% acetic acid, 10 ml red plastic top tube (1), effusion from the patient (1 drop)

Performing the Rivalta's Test

1. Place the distilled water and 100% acetic acid in the red plastic top tube and mix.
2. Gently place the single drop of effusion on top of the distilled water and acetic acid mixture.
3. Carefully observe the drop.

Determining the results

- Positive: The drop will precipitate completely at the bottom or top of the solution, or the drop will move slowly through the solution with a portion at the top and bottom continuing to connect through the solution.
- Negative: The drop will dissipate by separating to mix with the solution making the presence of the drop difficult to observe.

23.9.3 Toothbrush Technique for Dermatophytosis Culture

A culture to detect the presence of dermatophytosis will aid in diagnosis. Commercial DTM plates can be purchased. Once the sample is collected, the culture can be performed in-clinic or sent to a commercial laboratory.

Supply list: DTM Culture at room temperature, new toothbrush, examination gloves, hemostat (if needed).

Performing a DTM Culture

1. Do not prep the surrounding skin, as it may provide a false negative.
2. If crusts are present, gently remove them with a hemostat.
3. Brush the lesion with a toothbrush approximately 30 times, or until the toothbrush is filled with hair.
4. Then place the hair obtained on the toothbrush onto the DTM plate by stabbing it into the culture medium.
5. Store at room temperature (77–86 °F)
6. Examine for the presence of growth daily.

Determining the results

Colonies will appear white or pale in color with a change in the medium's color to red. Once growth is identified removal can be performed by obtaining a sample of the affected area via scotch tape stained with lactophenol blue, then placed on a microscope slide for identification of conidia or hyphae. Colonies can appear as soon as 5 days after DTM inoculation; however, a negative result is concluded upon no growth at 14 days after inoculation [13] (Figure 23.10, Figure 23.11).

With the presence of infectious diseases worldwide, the veterinary technician's knowledge of transmission methods, clinical signs, physical examination findings, therapies, and patient care techniques will be valuable when establishing hospital protocols. Outlining guidelines for common feline infectious diseases including pieces of PPE, isolation protocols, barrier nursing, cleaning and disinfection will guide the team to reduce spread and contamination is vital to combat infectious diseases.

See the companion website for further clinical references.

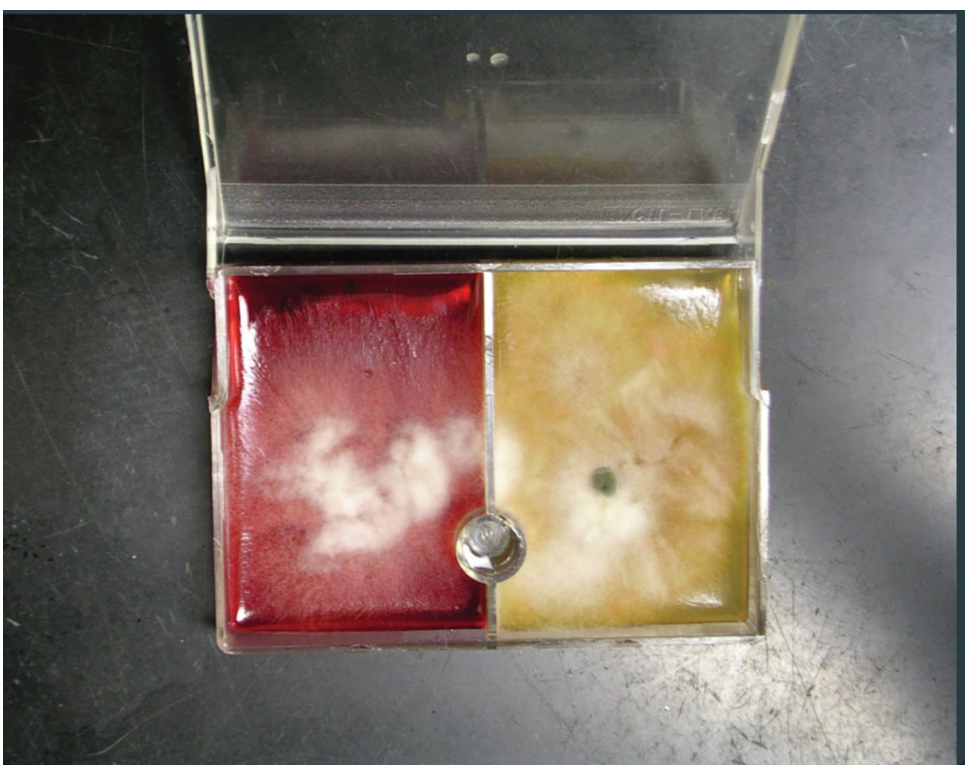


Figure 23.10 An example of a positive DTM culture. *Source:* A. Friedeck.

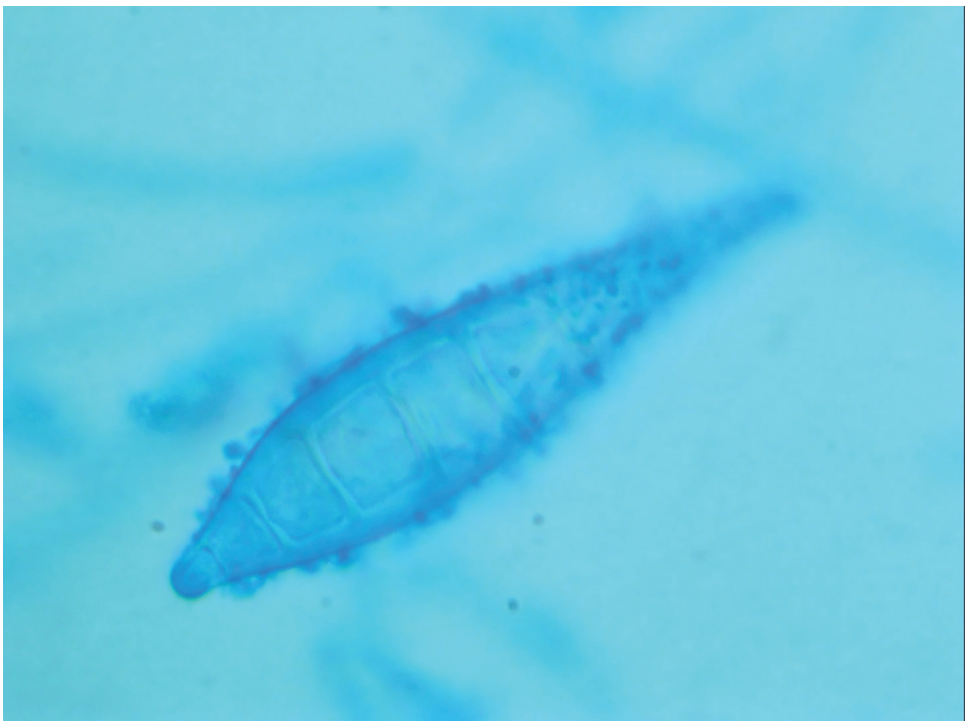


Figure 23.11 *M. canis* dermatophyte. *Source:* A. Friedeck.

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24

Oncology

Jaci Christensen, BAS, LVT, VTS (Oncology)

TECHNICIAN TIDBITS

- Cancer is one of the leading causes of disease-related death in cats.
- Cancer in feline patients can present in variable ways and is often similar to other common feline diseases.
- Multiple treatment modalities (radiation, surgery, chemotherapy) are often needed in order to achieve the best outcome.
- Due to the prevalence of feline patients experiencing severe stress with travel and clinic visits, considerations should be made regarding the quality of life if cancer treatment is pursued.
- Managing the feline cancer patient is inherently more difficult than managing the canine due to the frequency of comorbidities (e.g., renal disease, diabetes), limitations of medications that are safe for cats, and patient challenges regarding medicating and handling.
- Consider premedicating the feline patient with injectable anti-emetics during chemotherapy to minimize immediate side effects and alleviate the need for at-home administration for 24 hours.

Cancer has long been considered a disease of old age. With companion animals living longer as a result of better healthcare and preventive medicine, it is no surprise that the prevalence of cancer is on the rise. For our feline patients, more and more families have chosen to keep their cats indoors, which has contributed to an increased lifespan as well. Around 4 million cats develop cancer each year, making cancer one of the leading causes of disease-related deaths in feline patients [1]. Cancer is not a single disease, but instead is made up of many different diseases that often differ from species to species. The behavior of cancer is inherently variable, often requiring multiple treatment modalities with prognoses ranging from curable to terminal.

24.1 Patient History and "History Gathering Questions"

The patient's history is a vital piece of understanding and recognizing health issues in companion animals. Asking the right questions is the foundation of providing optimal patient care, and this responsibility falls on the veterinary technician in many veterinary settings. The following questions are often important in the early detection of neoplasia in the feline patient.

- "How old is the patient?"
  - While cancer in younger pets is possible, cancer becomes more likely as our pets age.
- "Does your pet seem to be losing weight?"
- "Has your pet experienced a decreased appetite, vomiting, or diarrhea?"
  - Most neoplasms in cats can be associated with weight loss and hyporexia. Vomiting and diarrhea may also be noted, particularly with neoplasms of the gastrointestinal (GI) tract.
- "How long have the symptoms been occurring?"
  - Cancer symptoms can be acute or chronic in nature, but knowing which of these the patient is experiencing can assist in narrowing down a differential diagnosis.
- "Has your cat been vaccinated for or previously tested for feline leukemia virus (FeLV)?"
  - FeLV-positive cats are far more likely to develop cancer, particularly lymphomas, compared to FeLV-negative cats.

24.2 Clinical Signs

Clinical signs associated with neoplasia in cats can be highly variable depending on the type and location of the disease. Common clinical signs that can be seen with multiple tumor types include decreased appetite, vomiting, diarrhea, and weight loss. It is important to realize that these clinical signs are also closely associated with other feline conditions, so the correlation between history, clinical signs, physical exam findings, and diagnostics will be important in making a diagnosis.

24.3 Physical Examination Findings

Similar to clinical signs, physical exam findings will be highly variable between neoplasms. Weight loss is associated with many feline cancers, so tracking a patient's weight over time may be a helpful tool when there is a suspicion of an underlying disease. Additionally, a normal physical exam does not rule out neoplasia, so it is important to consider the patient's entire clinical picture during evaluation.

24.4 Specific Nursing Care Considerations

Feline oncology patients often have specific considerations related to their nursing care. These considerations should be made for any feline patient undergoing cancer treatment. One major concern in the feline patient is ensuring proper nutrition. This can be challenging in patients undergoing various therapies in a hospital setting. While there may be a physiological reason for hyporexia in cats, occasionally this behavior is stress-induced in hospitalized patients. For stressed feline patients, gabapentin may be considered to manage anxiety associated with clinic visits and hospitalizations. See Chapter 8: "Introduction to Feline Pharmacology," for more information on gabapentin use in cats.

Nausea may also cause hyporexia in the feline patient, so anti-emetics should be considered when warranted. When conservative measures do not result in adequate nutrition, feline patients may require an esophagostomy tube during cancer treatment. This is particularly true in situations where the sense of smell is diminished (nasal tumors) or there is evidence of oral pain (oral tumor). The esophagostomy tube can be used not only for feeding purposes, but also for medication administration. See Chapter 12: "General Feline Nutrition," for more information on esophagostomy tubes.

Radiation therapy is a recommended treatment modality for many neoplasms in feline patients. Patients will typically undergo repeated general anesthesia for a set number of treatments. Due to the prevalence of chronic kidney disease (CKD) in older cats, many patients will require intravenous (IV) fluids for support throughout their protocol. This will require the veterinary technician to be diligent in providing daily intravenous catheter (IVC) care. This includes checking for patency regularly, performing bandage changes daily, and evaluating the insertion site for signs of phlebitis (bruising, swelling, redness, discomfort, etc.). During their stay, it is recommended that the environment be as feline-friendly as possible. See Chapter 3: "Preparing the Veterinary Hospital for the Feline Patient," for more information.

24.5 Treatment Modalities

24.5.1 Chemotherapy

The goals of chemotherapy will vary depending on the patient and cancer type. It is also important to realize that chemotherapy is rarely a single modality treatment for cancer. With the exception of hematopoietic tumors, nearly all tumors require multi-modality treatments (radiation, surgery, and chemotherapy) in order to obtain the best response. The goals for chemotherapy vary and consist of adjuvant chemotherapy (given following surgery and/or radiation), neoadjuvant chemotherapy (given prior to surgery/radiation), induction chemotherapy (attempting to induce remission with chemotherapy alone), rescue chemotherapy (following a relapse or lack of response), palliative chemotherapy (delivered to decrease clinical signs or slow progression), and radio-sensitization chemotherapy (given to enhance the cytotoxicity of radiation therapy). All chemotherapy drugs used in cats are considered off-label, as there are currently no FDA-approved chemotherapeutics for feline patients. See Table 24.1 for the most common drugs used, dosing information, and disease indications.

Table 24.1 The most commonly used chemotherapeutics in the feline patient.

Drug	Dosing	Indication
Chlorambucil	4 mg/m^2/day or 2 mg/cat/day or 20 mg/m^2 every 2 weeks	Small cell lymphoma (gastrointestinal, commonly)
Cyclophosphamide	200 mg/m^2	Lymphomas
Doxorubicin	1 mg/kg	Lymphomas, injection site sarcoma
Lomustine	40–60 mg/m^2	Lymphomas, mast cell tumors
Vincristine	0.5–0.7 mg/m^2	Lymphomas

Side effects occasionally occur, although they are less severe than what is encountered in human medicine. Since cytotoxic drugs interfere with the cell cycle to cause cell death, the speed at which cells divide will directly correlate with the severity of cell death. In other words, rapidly dividing cells die faster than slower dividing cells. Rapidly dividing cells include not only cancer cells but cells of the skin, GI tract, and bone marrow, which is why side effects, such as hair loss, GI upset, neutropenia, and thrombocytopenia are so common. Other side effects may include drug dependence. In the feline patient, the most common side effects noted from chemotherapy include nausea, inappetence, diarrhea, and myelosuppression [2]. The GI side effects are often well managed with anti-emetics, probiotics, and appetite stimulants. Occasionally, metronidazole may be needed to address diarrhea (Table 24.2). Myelosuppression generally presents as neutropenia and thrombocytopenia. Prophylactic antibiotics may be warranted for neutropenia to prevent a secondary infection from occurring. Rarely, patients present as febrile, and hospitalization would be warranted. Thrombocytopenia is occasionally seen, although rarely it causes notable symptoms. It is important to monitor complete blood counts (CBC) prior to each dose of chemotherapy to ensure that cell counts are adequate for additional treatments (Table 24.3).

It is always important to consider a patient's quality of life when determining if and which chemotherapy is appropriate. This is especially true for feline patients, as many cats are not amenable to car rides, veterinary visits, and/or medical procedures. When deciding to move forward with chemotherapy for a feline patient, the patient should be considered individually to ensure the chosen protocol (route of administration, frequency of administration, monitoring requirements) will not significantly impact the quality of life negatively.

24.5.2 Surgery

Surgery is an important part of cancer treatment. In fact, the first surgery offers the best chance of a cure when you are dealing with nonhematopoietic tumors. The surgical dose has to do with the degree of excision and will be considered either debulking, marginal, wide, or radical. A surgery that is considered debulking indicates that there is macroscopic disease left behind, which may be the case in biopsies or palliative surgeries. Marginal excisions (also referred to as

Table 24.2 Supportive care medications that may be used for chemotherapy-related side effects in the feline patient.

Indication	Medication
Nausea/vomiting	Maropitant Ondansetron
Hyporexia	Maropitant Mirtazapine Capromorelin
Diarrhea	Probiotics (Proviable®, FortiFlora®, Visbiome®) Fiber supplementation Metronidazole Tylosin

Table 24.3 Common hematologic abnormalities seen in the feline patient receiving chemotherapy, along with recommended guidelines.

	Grade/absolute count	Guidelines
Neutropenia	1/1500–2000 mm^3	Delay chemotherapy (if due)
	2/1000–1499 mm^3	Delay chemotherapy (if due)
	3/500–999 mm^3	Non febrile=oral antibiotics
	4/<500mm^3	Febrile=hospitalize, IV antibiotics
		Non febrile=oral antibiotics
		Febrile=hospitalize, IV antibiotics
Thrombocytopenia	1/100 000–150 000/uL	Active surveillance
	2/50 000–99 000/uL	Delay chemotherapy (if due)
	3/25 000–49 000/uL	Delay chemotherapy (if due)
	4/<25 000/uL	Consider intervention
		Delay chemotherapy (if due), consider intervention

"narrow" excisions) indicate that there is or may be residual microscopic disease left behind. Wide excisions obtain clean margins with 2–4 mm of normal tissue present. Radical excisions obtain extensive clean borders, such as the case with most amputations [3]. Goals of surgery are generally to remove the primary tumor with clean margins as well as any sites of metastasis. Due to limitations of biopsies representing the entire tumor, surgery may also be used to obtain a definitive diagnosis. In this scenario, it is essential that the primary goal of surgery remains obtaining an appropriate surgical dose, even if one of the goals is to obtain a diagnosis [4]. In other words, using surgery to obtain a diagnosis may result in the surgeon being conservative and ultimately not obtaining clean margins, which can dramatically impact the patient's treatment response and survival time. This is particularly true when dealing with aggressive tumors.

So, why is obtaining clean margins so important? To help illustrate, consider that the word "cancer" comes from the Latin word for "crab." This is because tumors resemble the shape of a crab, with a body and finger-like projections similar to legs. In many cases, the body of a tumor is generally hypoxic with the "legs" being the most aggressive part. Thus, if the "legs" of the tumor are not removed, it will almost certainly recur. This speaks to the importance of obtaining appropriate tumor margins (Figure 24.1).

24.5.3 Radiation Therapy

Radiation therapy is primarily administered using a radiotherapy unit called a linear accelerator. These units are becoming increasingly common at specialty centers offering radiation therapy due to their greater flexibility in treating both deep and superficial tumors. A veterinary radiation oncologist is responsible for planning and administering of radiation therapy. As of December 2022, the American Veterinary Medical Association (AVMA) reported that there are 141 veterinary radiation oncologists boarded in the United States, providing radiation therapy options in over 30 states [5]. This number is expected to grow each year, making radiation therapy increasingly available for pet owners.

Radiation therapy is considered a cytotoxic therapy for solid tumors and is rarely used as a sole modality. The goals of radiation therapy may consist of curative intent, palliative intent, or use as an anti-inflammatory. Radiation may also be used in an adjuvant or neoadjuvant setting when combined with surgery. Radiation damage relies on oxygen free radicals; thus, the success of radiation will partly depend on the oxygen within the cells. Normotoxic cells are three times more sensitive to radiation than hypoxic cells. Unfortunately, fast-growing tumors tend to be hypoxic due to the chaotic proliferation and the inability of adequate blood vessel formation. In about 90% of cases, radiation will cause mitotic cell death, meaning that the cells do not die until they reach mitosis [6]. Similar to chemotherapy, this means that the rate of response will depend on the rate of cell division. The response rate will also correlate with radiation side effects. Epithelial tumors (squamous cell carcinomas [SCCs], other carcinomas) take days to weeks to reach mitosis, so they tend to respond quickly to radiation. This means that these cases will also experience acute radiation side effects (e.g., "radiation burns") in the irradiated regions. Mesenchymal tumors (sarcomas) take months to reach mitosis, which means they are slow to respond to radiation and experience more delayed/chronic side effects to radiation (e.g., necrosis). Round cell tumors (lymphoma,

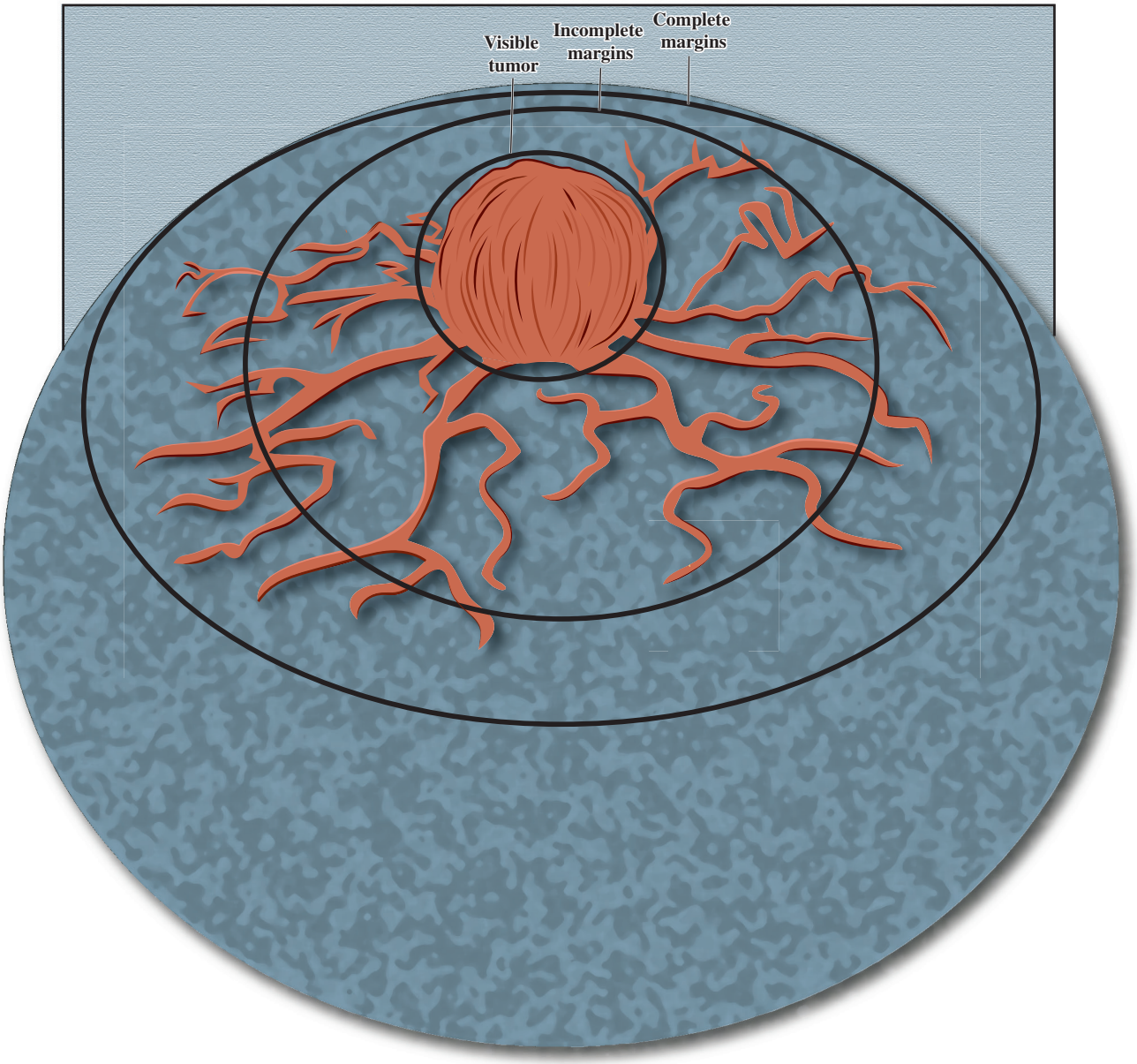


Figure 24.1 The "crab like" appearance of a tumor illustrating margins. *Source:* Kristen Cooley.

mast cell tumors) divide very quickly and tend to respond within hours to radiation, leading to a quick response and minimal side effects. However, the duration of response to radiation will vary due to the difficulty of treating a systemic cancer with a focused therapy.

In order to treat most tumors with radiation therapy, normal tissue will be impacted as well. Imagine putting cold lasagna in the microwave and setting the timer for 2 minutes. Electromagnetic radiation is emitted, and after 2 minutes, you check the lasagna to find the outside is extremely hot, then cut into it to find the center is lukewarm. The center of the lasagna has received an acceptable dose of radiation, while the outside is too hot. Now, imagine instead that the center of the lasagna is a tumor being treated with radiation therapy, and everything else is normal tissue. There is simply no way to irradiate an internal tumor without passing through normal tissue structures first, potentially causing radiation-related side effects in those areas (Figure 24.2). In addition, normal tissues might be irradiated for reasons within our control, such as patient movement. To increase the sparing of normal tissues from irradiation, patients must be immobilized during treatment with the use of general anesthesia. Each session of

radiation is referred to as a fraction, with protocols ranging from 4 to 20 fractions in total. Patient consideration is required when determining whether repeated general anesthesia is clinically appropriate.

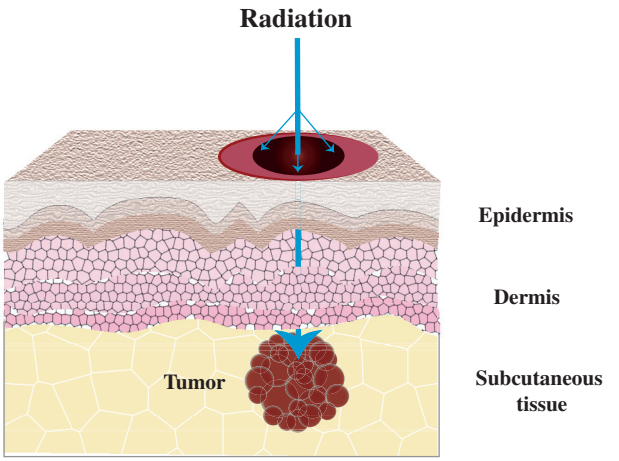


Figure 24.2 Radiation passing through healthy tissue to treat tumors illustrating how healthy tissue near the tumor cannot be spared from radiation. *Source:* Kristen Cooley.

24.6 Common Feline Neoplasms

24.6.1 Lymphoma

Lymphoma originates from the immune cells (or lymphocytes) of the body and can occur in nearly any organ or tissue. Lymphoma can be classified by the type of lymphocyte as well as the location and extent of the disease. The type of lymphocyte refers to whether the lymphoma originates from small mature lymphocytes or large immature lymphoblasts. Of the two, small-cell or "low grade" lymphoma is the most common in feline patients, offering a better response rate and prognosis than the large-cell forms.

Feline lymphoma (LSA) is the most common hematopoietic tumor in cats and may present in a variety of forms, including GI, extra-nodal (renal, nasal, cutaneous, etc.), and cranial mediastinal [7]. Multicentric lymphoma, while the predominating form in dogs, is rare in cats. The predominating forms in felines include GI and extra-nodal lymphoma. Other types of lymphomas (particularly mediastinal and multicentric lymphomas) have a direct correlation with the presence of feline leukemia (FeLV) and the widespread use of the FeLV vaccine has resulted in a sharp decline in the prevalence of these forms of lymphoma.

24.6.1.1 Gastrointestinal Lymphoma

Gastrointestinal lymphoma (GI LSA) represents up to 72% of the diagnosed felineLSAs. GI LSA can be classified as either small cell (low grade), large cell (high grade), or intermediate grade. GI LSA has an older, male, domestic shorthaired predisposition. Small cell GI LSA is the most prevalent and represents 75% of the GI LSA cases diagnosed in cats [8]. These malignancies tend to have a slower onset and progression, with the most common clinical sign being weight loss. This type of GI LSA may involve the small intestine, stomach, mesenteric lymph nodes, and liver. Rarely, cats may present with more acute symptoms associated with obstruction, intussusception, or perforation. Small-cell GI LSA may present similarly to other conditions that must be ruled out, such as irritable bowel disease, chronic pancreatitis, hyperthyroidism, and chronic renal failure. Symptoms associated with small-cell GI LSA include chronic weight loss, vomiting, and/or diarrhea. Large-cell GI LSA often presents with more severe and acute symptoms than small-cell GI LSA, and the disease often extends beyond the GI tract and may involve the spleen, peripheral lymph nodes, thoracic lymph nodes, and bone marrow. More than 80% of the cats diagnosed with large-cell GI LSA will present with palpable intra-abdominal abnormalities [9]. Clinical signs can include vomiting, diarrhea, anorexia, and weight loss. Intermediate-grade GI LSA is not as well described as the previously discussed classifications, but is known to act more aggressively than small-cell and less aggressively than large-cell lymphoma [7].

Full lab work should be evaluated in feline patients suspected to have intestinal lymphoma, including a CBC, chemistry panel, cobalamin levels, urinalysis, and FeLV/FIV screening. Anemia, neutrophilia, hypocobalaminemia, hypoglycemia, and hypoalbuminemia are often reported. More than 90% of GI LSA cases will have abnormalities found on an abdominal ultrasound, which makes this a diagnostic tool of importance in these cases [9] (Figures 24.3 and 24.4). However, abdominal ultrasound cannot provide a diagnosis of lymphoma, as some cases reveal only mild changes that may be consistent with other GI disorders. If GI LSA is suspected, then intestinal biopsies are often needed in order to confirm the diagnosis and determine the grade. Fine needle aspirates (FNAs) are unlikely to be useful in the absence of enlarged lymph nodes or intestinal masses. It is preferable that the biopsies be obtained endoscopically, although a full-thickness biopsy obtained via surgical exploration will be more accurate, as endoscopic biopsies are diagnostic approximately 70% of the time (see Chapter 19: "Gastroenterology," for more information on GI endoscopy) [8]. Surgical exploration may be preferable if the patient is obstructed or needs a resection due to the infiltration of the disease.

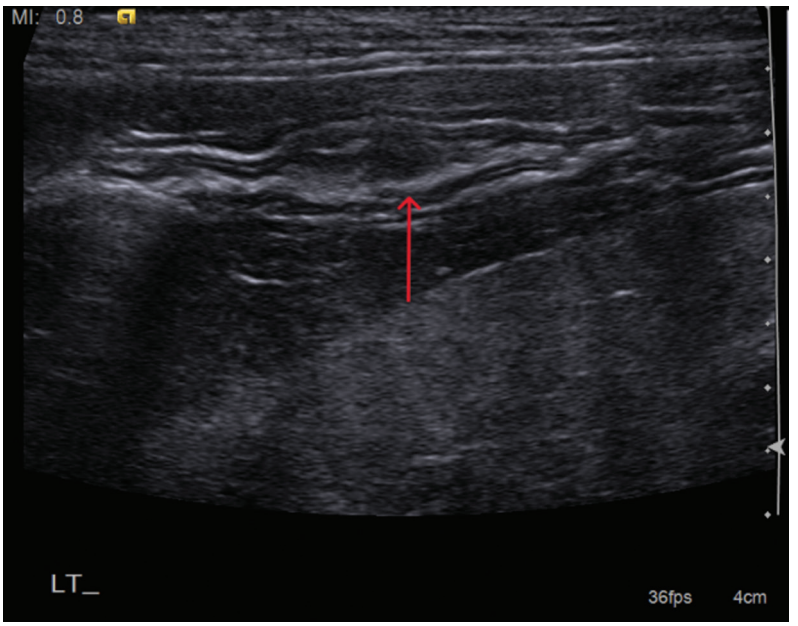


Figure 24.3 Gastric wall thickening and loss of layering noted on ultrasound in a confirmed GI LSA feline patient. *Source:* Jaci Christensen.

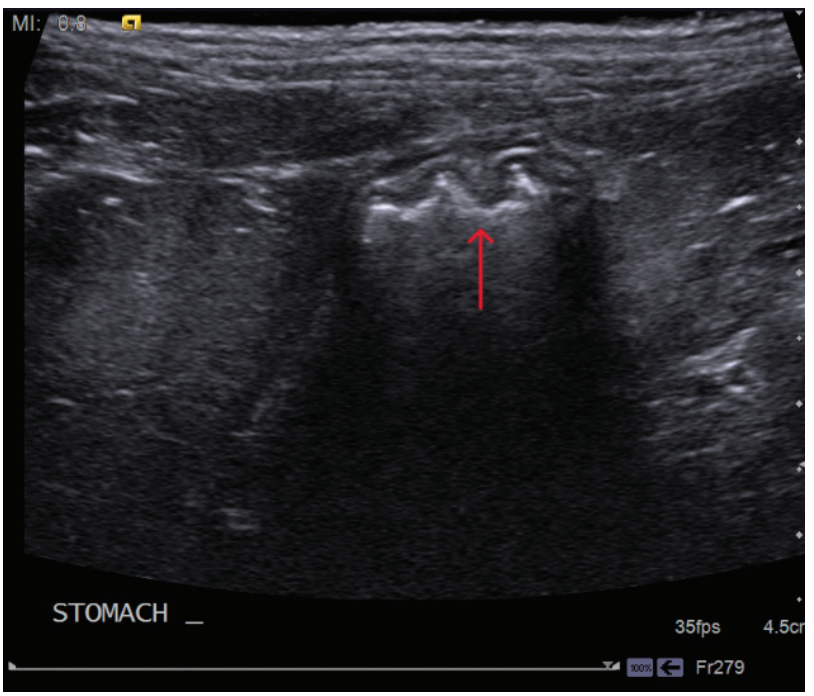


Figure 24.4 Resolution of gastric wall thickening and loss of layering on ultrasound of feline GI LSA patient 1 week after receiving chemotherapy. *Source:* Jaci Christensen.

Chemotherapy is generally the treatment of choice for this systemic disease. There are several chemotherapeutic options available, and the recommendations will vary depending on the severity and grade of the disease. Small cell GI LSA typically responds well to a protocol consisting of oral chlorambucil and prednisolone. Chlorambucil is a low-dose, metronomic chemotherapy that has been shown to be effective in the treatment of small-cell LSA. Prednisolone affects the immune system, particularly targeting lymphocytes. Initial treatment will start to reduce the number of tumor cells in the body, while continued treatment will assist with appetite stimulation and improved quality of life. Prednisolone will often be tapered and discontinued once an acceptable patient response to chlorambucil has been noted. The median survival time for cats

with small cell GI LSA treated with chlorambucil is 18–36 months [7]. Patients who have a good response to chlorambucil carry a better prognosis than those who progress while on the drug. If a patient is not responding to chlorambucil within 6–8 weeks, a more aggressive protocol should be started. More aggressive chemotherapy protocols are often necessary in intermediate to large-cell GI LSA cats. The CHOP protocol (cyclophosphamide, doxorubicin, vincristine, prednisolone) is considered the gold standard of treatment. However, this protocol requires that patients be treated weekly for 20–25 weeks, which may not be ideal in feline patients. Owners must consider the cat's quality of life if an intense protocol, such as this is chosen. CHOP may also not be feasible in cats with renal disease, as doxorubicin is renal toxic in cats. COP (cyclophosphamide, vincristine, and prednisolone) carries a similar survival time to CHOP, but is a less aggressive protocol and omits doxorubicin, making it a reasonable option in many feline patients. Lomustine is another less intensive chemotherapy option, although a durable response is difficult to achieve due to the profound myelosuppression noted in cats, which leads to an extended break between doses. Lomustine is administered orally once every 3 weeks, although many cats are only able to receive it every 5–6 weeks due to myelosuppression noted on the CBC. Large-cell GI LSA cats carry a poor prognosis, with a median survival time of 45–90 days when treated with combination therapies [9].

The option of radiation therapy should not be dismissed when treating the feline GI LSA patient. Radiation may be used as a stand-alone therapy in cats who have failed chemotherapy protocols; however, studies have shown a better response and prognosis when cats are treated with radiation therapy while in remission following chemotherapy. [10] One study evaluated the response rates of eight cats with large-cell GI LSA treated with radiation therapy. Two of the cats were not in remission at the time of treatment, and both relapsed shortly after. One cat was euthanized for other reasons, and on postmortem evaluation was in remission from lymphoma. The remaining cats had a remission time of 9–45+ months [9]. Another study evaluated the use of abdominal irradiation as a rescue therapy in 11 cats that had failed chemotherapy. This study noted a 90% response rate and a median survival time of 1 year [11]. More studies are needed to solidify the benefits of radiation therapy in our feline GI LSA patients.

In addition to the above-mentioned treatments, cats with GI LSA are often chronically hypocobalaminemic, which is believed to contribute to GI symptoms. One study found that 78% of cats with small cell lymphoma had low serum cobalamin concentrations [12]. These patients should have cobalamin levels monitored periodically (every 3–6 months), as well as supplementation if warranted.

24.6.1.2 Extra-nodal Lymphoma

Extra-nodal lymphoma is a type of lymphoma that occurs outside of the lymph nodes. This type of lymphoma is the second most common form following GI. The most common sites for extra-nodal lymphoma to occur include nasal and renal, but it is possible for the disease to be present in any tissue including the central nervous system, ocular, cutaneous, and laryngeal/tracheal.

24.6.1.3 Nasal Lymphoma

Nasal LSA is considered a local disease in cats. These patients generally present with epistaxis, congestion, nasal discharge, and hyporexia. Diagnosis is made by utilizing advanced imaging (CT scan) and obtaining biopsies via rhinoscopy. With nasal LSA being a local disease, radiation is often the treatment of choice, as a durable response is often achieved without the use of chemotherapy. However, chemotherapy may be considered in relapse patients that no longer respond to radiation or in patients with metastasis/systemic disease. Survival time in nasal LSA cats without treatment is only 45 days, compared to 1.5–3 years for 85% of the patients treated with radiation. A smaller percentage of cats will not achieve remission with radiation and have a reported survival time of 4.5 months [13].

24.6.1.4 Renal Lymphoma

Renal LSA occurs in the kidneys; however, in 75% of cases, there will be evidence of LSA elsewhere—most commonly the GI tract or multicentric [14]. These patients present with clinical signs similar to kidney disease (polyuria/polydipsia, weight loss, nausea, hyporexia, and azotemia). Bilateral renomegaly may also be palpated during a physical examination and confirmed with ultrasound. Diagnosis can be suspected based on these signs; however, confirmation generally occurs with the use of a fine needle aspirate of the kidney or other affected organ. Renal LSA is considered a high-grade, aggressive cancer; thus, chemotherapy is generally the treatment of choice. Unfortunately, cats with renal LSA have a poor overall prognosis. With the use of CHOP/COP, a median survival time of 4–7 months is reported [14]. It is important to note that COP is often preferred over CHOP due to the renal toxicity associated with doxorubicin-based protocols and the notable azotemia in most renal lymphoma cats.

24.6.1.5 Mediastinal Lymphoma

Mediastinal lymphoma involves the thymus and mediastinal/sternal lymph nodes. Generally, these patients present with dyspnea and pleural effusion. These cats tend to be younger (2–4 years) and FeLV-positive. In cases of pleural effusion, diagnosis can often be made through cytologic examination of the effusion. Thoracic radiographs are also helpful in the diagnosis of mediastinal LSA. In the patients where a diagnosis is not obtained by effusion or there is no effusion present, a fine needle aspirate of the mass or lymph nodes may be needed for confirmation. Mediastinal LSA is associated with a poor prognosis in cats that are FeLV-positive (2–3 months); however, with CHOP/COP-based protocols in non-FeLV cats, a median survival time of 1 year is reported [15]. Longer survival times may be noted with the addition of radiation therapy, although no published studies exist at this time.

24.6.2 Squamous Cell Carcinoma

SCC is considered a malignant tumor that originates in the epidermis from squamous cells. SCC is most associated with UV exposure, although other factors have been shown to contribute to its development (viral factors, immune status). In cats, SCC often occurs on the head in areas that are lightly haired and most exposed to UV light, such as the nasal planum. These lesions are generally ulcerated and may be invasive. Metastasis to the regional lymph nodes and/or lungs is also possible, particularly in the more invasive tumors. The treatment of choice is wide surgical excision, when possible, with local tumor recurrence being less than 10%, resulting in a good prognosis (Figures 24.5 and 25.6). Unfortunately, obtaining wide margins on facial SCCs is challenging and often other treatment modalities may be needed, specifically radiation therapy. For these cases, the median survival time ranges from 1.5 to 2.5 years, with patients generally dying from the progressive local disease. Strontium therapy is a good option for superficial, noninvasive tumors, which results in a median survival time of >3000 days. Chemotherapy is not well described in cats with SCC, particularly due to increased exposure risks to personnel from intralesional chemotherapy administration, as well as response rates being quite variable.

24.6.2.1 Oral Squamous Cell Carcinoma

Oral SCC is the most common oral tumor in cats, making up 70–80% of the oral tumors diagnosed [16]. This tumor is not associated with UV light, and although its development is not completely understood, it has been associated with flea collars, a high intake of canned tuna, and smoke exposure. Oral SCC most commonly occurs on the tongue, pharynx, or tonsils. These tumors commonly have bone involvement and are proliferative, ulcerative, and painful, with the most common symptoms being hypersalivation and anorexia. There is no treatment that creates a durable response. Cats treated with surgery alone had a median survival time of 45 days, radiation therapy induced a median survival time of 90 days, and combining the two therapies carries a median survival time of 1 year. Local disease is the cause of death in nearly all feline oral SCC patients [17].

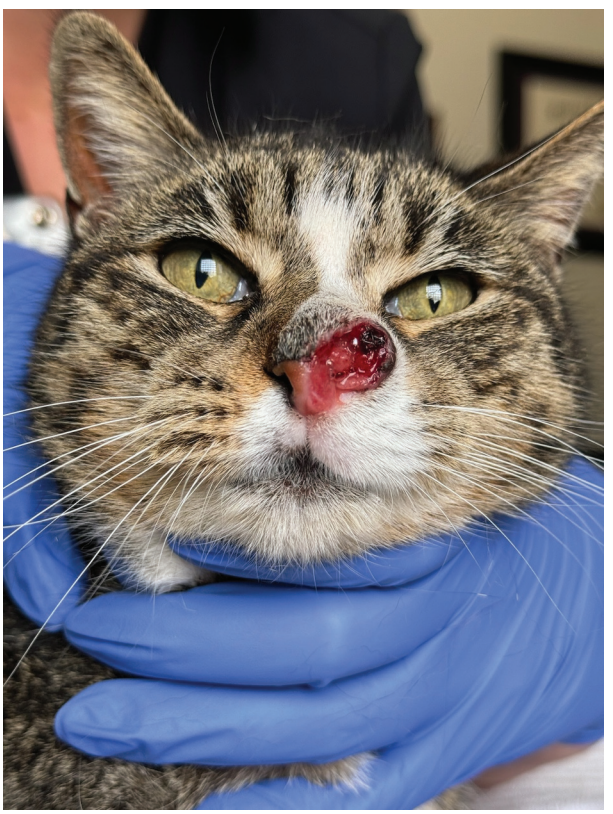


Figure 24.5 Nasal planum SCC in a feline, pretherapy. *Source:* Jaci Christensen.

24.6.3 Feline Injection Site Sarcoma

Feline injection site sarcomas (ISSs) are a type of soft tissue sarcoma (most commonly fibrosarcoma) directly related to the administration of vaccines (Figure 24.7). Non-ISSs are generally smaller, slow-growing tumors, whereas ISSs are much more aggressive in nature. Some studies have shown a strong association between ISS and inactivated vaccines (such as rabies and FeLV), which led to the recommendation to change vaccination sites from the intrascapular region to



Figure 24.6 Postoperative nasal planum SCC in a feline, completely excised. *Source:* Jaci Christensen.

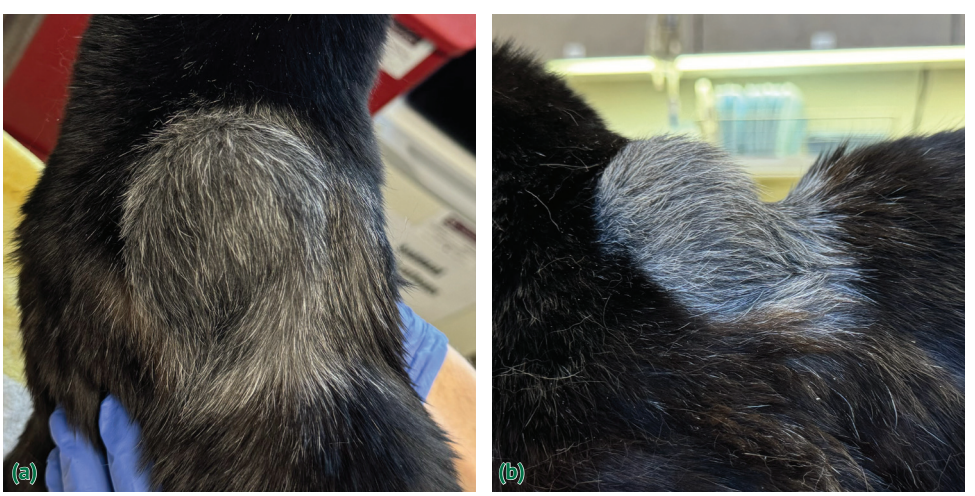


Figure 24.7 Cat with intrascapular ISS recurrence postradiation therapy. Radiation-induced leukotrichia is commonly seen when skin has been irradiated. (a) Demonstrates a dorsal–ventral view. (b) Demonstrates a lateral view of recurrence on this patient. *Source:* Jaci Christensen.

distal limbs, making patients more likely to have a positive treatment outcome if an ISS were to occur [18]. It is believed that ISS does not develop from the injection or the vaccine itself, but rather from an inflammatory reaction that some cats have to additives in the vaccine. The time from vaccination to tumor development is extremely variable, with some cats developing ISSs as early as 4 weeks postvaccination up to 10 years post. A correlation has also been discovered between the development of ISS and the administration of long-acting corticosteroid injections, such as those used for skin allergies. It is hypothesized that the inflammatory reaction induced by an injection leads to uncontrolled fibroblast proliferation and, thus eventual tumor occurrence [18].

When an ISS is diagnosed (usually via aspiration or biopsy), the next step prior to treatment is to perform advanced imaging, such as a CT scan or MRI. ISSs are commonly invasive and can present like an iceberg, so proper surgical or radiation planning can only be performed with advanced images. ISSs are poorly encapsulated, meaning that they can reach and infiltrate easily throughout surrounding tissues. Aggressive surgery is essential for the best prognosis, requiring at least 5 cm lateral margins and two fascial layers to be removed. When this surgical dose is applied, 95% of cases will be completely excised, with recurrence occurring on average about 1 year post-surgery. In cases where the ISS is only marginally removed, recurrence occurs on average 79 days after surgery [18]. Inadequate biopsy planning, pre-operative staging, or attempts at a first surgery will negatively impact response and survival. Additionally, studies have found that cats whose first surgery is performed at a referral center have better outcomes than those who do not. Thus, it is important for veterinary professionals to remember that the first surgery is the best chance of obtaining a successful outcome. If aggressive surgery is not possible, radiation therapy results in better local tumor control than surgery alone. Chemotherapy is not generally considered an effective treatment for ISS; however, some cats have shown a response to doxorubicin administration, which may be an option to consider for some owners. Metastasis is uncommon in ISSs, with most cats dying from local disease. ISS can be prevented or more easily managed if veterinarians practice not over vaccinating, using the recommended vaccination locations, and avoiding products with aluminum-based adjuvants when feasible.

24.6.4 Mast Cell Tumors

Mast cells are immune cells that play an important role in many inflammatory settings. When these cells undergo malignant transformation, mast cell tumors can occur. In cats, mast cell tumors behave very differently from those in canine patients and often occur as either cutaneous, splenic/visceral, or intestinal. The most common presentation is cutaneous in origin.

24.6.4.1 Cutaneous Mast Cell Tumors

Cutaneous mast cell tumors (cMCTs) are the second most common skin neoplasm in cats. These tumors generally appear as superficial, alopecic, pink-to-skin-colored nodules, often occurring on the head and neck. Typically, cMCTs are solitary but may also be present in multiples. cMCTs are often small in size with sizes varying from 0.5 to 3.0 cm in diameter. Occasionally, these nodules will appear ulcerated; however, in most cases, the patient is not bothered or aware of the mass.

Diagnosis consists of a fine needle aspirate, which is generally diagnostic for a mast cell tumor due to the ease of exfoliation with these tumors. While the majority of cMCTs are clinically benign in cats, further evaluation and staging may be beneficial, as a small percentage of feline cMCT will show more aggressive behavior. Staging would consist of baseline lab work, abdominal ultrasound, and regional lymph node evaluation. One study found that 7% of cats with cMCT had splenic involvement, suggesting that splenic aspirates may be beneficial in ruling out metastasis [19].

The definitive treatment for feline cMCT consists of surgical excision. Numerous studies have been performed to evaluate recurrence postoperatively. Even in the absence of clean margins, the majority of cats (83%) did not experience recurrence of their primary tumor, and none of the cats in the study were found to develop metastasis. The vast majority of data available suggests that cMCTs in cats are behaviorally benign and may not require as aggressive treatments compared to those in the canine patient [20].

24.6.4.2 Splenic Mast Cell Tumors

Splenic mast cell neoplasia (MCT) is one of the most common splenic tumors in cat. While typically a primary tumor with no evidence of cMCT, recent evidence suggests a correlation between cMCT and splenic MCT. Cats with splenic MCT often present as older cats (10–13 years old) with a history of anorexia, weight loss, and vomiting. Approximately one-third of cats with splenic MCT are reported to have either pleural or abdominal effusion, which may lead to reports of dyspnea and/or an extended abdomen. Abdominal palpation is generally abnormal, and organomegaly is often appreciated.

Baseline diagnostics should consist of lab work (CBC, chemistry panel), as well as thoracic and abdominal imaging. Coagulopathies are often reported in cats with splenic MCT, but they do not seem to have clinical significance. Cats with splenic MCT often have abnormalities on their CBC, notably anemia and eosinophilia. A diagnosis can be made via several routes depending on the patient's presentation. If effusion is noted, a diagnosis can often be made via fluid analysis, as eosinophils and mast cells are often present. A splenic fine needle aspirate may also be considered and is often diagnostic, although splenic sampling carries a greater risk compared to thoraco/abdominocentesis. Other findings that may aid in a diagnosis include circulating mastocytosis and buffy coat analysis, which increase the sensitivity of detecting mast cells.

For cats with splenic MCT, a splenectomy is the treatment of choice regardless of other systemic involvement. Due to the possible release of mast cell mediators during surgical removal, it is recommended that patients have both H_1 and H_2 blockers administered prior to surgery. Postoperative chemotherapy is generally not indicated, as feline patients with splenic MCT achieve durable survival times (12–19 months) following surgery. Disease progression often presents with circulating mast cells, so periodic monitoring of CBCs is recommended [21].

24.6.4.3 Intestinal Mast Cell Tumors

Intestinal MCT is the third most common primary intestinal tumor in cats, following lymphoma and adenocarcinoma [22]. These tumors often present in the small intestine, although occasional presentation is seen in the colon. Intestinal MCT is commonly metastatic to regional lymph nodes, as well as to the liver and spleen. Cats with intestinal MCT often present with hyporexia, weight loss, vomiting, and/or diarrhea. Physical exam findings often reveal palpable abdominal abnormalities.

Baseline diagnostics should include lab work (CBC, chemistry panel), as well as abdominal and thoracic imaging. Diagnosis can often be made with ultrasound-guided FNAs of the mass or other involved organs. Similar to splenic MCT, if effusion is noted, then a diagnosis may be made via fluid analysis. However, since peripheral mastocytosis is rare with intestinal MCT, the CBC and buffy coat evaluation may or may not contribute to a diagnosis.

Surgical excision is often the treatment of choice for this disease, with wide excision required for a more durable progression-free survival time. Without surgery, cats with intestinal MCT have a very poor prognosis. With surgery (+/− chemotherapy and corticosteroids), the median survival time reported is about 1.5 years [23]. The role of chemotherapy in the treatment of intestinal MCT is unclear, but there may be clinical benefit due to the frequency of metastasis at the time of diagnosis. Responses to both lomustine and toceranib phosphate (Palladia) have been reported [24, 25].

24.7 Diagnostic Techniques

24.7.1 Documentation

Any patient with masses or enlarged lymph nodes noted on physical examination should have the masses appropriately measured and documented. Thorough documentation includes the use of a body map as well as measurements obtained with calipers. Measurements may be documented in either millimeters or centimeters, but the unit should be clear and repeated at subsequent visits. A single measurement of the tumor's widest diameter is often appropriate for future reference. Measurements should always be taken prior to sampling.

24.7.2 Fine Needle Aspirates

FNAs are a simple and affordable diagnostic technique that can facilitate a diagnosis in many oncologic settings by obtaining cells for analysis or cytology. It is important to measure masses or enlarged lymph nodes prior to aspiration, as the size may change due to bleeding or inflammation after aspiration. There are two primary techniques for obtaining an FNA, including coring and aspiration.

24.7.2.1 Coring Technique

Supplies: 6 or 12 ml syringe, 22-g needles*, slides

Procedure: Secure the mass with one hand while holding the needle in your other hand between your thumb and index finger. Insert the needle through the skin and into the mass. Slide the needle back and forth within the mass while



Figure 24.8 Fine needle aspirate, coring technique. *Source:* Jaci Christensen.

redirecting at different angles (woodpecker motion). Do not exit the skin until the aspiration has been completed. The goal is to fill the needle full of cells. Once you have redirected several times, withdraw the needle from the mass, and attach it to a syringe that has been prefilled with air, and spray your sample onto a clean slide (Figure 24.8).
*Any size needle may be used; however, larger gauge needles may result in hemodilution whereas smaller gauge needles may result in an inadequate sample.

24.7.2.2 Aspiration Technique

Supplies: 6 or 12 ml syringe, 22-g needles*, slides
Procedure: Attach your needle to the empty syringe. Secure the mass with one hand while holding the syringe in your other hand between your thumb and index finger. Insert the needle through the skin and into the mass. Slide the needle back and forth within the mass while redirecting it at different angles (woodpecker motion). While doing so, use your other fingers to apply suction to the syringe. Do not exit the skin until the aspiration has been completed. The goal is to fill the needle full of cells. Once you have redirected several times, release the suction from your syringe, withdraw the needle from the mass, separate your syringe and needle and fill the syringe with air, reattach it to the needle, and spray your sample onto a clean slide (Figure 24.9).
*Any size needle may be used; however, larger gauge needles may result in hemodilution whereas smaller gauge needles may result in an inadequate sample.

24.7.3 Slide Preparation

Supplies: 3–4 slides, single-end frosted preferred
Procedure: Once you have collected a sample via FNA, the next step is to prepare several diagnostic slides. Single-end frosted slides are preferred, as they allow for easy labeling with a pencil. Your sample should be placed close to the frosted edge to allow space for sample spreading. There are two primary techniques for slide preparation: vertical pull-apart and horizontal smear.



Figure 24.9 Fine needle aspirate, aspiration technique. *Source:* Jaci Christensen.

24.7.3.1 Vertical Pull-apart

The vertical pull-apart is best used when cells are fragile, as it is less damaging than other techniques. With this technique, the slide with the sample is held in one hand while a clean slide is held in the other. Making a "t" shape with the slides, the clean slide will be placed on top of the sample, compressing the sample onto both slides. Once this has occurred the top slide is pulled straight up to separate the slides—resulting in two diagnostic slides.

24.7.3.2 Horizontal Smear

The horizontal smear is best when the sample is fluid consistent or thick. With this technique, a clean slide is pressed upon the sample, as in the vertical pull-apart, followed by a motion that slides the sample towards the glass edge of the slide, creating a feathered edge. This technique results in one diagnostic slide, as the slide used to spread the sample will likely be composed of ruptured cells from the technique.

24.8 Chemotherapy Administration

24.8.1 Safety

Prior to handling chemotherapy, it is crucial that safety mechanisms are in place to minimize exposure to these drugs. Research has shown that human healthcare personnel working with hazardous drugs have higher instances of reproductive difficulties, fetal loss, DNA changes, and cancer [26–29]. Minimal replica studies have been performed in veterinary medicine. It can be assumed that the exposure of veterinary personnel handling these drugs is higher than in human medicine due to lack of regulations, patient noncompliance, frequent exposure to contaminated patient excrement, variable personnel training, and variable access to safety equipment and devices. Veterinary technicians must be educated and empowered to self-advocate to protect themselves from the risks of working with hazardous drugs.

24.8.2 Personal Protective Equipment

Exposure to hazardous drugs can occur at any point from the receipt of the drug to when it is excreted from the animal and into the environment. The routes of exposure for healthcare workers include:

1. **Skin or eye contact:** Direct skin contact or splashing of eyes with hazardous drugs can occur during spills, leaks, or handling of patient excrement containing drug metabolites. Direct skin contact may also occur when contaminated items travel beyond the preparation or administration area.

2. **Inhalation:** Drugs can aerosolize during preparation, administration, or disposal and then be inhaled by healthcare workers.
3. **Ingestion:** Healthcare workers can ingest drugs by eating, drinking, or touching their mouths with contaminated hands or items.
4. **Sharps injury:** Healthcare workers can be exposed through an accidental needlestick when handling contaminated needles.

Personal protective equipment should be worn during all parts of drug handling and may consist of chemotherapy-rated gloves, face/eye protection, and chemotherapy-rated gowns. Double gloving is often required. Facility controls, such as negative pressure rooms and biological safety cabinets, are also required for any chemotherapy manipulation apart from oral chemotherapy that is in its final dosage form. For full guidelines regarding hazardous drug handling, please reference the United States Pharmacopeia General Chapter 800 (USP 800) [30].

Pet owners must be informed of the risk of handling chemotherapy drugs and patient excrement. Individuals who are pregnant, trying to get pregnant, breastfeeding, or immunocompromised should not handle chemotherapeutics or patient excrement. Gloves should be worn when handling chemotherapy or cleaning patient excrement. Dust-free cat litter should be used for feline patients receiving chemotherapy to minimize inhalation during cleaning. Urine and feces should be disposed of in an outside trash can. Good hand hygiene is recommended for individuals who may be exposed to chemotherapy drugs or excreted metabolites.

24.8.3 Administration

Chemotherapy drugs are available in both injectable and oral formulations. Most chemotherapy drugs are considered either vesicants or irritants, meaning that extravasation can cause either mild, moderate, or severe tissue damage and/or necrosis. It is essential that any IV chemotherapeutics are administered via a clean-stick catheter to prevent complications. Veins that have been punctured in the previous 48 hours should not be used for chemotherapy administration, thus the veterinary technician should consider if jugular venipuncture is appropriate for prechemotherapy blood work. Sedation may be warranted for some feline patients receiving chemotherapy to minimize the risk of extravasation. It is also recommended that a small gauge IV catheter is used (22–25 g) and care should be used during the aseptic preparation of the vein to avoid skin irritation.

Oral formulations of chemotherapy may present a challenge to pet owners due to the difficulty in medicating the feline patient. Cats that hypersalivate, bite into capsules, or spit out pills may increase the chemotherapy exposure risk to their owner. Chemotherapeutics should never be compounded into liquid formulations due to the increased exposure risk to the pet owner. Additionally, chemotherapy pills should never be crushed or hidden in food due to increased exposure risk as well as the difficulty in determining how much of the drug was eaten. If a patient is difficult to medicate, discussions should occur with the pet owner to determine if the patient should return to the clinic for in-hospital administration rather than at-home administration by the owner.

Cancer in feline patients will continue to be an ongoing challenge as we face the many complexities of prevention, early detection, diagnostic methods, and treatment modalities. Positive patient outcomes rely on the strong collaboration between all members of the medical team, including primary veterinarians, veterinary technicians, and oncology specialists. It remains the responsibility of all team members to maintain continued education, as veterinary oncology is a constantly evolving field with unceasing research and discoveries.

See the companion website for further clinical references.

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Respiratory

Paula Plummer, LVT, VTS (ECC, SAIM, CP-fe)

TECHNICIAN TIDBITS

- Cats with respiratory disease are on the precipice and can easily be pushed into respiratory arrest if not handled appropriately.
- The respiratory system's main function is to provide oxygen to tissues and removal of carbon dioxide.
- Oxygen requirements are determined by the metabolic rate. The metabolic rate is an ever-changing factor, determined by body condition and current activity level.
- The upper airway consists of the nares, nasal passages, pharynx, and larynx.
- The lower airway consists of the left and right mainstem bronchi, followed by lobular bronchi and bronchioles.
- Persistent panting in a cat should always be taken seriously. Although there are nonrespiratory causes of panting (stress, pain, and heat), persistent panting is commonly a result of respiratory disease and should be addressed immediately.
- A thoracocentesis should be performed on the cranial aspect of the 7–9th intercostal space.

The respiratory system's main functions include oxygenation and ventilation. This chapter will break down these processes, along with other respiratory functions. When a feline patient experiences dysfunction or failure of the respiratory system, outcomes may require emergency stabilization. Veterinary technicians are commonly asked to describe clinical signs to the doctor and physical exam findings to the client, as well as appropriately respond to patients in respiratory distress. See Table 25.1 for a brief description of terms used to describe respiratory patients. Respiratory diseases in feline patients can be challenging due to the nature of the respiratory system and the fragility of the patient. Maintaining the patient in a low-stress state will help ensure a successful outcome.

Anatomically, the respiratory system is divided into sections called the upper and lower airways. The upper airway consists of the nares, nasal passages, pharynx, and larynx. The trachea is the connecting structure between the upper and lower airways. The lower airways consist of the left and right mainstem bronchi, which branch into smaller lobular bronchi and bronchioles. The alveolar ducts, alveolar sacs, and alveoli conduct gas exchange within their regions in each bronchi lobe (lung lobe) [1]. See Figure 25.1 for the anatomical features of the feline respiratory system. The alveoli are where gas exchange occurs. Gas exchange is the movement of oxygen across the capillary wall into oxygen-depleted blood to increase the oxygen content in circulation, while simultaneously CO_2 moves from circulation across capillaries and into lungs to be expelled during expiration. The movement of these gas molecules across the capillary walls is known as diffusion. See Figure 25.2 for a demonstration of gas exchange at the alveoli. The gas exchange process will be broken down further in this section, while discussing the anatomic and physiologic features of inspiration and expiration.

The body's oxygen requirements and level of carbon dioxide produced are dependent on a patient's body surface area (weight ratio) and activity level. The drive for inspiration is controlled by the autonomic nervous system. Receptors throughout the body detect changes in the chemical composition (O_2 and CO_2) of the blood, the presence of toxins/foreign material in the lungs, and the level of energy exertion. With a feedback control system, if any receptor detects derangements in any of these factors, a message is sent to the respiratory center in the brainstem (pons and medulla) to initiate inspiration [2].

Contraction and relaxation of the diaphragm, along with the respiratory muscles and the negative pressure within the pleural cavity, are all required for normal respiration. Inspiration involves the contraction of the diaphragm and respiratory muscles, resulting in forward and outward the movement of the ribs to enlarge the thoracic cavity. During this process, the

Table 25.1 Terms and definitions commonly used to describe respiratory patients.

Dyspnea: difficult/labored breathing
Hypoxemia: decreased concentration of arterial oxygen. Commonly abbreviated as PaO_2.
Hypoxia: decreased concentration of oxygen in the tissue.
Orthopnea: difficulty breathing in recumbency, which is relieved or reduce when sitting or standing
Oxygen saturation (SaO_2): the amount of hemoglobin in circulation that is bound to oxygen, measured in a percentage (%).
Paradoxical respirations: the reverse of normal chest wall movements, the chest wall moves inward on inspiration and outward on expiration.
Partial pressure of carbon dioxide ($PaCO_2$): the measurement of arterial ventilation.
Respiratory distress: a condition in which the body requires more oxygen. As a result, the patient will have a change in respiratory rate or characteristics.

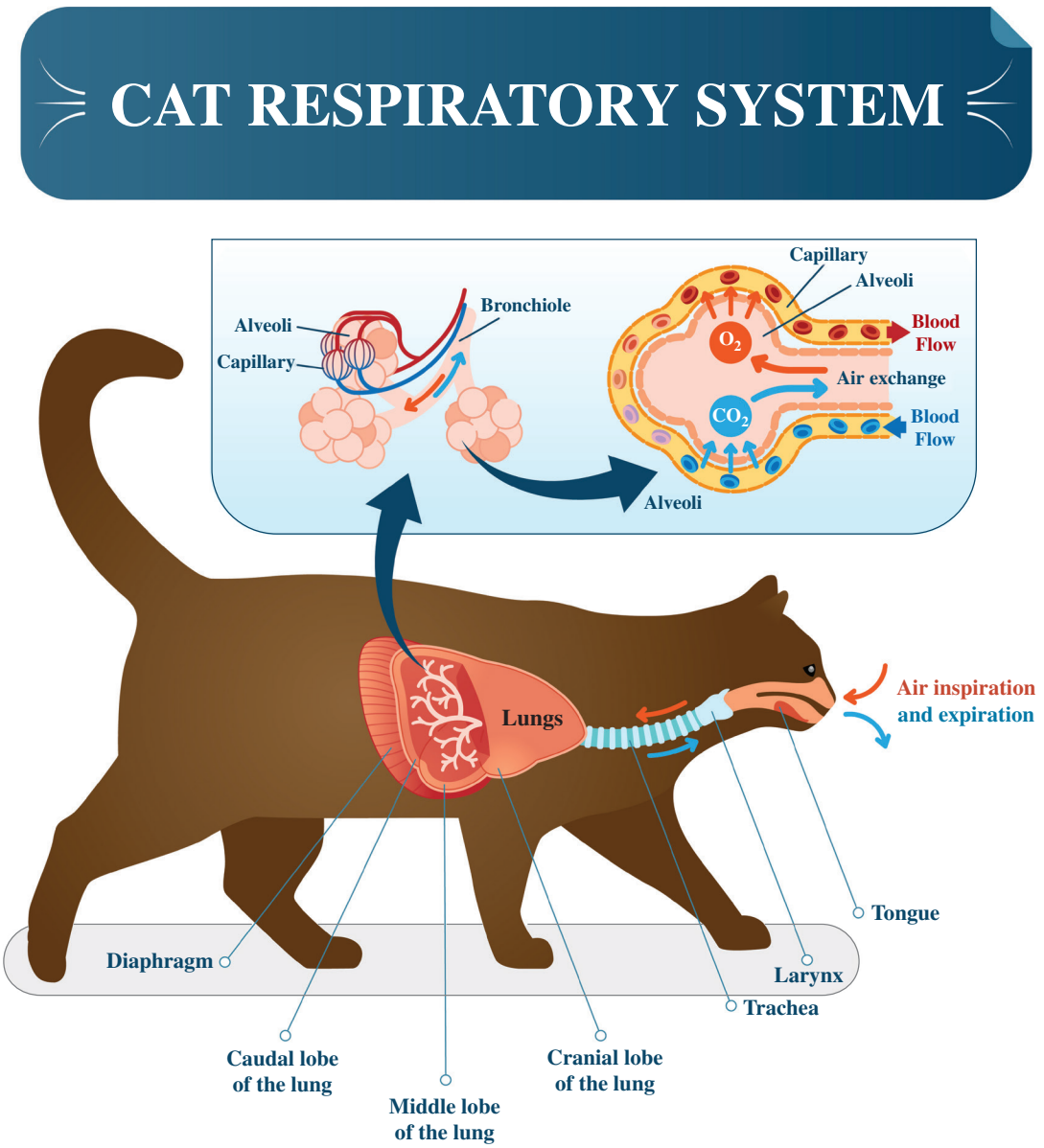


Figure 25.1 The feline respiratory system. *Source:* Wiley.

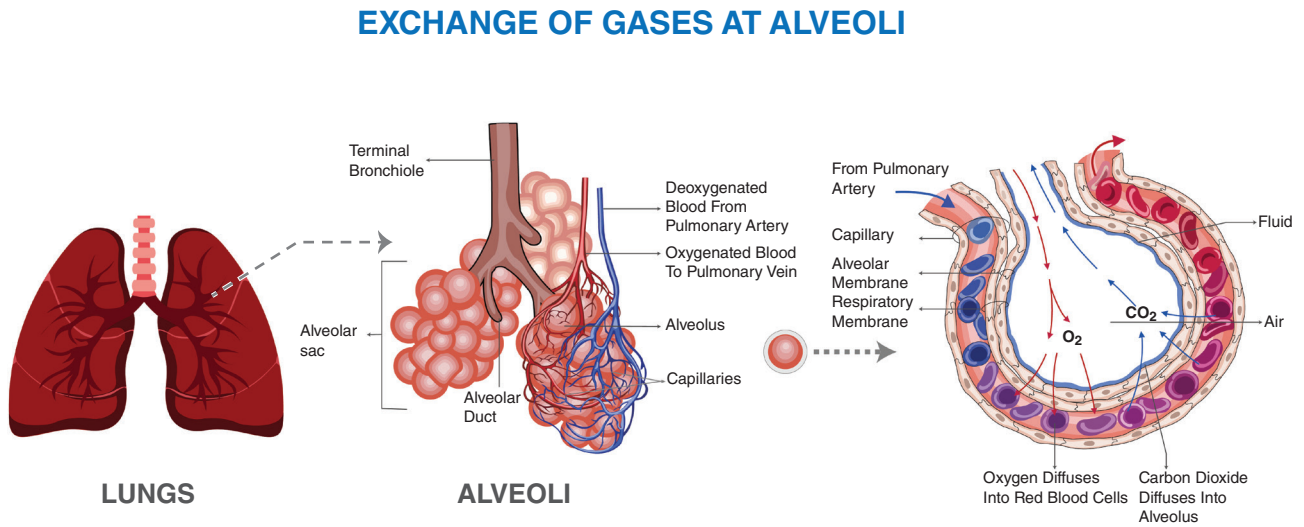


Figure 25.2 Exchange of gases at alveoli. *Source:* Wiley.

abdominal muscles relax, allowing the abdominal organs to move caudally, thereby further expanding the pleural space. As the thoracic cavity expands, air is taken in through the nostrils and travels to the lungs via the bronchial tree, ending in the alveoli. Simultaneously, the diaphragm relaxes, returning to its normal position and pushing air out of the lungs. The thoracic cavity then returns to its normal size during expiration.

Blood flows into the lungs via pulmonary and bronchial circulations. Blood within bronchial circulation provides nutritional support to the structures of the lower airway by separating into a superficial and deep system, where the superficial returns to the right side of the heart, while the deep system shunts into the pulmonary vein, which then enters the left ventricle [3]. The deoxygenated blood from the bronchial circulation mixes with oxygen-rich blood in pulmonary circulation, and then flows into systemic circulation [3]. The blood in pulmonary circulation comes from the right ventricle, which contains the oxygen-depleted blood returning to the heart from circulation. The primary function of pulmonary circulation is gas exchange. During this process, oxygen crosses the capillaries into circulation, attaching to hemoglobin and resulting in deoxygenated blood becoming oxygen rich.

Hemoglobin, a protein found in erythrocytes, is the primary carrier of oxygen throughout the bloodstream. Each hemoglobin molecule can carry four oxygen molecules [4]. Under normal respiratory conditions, oxygen molecules bind to all four receptors, resulting in blood oxygen saturation of greater than 97%. Once oxygen is bound to the hemoglobin it is transported to tissues via circulation.

CO_2, a byproduct of oxygen metabolism, plays an important role in acid-base regulation and respiratory drive. Exhalation is the primary mechanism for CO_2 excretion. CO_2 levels in the body are highly regulated by central chemoreceptors in the medulla, which detect changes in the blood CO_2 content at the blood–brain barrier, while peripheral chemoreceptors in the carotid and aorta detect these changes peripherally [5]. Alterations in CO_2 affect acid-base status, with an increase in CO_2 (hypercapnia) inducing respiratory acidosis and a decrease in CO_2 (hypocapnia) inducing respiratory alkalosis. CO_2 is converted into bicarbonate and released into the plasma. After being transported to the alveoli via circulation, bicarbonate combines with hydrogen to form carbonic acid, which is in equilibrium with CO_2 and water. Diffusion of CO_2 across the pulmonary capillary membrane and exhalation are the final steps in this process.

25.1 Patient History and "History Gathering Questions"

The veterinary technician gathering information about the respiratory patient not only establishes clinical signs surrounding the present situation but also the timeline for the disease process. Respiratory clinical signs noticed by owners can be of nonrespiratory disease origin (cardiac, infectious disease, etc.); therefore, establishing all concurrent medical conditions is key to efficiently obtaining a diagnosis and formulating the most appropriate plan. Below are examples of history-gathering

questions that can be included in a patient's history of respiratory conditions. Not all questions may be applicable to every patient, as some are indicated only for emergency situations.

- Please describe your pet's clinical signs.
- How long have you noticed these clinical signs?
- Does your pet have any concurrent medical conditions?
- Does your pet have any past medical conditions?
- What medications is your pet taking?
- When was the last time your pet received these medications?
- Did you witness a traumatic or triggering event before the clinical signs began?
- Describe your pet's home environment.
- Has your pet traveled recently? If yes, when and where?
- When was the last time your pet was around another animal? Are there other than pets within your household?

25.2 Clinical Signs

Clinical signs of a hypoxic patient include cyanosis, dyspnea, panting, tachypnea, tachycardia, and open-mouth breathing. Cyanosis (or blue mucous membranes) is not commonly noticed by owners because the untrained eye usually notices this clinical sign only when respiratory distress is severe, and in the author's experience, other clinical signs are noticed by the owner before this point.

Other common clinical signs noted with respiratory distress include repeated coughing/hacking, neck extension in association with coughing or breathing, restlessness, odd body positioning, hiding, vocalizing, audible respiratory noises, tachypnea, panting (open-mouth breathing), and ptyalism (hypersalivation) with "shoestrings." See the companion website for example videos of cats experiencing respiratory disease. It is important to understand that every patient with a respiratory disease is not necessarily in distress. Patients with stable/chronic respiratory conditions often exhibit milder clinical signs, such as nasal discharge or other signs without overt distress. Specific clinical signs associated with each disease will be included in their respective section of this chapter.

25.3 Physical Examination Findings

Naturally, cats are known not to reveal clinical signs to owners or veterinary staff. This is why it is paramount to notice even the most subtle physical examination findings. The feline patient in respiratory distress will exhibit physical examination findings that are completely different from those of canine counterpart. Many feline patients in respiratory distress are closely observed during this time while being placed in a quiet space or oxygen cage (if indicated) until deemed stable enough by the veterinarian to have a physical examination performed. It is of the utmost importance for the veterinary team to recognize the feline respiratory patient as fragile, taking precautions to prevent factors, such as stress, that may result in decompensation, as respiratory arrest can result from overhandling during this time. Often the physical examination is broken down strategically into sections to allow the patient to recover at their own pace.

Cyanosis is commonly identified as a classic clinical sign for respiratory distress. Often, physically checking mucous membrane color in a cat can be stressful; therefore, observing the color of their tongue during vocalization or panting can substitute for lifting the patient's lip for an assessment. Cyanotic mucous membranes appear blue in color due to the lack of hemoglobin, the oxygen-carrying component of an erythrocyte [6, 7]. Variations of the mucous membrane color can range from a "blue hue" to a dark purplish-blue. All veterinary staff should be trained to understand any variation of blue coloration to the mucous membranes requires *immediate* oxygen therapy and should be considered to be an emergency. See "Oxygen Supplementation" section for further information on options for oxygen supplementation in the feline patient.

The body position of the dyspneic patient can be an indicator of respiratory compromise as well. The feline patient will lie sternally, often in a "loaf" position with their forelimbs tucked underneath themselves. However, with closer observation, their sternum will not be touching the surface below them. While in this position, they can also subtly abduct their elbows. Identification of this body position can be challenging in long-haired patients or in patients in a

Table 25.2 Respiratory sound descriptions.

Crackles: originating in the lower airway due to the opening and closing of the bronchi. The intensity of the sound can vary, and the sound may be described as two pieces of paper being rubbed together.
Normal: quiet and barely audible during auscultation.
Quiet, dull, or decreased: these terms may be used to describe reduced levels of sound on thoracic auscultation. These sounds can be due to reduced airflow, the presence of air or fluid accumulation.
Rales: harsh sounds originating in the lower airway due to narrowing or turbulent flow.
Stertor: A low-pitched respiratory noise originating from the upper airway due to flaccid tissue.
Stridor: A high-pitched respiratory noise originating from the upper airway, usually the larynx or trachea, due to vibrations from rigid tissue.
Wheezes: Loud, squeaky sounds originating from the lower airway or bronchi, associated with bronchial disease, such as asthma.

low-light environment, such as the back of their carrier or cage. Another body position of the dyspneic feline patient may include neck extension, in a less obvious manner than their canine counterpart.

During distress, cats can also be seen open-mouth breathing or "cheek puffing." In this situation, the cat will open their mouth to varying degrees to breathe through their mouth. Some cats will open their mouth the slightest amount, making it challenging to notice. Visualizing the area of their mouth just below the nasal planum will help the veterinary technician identify the slightest opening of the patient's mouth. Occasionally, the patient may have the outward appearance of having their mouth closed, but with each expiration, cheek movement is noticeable. This can be another indicator of open-mouth breathing in a cat. See the companion website for a video demonstration of a cat open-mouth breathing.

Panting in a cat should always be taken seriously. Although there are several nonrespiratory causes (e.g., stress, pain, heat), panting as a result of respiratory disease should be addressed immediately. Cats can intermittently pant, or only pant at certain phases of a respiration unlike their canine counterparts who pant nonstop when in a hot environment or during periods of stress. Since panting can be due to nonrespiratory causes, it is important to consider the entire clinical picture to determine the origin and attempt to remove any nonrespiratory causes.

Finally, respiratory rate and effort should be observed during physical examination when respiratory status is a concern. With the ongoing debate about what a normal respiratory rate in the hospital is, variations in references can be observed. A rate that is considered normal within the hospital can be different from in the cat's home environment, due to the stress of transport and the clinic environment. Most respiratory rates published for cats are for those resting in their home environment. One study stated that a respiratory rate in healthy cats in the veterinary setting was recorded at a range of 28–176 breaths per minute (brpm), with a median of 64 brpm, making it challenging for the veterinary technician to determine which rate is considered eupneic vs. tachypneic [8]. The textbook-published respiratory rate is 20–24 brpm for the feline patient [9]. Tachypnea, by definition, is a rapid respiratory rate. However, looking at the entire physical examination and clinical picture will help determine the origin of tachypnea and whether the patient is in respiratory distress. Observation of inspiratory and expiratory effort with attention to any audible respiratory noises will complete the respiratory portion of the physical examination. See Table 25.2 for a guide to respiratory sounds. Respiratory sounds can be heard with or without a stethoscope and should be considered abnormal when present. As the patient allows, performing thoracic auscultation bilaterally on all lung lobes should be included in the physical examination. See "Diagnostic Techniques" section for further information on thoracic auscultation. Physical examination findings will vary with each respiratory disease. See "Respiratory Diseases" section for further information specific to each respiratory disease.

25.4 Specific Nursing Care Considerations

Cats with respiratory disease are very fragile and can easily be pushed into decompensation or respiratory arrest if not handled appropriately! The veterinary technician should continuously use critical thinking skills and patient advocacy with these patients. See Chapter 10: "Critical Thinking and Kirby's Rule of 20," for further information on critical thinking techniques. Patients with respiratory disease can experience acute, chronic, or acute-on-chronic episodes requiring care

from the veterinary team. These patients may present as medically stable or unstable, requiring the veterinary technician to apply critical thinking techniques. Acute-on-chronic episodes may occur when the feline patient has been previously diagnosed with a respiratory condition, and then an event may trigger an acute event, putting the patient in distress requiring immediate intervention. This section will review nursing care and patient monitoring techniques for the feline patient.

General nursing care tasks the veterinary technicians should attend to begins with keeping the patient's nostrils dry and clean from debris. With some disease processes, nasal discharge can become dry and obstructive, so the patient struggles to properly breathe and smell. The general cleanliness of the patient and their environment is important as well. General husbandry, such as clean litter boxes, clean bedding, and fresh food (when medically indicated), and water should continuously be addressed. In scenarios where patients require oxygen support, grouping these tasks together to maximize oxygen support may be necessary. Patients requiring long-term oxygen support should receive humidified oxygen, so the environment does not dry the nasal passages or mucous membranes, causing irritation to the patient.

Nutritional support is often a concern in patients with a respiratory condition. Commonly, these patients will not voluntarily eat, either due to their disease and/or their decreased sense of smell; therefore, warm, palatable food options can be offered until the patient is stable enough to undergo general anesthesia for feeding tube placement. See Chapter 12: "General Feline Nutrition," for further recommendations.

Patient monitoring methods can be tailored to the individual needs. Patients requiring oxygen therapy may need only "hands-on" treatments done at specific times of the day, grouping treatments together as much as possible to maximize oxygen therapy. Those patients can receive "hands-off" treatments as prescribed by the veterinarian. Hands-off treatments may include a mentation status check, respiratory rate, or respiratory effort in time intervals indicated based on the status of the patient. Often patients with respiratory concerns are monitored at a minimum hourly, sometimes more frequently.

Monitoring oxygenation and ventilation of the patient often falls to the veterinary technician to determine the response of therapy. Depending on the needs of the patient, different methods for monitoring may be prescribed by the veterinarian.

Obtaining an arterial blood gas is the diagnostic of choice to diagnose hypoxemia, but acquiring such a sample requires a high technical skill set and is only warranted in specific cases due to the stress induced during the process. When diagnosing hypoxemia, the partial pressure of arterial blood (P_aO_2) is the value that is necessary to assess the oxygenation status of the patient using an arterial blood gas sample. The fraction of inspired oxygen (F_iO_2) is the concentration of oxygen that the patient is breathing. Room air has a F_iO_2 of 21%. A normal P_aO_2 is considered to be four to five times the amount of F_iO_2. Therefore, the normal P_aO_2 of a patient breathing room air is 80–100 mmHg, while the normal P_aO_2 of a patient breathing 100% oxygen is 400–500 mmHg. The oxygenation level of a patient cannot be assessed using a venous blood sample.

If the ability to obtain an arterial blood sample to assess oxygenation is not available, determining oxygen saturation using a pulse oximeter (SpO_2) and the oxygen-hemoglobin dissociation curve can be used to help determine the oxygen saturation of the patient. The oxygen hemoglobin dissociation curve demonstrates the correlation between oxygen saturation and the partial pressure of oxygen in arterial blood to determine the ability of hemoglobin to bind to oxygen. In the curve, it shows that when hemoglobin saturation is at 92% the P_aO_2 is 80 mmHg. It is recommended that when the P_aO_2 is less than 70 mmHg (e.g., when hemoglobin saturation is 93%), oxygen therapy should be initiated [10]. Normal ranges of a SpO_2 will be from 95 to 100%. Potential risk factors for shifting the oxygen-hemoglobin dissociation curve include acidosis, increased P_aCO_2, hyperthermia, and increased 2,3-diphosphoglycerate (2, 3 DPG). A rightward shift of the curve causes oxygen to separate more readily from hemoglobin, thus delivering more oxygen to tissues. A left shift causes hemoglobin to bind more tightly to oxygen, ultimately supplying less oxygen to the tissues [11]. See Figure 25.3 for a demonstration of the oxygen hemoglobin dissociation curve with a right and left shift.

Oxygen saturation can be determined using a SpO_2 monitor either as a stand-alone monitoring tool or in conjunction with the oxygen-hemoglobin dissociation curve. The SpO_2 monitor measures oxygen saturation using light wavelengths to determine the amount of oxygenated hemoglobin flowing through the capillaries at the monitoring site. The monitoring unit is typically small, making it easy to transport and accommodate different patient needs and procedural requirements. *It is important to remember that some feline patients find the probe, monitor, and their noises stressful. As always, assess the patient's stress level when using this monitoring tool.* A probe attaches to the base SpO_2 unit. The probe has different methods to attach to the patient. All probe types contain an LED and photodetector to measure the amount of light passing through the capillaries within the vascular bed.

There are two types of SpO_2 probes: a transmission probes and a reflectance probes. Transmission probes contain the sensor on one side of the probe and the light emitter on the other, while reflectance probes have the light emitter and sensor side by side. See Figure 25.4 for an example of a transmission and a reflectance probe. Reflectance probes need

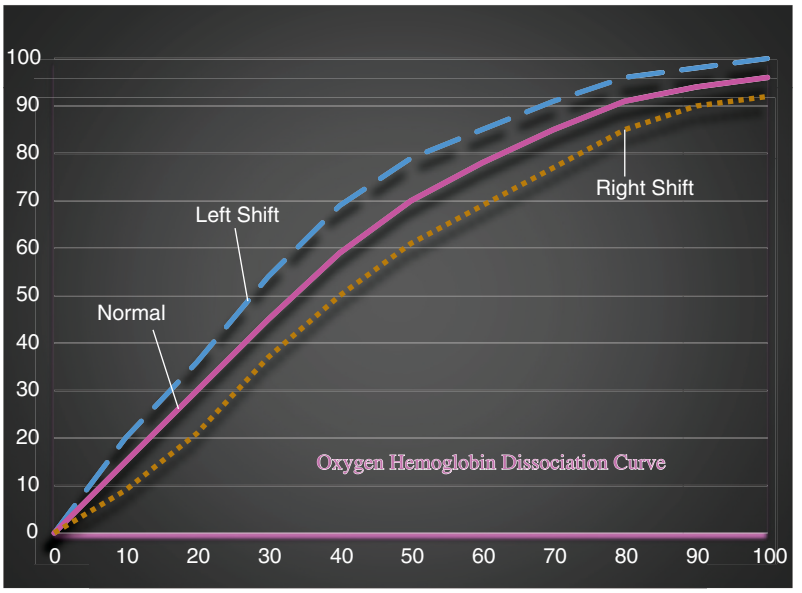


Figure 25.3 Oxygen-hemoglobin dissociation curve. *Source:* Paula Plummer.



Figure 25.4 The transmission probe is pictured on the right. In this style of probe, the sensor is on one side of the probe and the light emitter on the other. The reflectance probes (2) are pictured on the left. In this style of probe, the light emitter and sensor are side by side. *Source:* Paula Plummer.



Figure 25.5 Pictured are common clip-style pulse oximetry probes used in feline patients. The probe in the middle and right can be placed on the lip, pinna or tongue. The probe on the left is a portable human finger probe that can be placed over a digit or tongue in an appropriately sized feline patient. *Source:* Paula Plummer.

to be placed flat against the tissue. The probe produces pulses of red and infrared light, and the machine calculates the oxyhemoglobin saturation [4]. With multiple types of SpO_2 probes commercially available, it can be challenging for the veterinary technician to choose the appropriate probe for the feline patient. The most common type of probe is the clip-style shown in Figure 25.5. This type of probe is versatile and can be used in multiple locations, such as the lip, pinna, tongue, or between the toes.

When troubleshooting the efficacy of an SpO_2 monitor, the patient's heart rate should be counted and compared with the heart rate on the monitor. Patient factors, such as excessive movement and pigmented skin, can result in erroneous readings. In the author's experience, when the battery is low, delayed results and errors on the machine are more frequent. Furthermore, ill-fitting probes will not produce accurate results. Ensure both sides of the probe (in transmission probe models) lie flat on the patient with adequate contact between the patient and the probe. Transmission probe clips that have been in the same position for a prolonged period may begin to read a lower SpO_2 than is actually present in the patient due to excessive compression of the capillaries in that region, resulting in a focal lack of blood flow.

Capnography is a valuable monitoring tool for assessing the ventilation aspect of the respiratory patient. See Chapter 6: "Anesthesia Considerations for the Feline Patient," for detailed information on capnography.

25.5 Oxygen Supplementation

Conventional oxygen supplementation can be provided in a variety of methods. The feline patient, compared to their canine counterpart, may require supplementation in different forms due to their fragility during respiratory disease and the increased stress that may accompany certain oxygen delivery methods.

Commercial oxygen cages are available in many sizes and price ranges. However, not all hospitals have the space or budget to accommodate this need for the feline patient. When a commercial oxygen cage cannot be purchased, a temporary oxygen cage can be constructed using an incubator or small cage. Temperature control, oxygen content, and humidity levels should always be monitored when modifying a unit into an oxygen cage. Low-cost, high-quality commercial oxygen monitors, thermostats, and in-line humidifiers can be purchased to place in oxygen cages. When a patient is in an oxygen cage, "hands-off" care should be maximized to provide the desired concentration of oxygen to the patient. Every time the oxygen cage door is opened to perform a treatment, the oxygen level returns to room air (21%). Grouping "hands-on" treatments together will help increase the amount of time the prescribed oxygen level is administered to the patient.

An oxygen hood can be purchased commercially, or an Elizabethan collar can be adapted into an oxygen hood. When adapting an Elizabethan collar to serve as an oxygen hood, only 60–70% of the front surface should be covered with clear plastic wrap to reduce the risk of overheating and carbon dioxide buildup. A humidified oxygen line can be secured

inside the back of the collar as an oxygen source. There are pros and cons to each method of oxygen supplementation. It is important to use the best method of oxygen supplementation for the individual.

Oxygen supplementation provided by flow-by oxygen is often not an option for the feline patient as in their canine counterpart. Flow-by oxygen requires a member of the veterinary team to hold the oxygen to the patient, often causing more stress to the feline patient. As previously discussed, the feline patient in a respiratory emergency is in a fragile state, requiring extremely low-stress interventions during this period.

Oxygen supplementation is most commonly supplied at 40% oxygen to avoid complications associated with long-term high oxygen levels. When high rates of oxygen are administered, complications, such as oxygen toxicity, hypercarbia, and atelectasis, can occur. If 100% oxygen is administered for longer than 24–72 hours, patients may be at risk for complications. Clinical sequelae of such complications include pulmonary edema, pleural effusion, and changes to the airway epithelium. The least amount of oxygen supplementation required to adequately oxygenate the patient should be used. For long-term use (>72 hours), supplementation should be less than 50%.

25.6 Respiratory Diseases

25.6.1 Upper Airway Disease

25.6.1.1 Brachycephalic Airway Syndrome

Brachycephalic airway syndrome (BAS) in dogs is described as a grouping of upper airway anatomical airways, including narrowed nostrils (stenotic nares), an elongated soft palate, and everted laryngeal saccules. Overall, BAS is less commonly seen in cats; furthermore, the extent of anatomic changes is less pronounced, with stenotic nares being more commonly noted than an elongated airway in feline BAS patients [12]. However, a few studies do report the full range of upper airway anatomic aberrations in feline BAS cases [13]. Some of the more popular brachycephalic cat breeds include Persian, Himalayan, Burmese, British Shorthair, and Exotic Shorthair. BAS can result in difficulty breathing, audible respiratory sounds (e.g., snoring or stertorous breathing), and sneezing. Other consequences of brachycephalic breed conformation, in addition to airway alterations, include keratitis, increased risk of corneal ulceration, dental disease, mandibular/maxillary abnormalities, dystocia, and dermatitis due to excessive facial skin folds [14].

Stenotic nares are typically diagnosed during physical examination. Surgical correction of narrowed nares, and other BAS abnormalities, is often the treatment of choice. As a precaution, feline patients can recover postoperatively in an oxygen cage until they have fully recovered and are oxygenating adequately. Typically, cats with BAS undergoing surgery have a good prognosis.

25.6.1.2 Feline Respiratory Disease Complex

Feline respiratory disease complex (FRDC) was previously referred to as an upper respiratory infection. Terminology changed when it was recognized that this disease complex is caused by certain organisms, specifically a single or complex viral infection. Feline viral rhinotracheitis (feline herpesvirus type 1) and calicivirus are the viral infections consistent with FRDC; however, *Chlamydia spp., Mycoplasma spp.*, and feline infectious peritonitis (FIP) have also been reported in FRDC [15]. Clinical signs and physical examination findings of FRDC may include nasal discharge, sneezing, conjunctivitis, and oral ulceration. See Chapter 23: "Infectious Diseases," for further information on diagnostics and treatment protocols for each organism.

25.6.1.3 Rhinitis

Rhinitis is characterized by nasal discharge due to inflammation of the mucosal lining of the nose and is commonly caused by viral or bacterial organisms. In cases where the sinuses also become inflamed, this is called "rhinosinusitis." Over time, chronic inflammation will destroy the nasal and sinus mucosa, causing damage or complete deterioration. Feline viral rhinotracheitis (feline herpesvirus type 1) and calicivirus are common inciters of rhinitis. Secondary bacterial infections may occur, warranting antibiotic therapy. Other causes of rhinitis include foreign bodies, allergies, fungal infection, idiopathic, and occasionally neoplasia, severe dental disease, or middle ear disease [16].

Clinical signs can vary in severity. They include clear or mucopurulent, unilateral or bilateral nasal discharge (Figure 25.6), sneezing, open-mouth breathing, ocular discharge, and conjunctivitis. Successful treatment hinges on a thorough physical exam, appropriate diagnostics, and identification of an underlying cause(s). Computed tomography (CT) and rhinoscopy with biopsies or oropharyngeal and conjunctival swabs can be obtained and submitted for infectious disease, polymerase chain

reaction (PCR), and a commercial laboratory. Culture and sensitivity of an aerobic swab from the same location(s) can be submitted when secondary bacterial infections are suspected. See Chapter 23: "Infectious Diseases," for further reading on viral, bacterial, and fungal diseases in the feline patient.

Obtaining a definitive diagnosis can be challenging in certain cases. Supportive care with intravenous fluids and nutritional support, in addition to targeted therapy for the etiologic agent, are the mainstay of therapy. Chronic rhinosinusitis can be difficult to manage due to nasal mucosa and/or turbinate destruction with the presence of latent and recurrent secondary infections. Management strategies aimed at maintaining a good quality of life are often the goal in treatment of rhinitis, as, oftentimes, a true cure can be difficult to obtain [16].

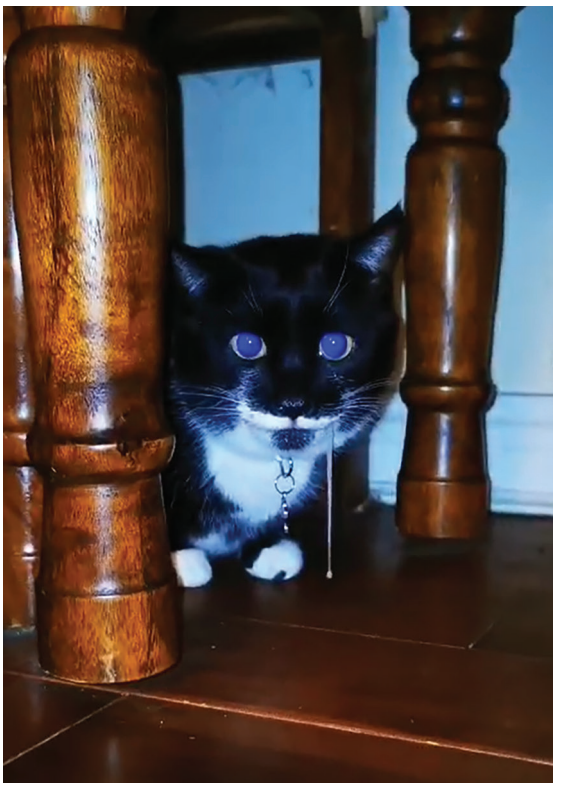


Figure 25.6 A patient with mucopurulent nasal discharge due to idiopathic rhinitis. *Source:* Amanda Lawlor.

25.6.2 Lower Airway Disease

Lower airway disease commonly affects cats. Obtaining a definitive diagnosis can be challenging, as the clinical signs of many feline lower airway diseases often mimic one another.

Feline asthma is categorized as a type I hypersensitivity that occurs after exposure to an aeroallergen [17]. A type I hypersensitivity is defined as an immediate reaction involving the release of antibodies to counteract antigen exposure. This is an immune system response involving IgE antibodies primed to recognize an aeroallergen, often resulting in an exaggerated response from inflammatory mediators, such as histamine and mast cell degranulation, once that allergen is encountered [18, 19]. Often, the aeroallergen or specific trigger for the individual is not identified. Studies have shown Bermuda grass, house dust mites, and pollen as known environmental triggers [19, 20].

Chronic bronchitis is characterized by thickened airways with the overproduction of mucous, usually resulting from a previous infection or ongoing disease [18]. There is no age, breed, or sex predilection for feline lower airway disease; however, different etiologies may affect different age groups of cats. For example, young to middle-aged cats may have a higher incidence of feline asthma. This disease process can be acute or chronic in nature, with the patient experiencing episodes of respiratory distress when exposed to their trigger(s). When a patient is in crisis, clinical signs, such as open-mouth breathing, tachypnea, and increased abdominal effort on *expiration* will occur. Cats with chronic bronchitis differ slightly in regard to clinical signs, as they commonly cough on a daily basis and experience respiratory distress during end-stage disease.

Thoracic radiographs often reveal a bronchial-to-bronchointerstitial pulmonary pattern, while lung lobe collapse and bronchiectasis (permanent widening of the airways) are seen less commonly. Patients in crisis are very fragile, and performing thoracic radiographs can add enough stress to the patient for them to progress into pulmonary arrest. Other diagnostic methods include an endotracheal wash or bronchoalveolar lavage (see "Diagnostic Techniques" section) to obtain a definitive diagnosis through cytological examination.

The most effective treatment for a feline asthma patient is removal of the inciting allergen. Oral (liquid or tablet) or inhalant glucocorticoids are the mainstay of treatment until remission occurs, at which time, the steroid dose can be tapered and potentially discontinued. Prednisolone is the glucocorticoid of choice for oral therapy, and fluticasone is the glucocorticoid of choice for inhalant therapy. Due to bronchoconstriction (constriction/narrowing of the airways), patients with asthma will respond to bronchodilator therapy, whereas patients with bronchitis (inflammation of the airways) will not. Albuterol and terbutaline are the bronchodilators of choice for the treatment of asthma [18]. See Chapter 5: "Client Education and Communication Topics for the Feline Owner," for further information on educating clients about administering oral medications and inhalant medications using a metered-dose inhaler at home.

25.6.3 Pulmonary Parenchymal Disease

25.6.3.1 Pneumonia

Pneumonia is an inflammatory process or infection of the pulmonary parenchyma. The presence of edema, leukocytes, and fibrin in the lungs is characteristic of pneumonia, leading to hypoxemia and occasionally hypercapnia [21] (Figure 25.7). Etiological agents of feline pneumonia include viral, fungal, protozoal, bacterial, and parasitic. Although bacterial pneumonia is less common in cats than in their canine counterparts, bacterial etiologies can still occur in feline patients as a result of regurgitation with aspiration, upper airway disorders, anatomical abnormalities, force-feeding, or infectious diseases. Patients with dysfunctional immune systems that alter the functions of the respiratory tract, specifically the ability of cilia to move pathogens and mucus up and out of the lungs, are more prone to pneumonia. At times, the etiologic agent of pneumonia is not identified, resulting in the diagnosis of idiopathic pneumonia.

Factors such as recent anesthesia, vomiting, medication administration, force-feeding, or concurrent medical conditions can lead the veterinary team to suspect or identify the cause of pneumonia. Clinical signs include dyspnea, cyanosis, abnormal respiratory patterns, and wheezing. Respiratory auscultation of the patient with pneumonia can include crackles, wheezes, and decreased or absent lung sounds. Physical examination findings can vary in severity and are often nonspecific to pneumonia. Predisposing conditions may present physical examination findings in addition to respiratory findings.

Routine lab work (complete blood count and biochemistry panel) may reveal changes suggestive of the degree of respiratory compromise or other underlying conditions; however, these changes are not specific for pneumonia. The diagnosis of pneumonia can be made with thoracic radiographs. The pulmonary pattern on thoracic radiographs can aid in the classification of pneumonia. For instance, aspiration pneumonia most commonly results in an alveolar pattern in the right middle lung lobe; however, it is also possible for aspiration pneumonia to affect other lung lobes. Bronchopneumonia often results in a lobar pattern, which appears as an alveolar pattern affecting the entire lung lobe [21, 22] (Figure 25.8a–c). Other imaging modalities, such as computed tomography (CT), can be used to aid in the diagnosis of pneumonia, but are often not required. Diagnostics, such as transtracheal washes or bronchoalveolar lavages, can be performed to diagnose the underlying cause of pneumonia.

Treatment should be tailored to each patient's needs and may include oxygen therapy and treatment of the underlying condition, if known. See "Oxygen Supplementation" section for further information. Symptomatic therapy can be initiated for patients with idiopathic pneumonia.

25.6.3.2 Pulmonary Edema

Pulmonary edema is the accumulation of fluid within the pulmonary parenchyma or alveoli due to an increase in the hydrostatic pressure of the pulmonary capillaries, potentially in combination with alveolar epithelial damage. It is important to determine if the source is cardiogenic or noncardiogenic in order to institute the most appropriate treatment. Patients will commonly present to the hospital in respiratory distress with an increased respiratory rate and effort. A detailed patient

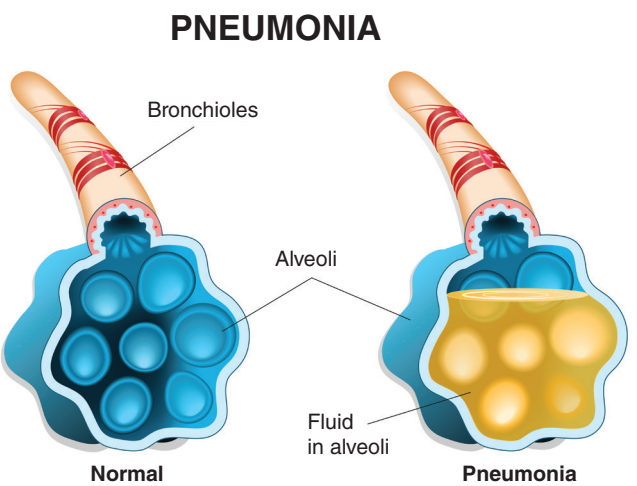


Figure 25.7 This figure demonstrates the presence of fluid-filled alveoli indicative of pneumonia. *Source:* Wiley.

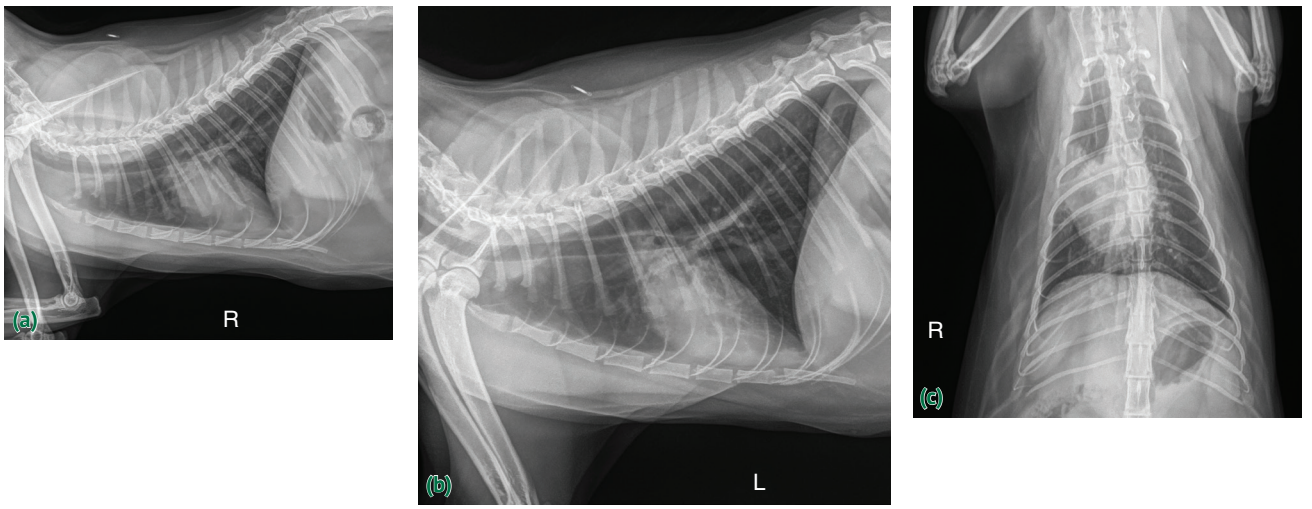


Figure 25.8 These thoracic radiographs represent an alveolar lung pattern in a feline patient with idiopathic aspiration pneumonia. (a) The right lateral view, (b) the left lateral view, and (c) the dorsoventral view. *Source:* Ellen Carozza, LVT, VTS.

history to identify concurrent medical conditions, exposure to toxins, and any potential trauma will guide the team in diagnosing the underlying condition and help target therapy. Physical examination findings specifically related to the presence of pulmonary edema include increased lung sounds, crackles, or wheezes on auscultation. Other findings may be present on physical examination leading the team to the cause of pulmonary edema.

Cardiogenic pulmonary edema is caused by left-sided heart failure and is reported to be the most common cause of respiratory distress in cats [23]. See Chapter 14: "Cardiology/Cardiovascular Diseases," for further information regarding cardiogenic pulmonary edema.

Noncardiogenic pulmonary edema can be due to systemic inflammatory response syndrome (SIRS), acute respiratory distress syndrome (ARDS), airway obstruction, neurologic diseases, such as trauma or seizures, or trauma (electrocution, drowning) [24]. In one study, SIRS was identified as a more common cause of pulmonary edema in feline patients in contrast to ARDS, the latter of which tends to be a more common cause in canine patients [24, 25].

Due to the variety of underlying conditions, treatment protocols will not be uniform for all patients with pulmonary edema. Treatments should be tailored to the underlying cause, providing oxygen supplementation and diuretics as needed for the patient. Prognostic factors depend on the underlying etiology, the magnitude of pulmonary edema, and the patient's response to treatment.

25.6.4 Pleural Space Disease

25.6.4.1 Pneumothorax

Pleural space disorders can include pneumothorax or pleural effusion. Pneumothorax refers to the accumulation of air or gas in this pleural space. Accumulation of a significant amount of air or gas can result in the collapse of one or more lung lobes. Pneumothoraces are classified into three groups: closed, open, or tension. See Table 25.3 for the factors involved in the classification of a pneumothorax. Often, a pneumothorax is the result of a traumatic event.

Clinical signs are dependent on the severity and type of pneumothorax. They can include severe respiratory distress, cyanosis, tachypnea, or even sudden death. On physical examination, thoracic auscultation can result in abnormalities ranging from dull to absent respiratory sounds with a shallow respiratory pattern. Cyanosis and a body posture of an extended neck and abducted elbows may be present, indicating respiratory distress. When the patient is stable enough to withstand the procedure, thoracic radiographs can be performed to diagnose pneumothorax. Alternatively, a thoracic-focused assessment with sonography for trauma (TFAST) can be performed by a competent team member.

Thoracocentesis can be performed as a diagnostic and therapeutic measure for a patient in discomfort. See "Diagnostic Techniques" section for further information. Chest tube placement should be considered when multiple thoracocenteses have been performed without improvement or if negative pressure cannot be achieved. Once the thoracostomy tube is placed, the patient can be placed on continuous suction or undergo intermittent air evacuations.

Table 25.3 Classification of pneumothorax [26, 27].

Classification	Definition	Cause
Closed	A rupture of a small airway or alveoli due to increased intra-thoracic pressure from within the pleural space.	Blunt trauma, lung laceration, iatrogenic
Open	Air accumulation due to an open wound or physical defect resulting in the collapse of the affected lung lobe.	Penetrating wound, flail chest
Spontaneous	Collection of air within the pleural space.	Nontraumatic, iatrogenic, airway disease
Tension	Air collection of the pleural space affects cardiac and respiratory function due to the continuation of air collection without the ability to exit. This is considered a life threatening emergency.	Trauma, lung disease, excessive pressure

Supportive therapy, such as oxygen supplementation, analgesics, or intravenous fluid therapy, may be needed to help stabilize the patient. Specific treatment modalities will be recommended based on the cause and type of pneumothorax. Commonly in the feline patient, medical management is successful; however, surgical intervention may be indicated in an open pneumothorax. A tension pneumothorax requires immediate, lifesaving intervention, such as thoracocentesis and surgical intervention. Depending on the type and cause of the pneumothorax, the prognosis can be positive [27].

25.6.4.2 Pleural Effusion

Pleural effusion is the accumulation of fluid within the pleural space. The type or classification is based on cellular and protein content due to a variety of causes [27]. Patients can be in respiratory distress and may have muffled cardiac sounds, tachypnea, tachycardia, weight loss, and depression on physical examination. One study reported clinical signs of a chylothorax being present for 1–4 weeks before presentation [28]. Once effusion is diagnosed, many patients require a thoracocentesis to relieve respiratory distress. Samples of fluid should be collected for submission for cytology and bacterial culture and sensitivity. Patients that continue to require therapeutic thoracocenteses will benefit from thoracostomy tube placement. Identification of the underlying cause of effusion, in addition to diagnosis of the type of effusion, will help guide treatment protocols.

Suppurative infiltrate within the pleural space is called a "pyothorax." Commonly, penetrating wounds, foreign body migration, or aspiration of bacterial contents are the causative agents of pyothorax in cats [27]. Removal of contents via thoracocentesis and submission of cytology and culture and sensitivity will not only obtain a diagnosis but be therapeutic to the patient as well. Antimicrobials targeted at treating the pathogen identified on culture and sensitivity are considered the best practice. Many patients will recover with conservative therapies; however, surgical intervention may be indicated for those who fail medical management or require surgical intervention due to the identification of a lesion.

Chylothorax is the accumulation of lymphatic fluid in the pleural space. Often the fluid is white to an opaque pink in appearance due to the fat content. Obtaining a sample for biochemistry evaluation will help differentiate between chylous and nonchylous fluid, as a triglyceride count of $\geq$100 mg/dl is necessary for the classification of a fluid as being chylous [27]. Often the underlying condition is undetermined (idiopathic); however, feline chylothoraxes may result secondary to heart disease or obstruction of lymphatic drainage [29]. Once the patient is stabilized, treatment is individualized by treating the underlying cause, if identified, and providing supportive care, such as repeated thoracocentesis and a low-fat diet. A supplement called rutin has shown benefit in some cases [29]. In certain cases of idiopathic chylothorax, a thoracic duct ligation may be indicated to redirect the lymph flow and decrease the rate of chyle accumulation. In addition to thoracic duct ligation, a pericardiectomy can be performed to reduce pressure on the right side of the heart. Treatments for chylothorax are individually based, and many procedures do not go without risk of significant complications. Patients with uncontrolled or untreated chylothorax are at a high risk of developing fibrosis of the pericardium and/or pleural space, resulting in further complications.

Other types of pleural fluid accumulation include hemorrhage (hemothorax), neoplastic effusion, or exudates secondary to FIP. Hemothorax can be a result of trauma, coagulopathy, or neoplasia. Neoplastic effusions can result from metastasis of primary neoplasia or primary pulmonary neoplasms. FIP is a common infectious disease resulting in pleural effusion. The classic features of FIP effusion are a straw-colored clear fluid with a high protein content. See Chapter 23: "Infectious Diseases," for further information on FIP.

25.7 Diagnostic Techniques

25.7.1 Bronchoalveolar Lavage

Indications: diagnosis of lower airway disease. This procedure can be performed with the assistance of a bronchoscope or "blind" (i.e., without the assistance of a bronchoscope). Samples should be submitted for cytology, culture and sensitivity, and infectious disease PCR.

See Figure 25.9 for supplies needed for a bronchoalveolar lavage.

Procedure:

1. Induce the patient into a light plane of anesthesia and intubate with a sterile endotracheal tube.
2. Measure the distance from the last rib to the adaptor of the endotracheal tube for an estimation of length for catheter advancement.
3. Introduce a sterile red rubber catheter gently through the endotracheal tube into the lower airway to prevent iatrogenic pneumothorax.
4. Infuse 5 ml of sterile saline, then rapidly remove the contents by aspirating back repeatedly on the plunger of the syringe. Within the syringe, surfactant (white, foamy material) should be noted.
5. Step 3 can be repeated up to three times to obtain an appropriate sample volume [17].
6. Patients should recover from anesthesia while being supplied with supplemental oxygen and their oxygen saturation continuously monitored until they are fully recovered.

25.7.2 Thoracic Auscultation

Once the preferred stethoscope has been chosen, finding the optimal environment for thoracic auscultation is key for success. An optimal auscultation environment consists of a quiet space with reduced background noise. Ideally this location would be low stress for the patient to obtain the most accurate result. The stability of the patient or surrounding circumstances may preclude the veterinary technician from finding the optimal location, requiring auscultation to be performed where the patient is currently located.

Interfering noises from the patient's haircoat, motion, or vocalization (meowing, purring, growling) should be considered during auscultation to assess thoracic sounds. Stopping a cat from purring can be challenging. One study demonstrated that the best methods to stop a cat from purring are running tap water, blowing in the cat's ear, or spraying an aerosol near the cat. In the same study, 7% of cats did not stop purring despite the methods described above [30, 31].

Auscultation should be performed while the patient is in a standing position with bilateral auscultation starting near the base of the heart then moving in all directions (cranial, caudal, dorsal, and ventral) to assess each lung lobe. In each

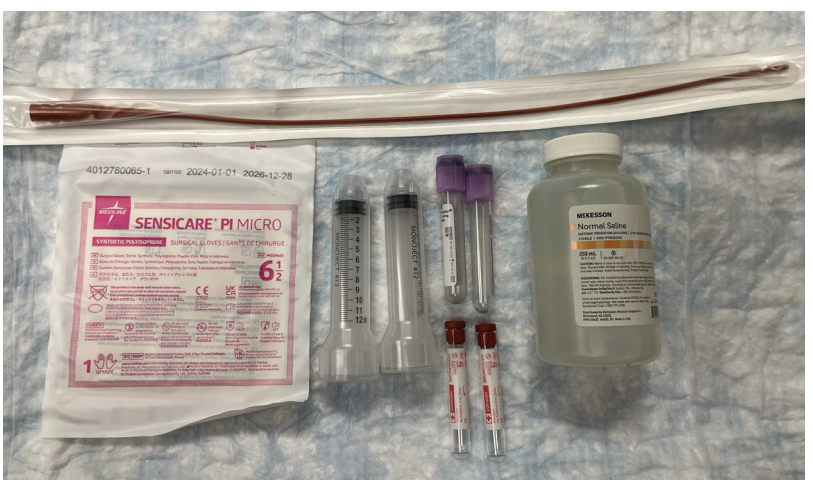


Figure 25.9 Supplies needed for a bronchoalveolar lavage: 8 FrFrench red rubber catheters (size can be adjusted depending on patient size), sterile gloves, 10–12 ml syringes (2–3), sterile saline (0.9% NaCl, bottle size can be adjusted dependent upon availability), sample collection supplies (exact sample collection supplies can be adjusted depending on diagnostic test submissions, check sample requirements with the laboratory). *Source:* Paula Plummer.

location, inspiratory and expiratory sounds should be assessed. To conclude the exam, the trachea should be auscultated to assess for the presence of upper airway noise. See Table 25.2 for a description of respiratory sounds.

25.7.3 Thoracocentesis

Indications: To remove fluid or air from the pleural cavity due to hemothorax, chylothorax, other pleural effusion, or pneumothorax. Fluid removal from the pleural space can be considered diagnostic or therapeutic in nature.
Supplies Needed: clippers, surgical preparation supplies, sterile gloves, a local anesthetic (optional), an instrument to remove fluid/air (large bore IV catheter, butterfly catheter, another item), three-way stopcock (optional), syringe (size dependent on the goal of thoracocentesis), fluid extension set (optional), collecting bowl, ultrasound, flow by oxygen (if indicated), patient analgesics and sedation.

Procedure:

1. Administer the ordered analgesics and sedation to the patient.
2. Place the patient in sternal or lateral recumbency.
3. Clip a large area on the lateral chest between the 7th and 9th rib spaces.
4. Administer local anesthetic (optional).
5. Identify the fluid location with an ultrasound.
6. Prepare the shaved site with surgical preparation supplies.
7. Assemble semi-closed collection system.
8. Insert the thoracocentesis device at the cranial aspect of the 7–9th intercostal space.
9. Advance the device slowly into the pleural space dorsally to obtain air and ventrally to obtain fluid.
10. Attach the collection device and syringe.
11. When removing fluid, collect a small amount for cytology and/or culture, and submit it for diagnostic testing when applicable.
12. Continue removing contents until negative pressure is achieved.

The respiratory patient in crisis often presents to the veterinary hospital, requiring prompt, stress-free care from the veterinary team. The veterinary technician will continuously observe and monitor these patients while being their advocate. Recognition of respiratory distress, quick responses, and understanding procedure risks and potential triggers are the mainstays of patient advocacy for the respiratory patient.

See the companion website for further clinical references.

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26

Urinary and Renal

Rhonda South-Bodiford, LVT, VTS (SAIM)

TECHNICIAN TIDBITS

- Blood work changes do not begin until greater than 75% of the renal nephrons are lost or injured.
- 20–40 ml/kg/day is the normal urine output for a cat [1].
- A cat with dehydration and a urine specific gravity (USG) greater than 1.035 has ample renal function.
- USG should be evaluated prior to fluid therapy.
- A urinalysis (UA) should be performed immediately after collection to ensure an accurate assessment of crystalluria due to crystal formation as the sample cools. Refrigerated samples must be warmed to room temperature before analysis.
- An otoscope cone can be used to see the urethral orifice in a female cat making it easier to pass a urinary catheter.
- Discard the first few milliliters of urine when collecting the sample from a urinary catheter as it may contain detritus carried into the bladder by the catheter.
- Lidocaine gel can be used on the tip of the urinary catheter to offer some local anesthetic benefits.
- The supernatant can be used for the dipstick analysis once the cloudy or bloody urine sample has been centrifuged.
- The normal cat kidney size is 2.5–3.5 times the length of vertebrae L2 on a right lateral radiograph and 3–4.3 cm on an ultrasound.
- Post-obstruction diuresis is common following correction of a urethral obstruction.
- Normal cat urine pH is 5.5–7.5.
- Higher USG valves are more common in urine samples obtained in the morning than those obtained in the evening.

At the beginning, the urinary tract consists of the kidneys, which are bean-shaped, reddish brown in color, and covered by a fibrous capsule. They are held in place by connective tissue. There are three major components of the kidneys: the cortex, the medulla, and the renal pelvis. The cortex starts the process of urine formation and filters blood. The medulla concentrates the urine, and the renal pelvis is responsible for collecting urine before it exits the kidneys and goes into the urinary bladder. The urinary bladder is a balloon-shaped reservoir in the caudal abdomen and is held in place by several ligaments. The urethra is responsible for ushering urine outside the body and is connected to the neck of the urinary bladder [1].

Urine is formed and concentrated by blood being filtered through the nephrons in the kidneys. The nephrons are made up of the glomerulus, Bowman's capsule, proximal tubule, loop of Henle, distal tubule, and collection ducts. The nephron is the kidneys' basic function unit and cats have about 200 000 nephrons per kidney. The kidneys receive approximately 25% of the cardiac output that makes them susceptible to injury from hypotension and hypertension.

The kidneys are responsible for toxin removal, water conservation, blood pressure (BP) regulation, red blood cell (RBC) maintenance, protein conservation, drug processing, pH balance, calcium-phosphorous balance, sodium-potassium balance, and maintaining homeostasis [2] (Figure 26.1).

26.1 Patient History and "History Gathering Questions"

Cats with renal disease often exhibit polyuria (PU), polydipsia (PD), anorexia, gastrointestinal disturbances, weight loss, and poor coat quality. Cats with lower urinary tract disease or disorders exhibit hematuria, dysuria, stranguria, pollakiuria, or urinary incontinence. History from the owner should include frequency and volume of water intake, and characteristics of the cat's urination such as ease of urination, color, quantity, and frequency of urination. Questioning

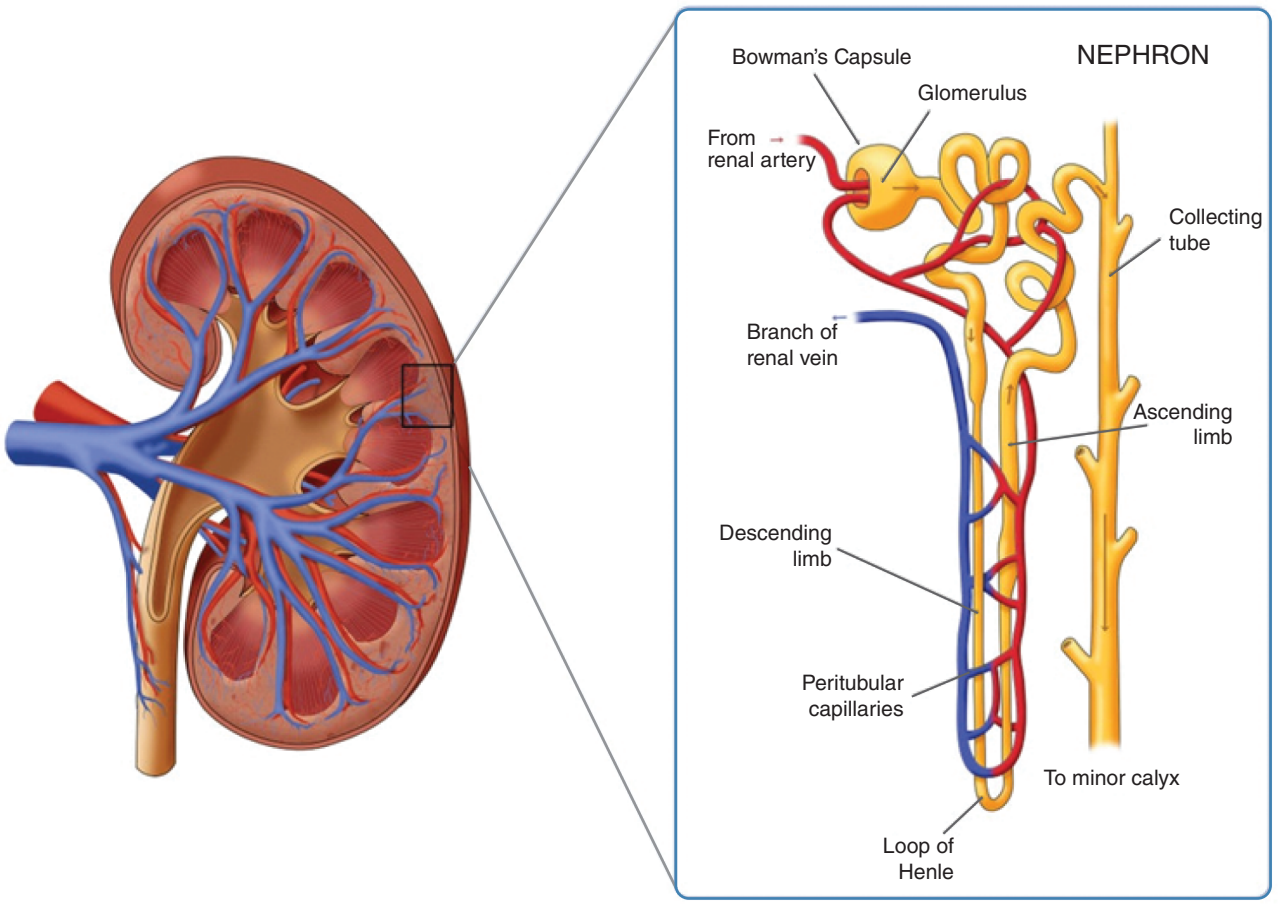


Figure 26.1 Kidney and nephron. *Source:* Wiley Media Manager.

the owner about the observation of stranguria, dysuria, and pollakiuria will complete the history-gathering question for the renal or urinary patient.

26.2 Clinical Signs

Upper and lower urinary tract disorders can produce nonspecific clinical signs. Clinical signs can include an elevation of blood urea nitrogen (BUN) and creatinine serum levels as well as electrolyte disturbances and anemia. The cat can exhibit PU, PD, anorexia, gastrointestinal disturbances such as vomiting and diarrhea, cachexia, weakness, poor hair coat quality, low specific gravity, proteinuria, hypertension, stranguria, dysuria, hematuria, pollakiuria, and anuria. The cat should be monitored for proteinuria, metabolic acidosis, and dehydration [1]. For specific clinical signs of each disease, see the "Renal and Urinary Diseases" section of this chapter.

26.3 Physical Examination Findings

Physical exam findings in a cat with upper and lower urinary tract disorders may include weight loss, poor quality hair coat, painful abdomen, small or enlarged kidneys, firm full bladder, thickened bladder wall, weakness, anorexia, and hypertension. Stranguria and hematuria may also be noticed during the physical exam if the patient is experiencing a lower urinary disorder [1]. For specific physical examination findings of each disease, see the "Renal and Urinary Diseases" section of this chapter.

26.4 Specific Nursing Care Considerations

Special nursing care considerations include correction of dehydration and electrolyte disturbances by the administration of fluid therapy, monitoring BP, and addressing pain and nausea. Nutritional considerations should also be provided. Feeding diets that support patients with renal compromise, such as those low in sodium and protein for renal disease, or urinary diets for cats with lower urinary tract disease. A feeding tube may be considered for cats that are chronically anorexic. Treatment for anemia may be needed as well. Urinary catheter placement may be needed for lower urinary tract disorders. The urinary catheter should be kept sterile and cleaned every 4 hours with betadine or diluted chlorhexidine solution. The patient should be monitored for discomfort, infection, or other complications. The cat should wear an Elizabethan collar to protect the urinary catheter from being chewed or dislodged. Color and amount of urine should be monitored as well.

Hypertension is the sustained increase in systemic arterial BP and can be primary or secondary in origin. Primary hypertension is referred to as idiopathic hypertension and occurs when there is not an identifiable cause. Secondary hypertension is the most common cause of hypertension in cats and occurs when there is a clinical disease, condition, or medication such as glucocorticoids and mineralocorticoids that contribute to the hypertension.

Sustained hypertension will result in injury to vital organs, such as the eyes, kidneys, heart, and brain; this is referred to as end-organ damage. Sustained hypertension can have an effect on the glomerular capillary beds leading to injury and loss of nephrons that is manifested as glomerular atrophy, proliferative glomerular nephritis, and glomerulosclerosis. With preexisting renal disease, this damage will increase the decline in renal function and can lead to proteinuria.

Regardless of age, a routine BP measurement should be a part of any physical examination, especially for those with underlying diseases such as chronic renal failure, acute renal failure/injury, diabetes mellitus, or a history of epistaxis, deranged mentation, sudden blindness, and in cats on prescribed medication that is known to affect BP.

Variability in results can be associated with factors, such as BP instrumentation, the cat's personality, body condition score, breed, age, health status, and its tolerance to being handled and restrained. Diagnostics for hypertension include serial BP, complete blood count (CBC), serum biochemistry panel, UA, thoracic and abdominal radiographs, and testing for endocrine disorders. Once developed, hypertension will accelerate injury to the kidneys, causing a vicious cycle of glomerulosclerosis that causes increased vascular resistance and further loss of nephrons that further exacerbates the development of hypertension associated with renal disease.

The normal BP range for a cat using a Doppler device is 140 mm HG systolic. A series of 5 to 10 consecutive systolic BP measurements should be taken and averaged. Systolic pressures are the most important determinant of hypertension tissue damage. When using a Doppler device only the systolic BP should be recorded (Figure 26.2). Refer to the "Diagnostic Techniques" section in Chapter 14: "Cardiology/Cardiovascular Diseases" to review the process of obtaining a Doppler BP. In addition to the BP readings, the cuff size and the cat's stress level should be documented for future reference [1, 3, 4] (Table 26.1).

26.5 Renal and Urinary Diseases

26.5.1 Chronic Kidney Disease

The most common renal disorder in cats is chronic kidney disease (CKD) [1]. It refers to kidney damage or decreased renal function that has persisted for at least 3 months or more. Kidney disease, kidney insufficiency, kidney failure, azotemia, and uremia are all terms used to describe disorders of the kidney, but CKD is the preferred term. CKD refers to an irreversible and progressive loss of kidney function.

Although there is no definitive cure for CKD, treatment can improve and prolong the lives of cats with CKD. Therapy is geared toward minimizing the buildup of toxic waste products in the bloodstream, maintaining adequate hydration, correcting electrolyte imbalances, supporting appropriate nutrition, and controlling hypertension to help slow the continuance of renal disease.

Dietary modification is an important and proven aspect of CKD treatment. Therapeutic diets that are restricted in protein, phosphorous, and sodium content and high in water-soluble vitamins, fiber, and antioxidants may prolong life and improve the quality of life in cats with CKD. Decreasing urinary protein loss, controlling hypertension, and addressing anemia are important objectives in cats that develop these conditions.

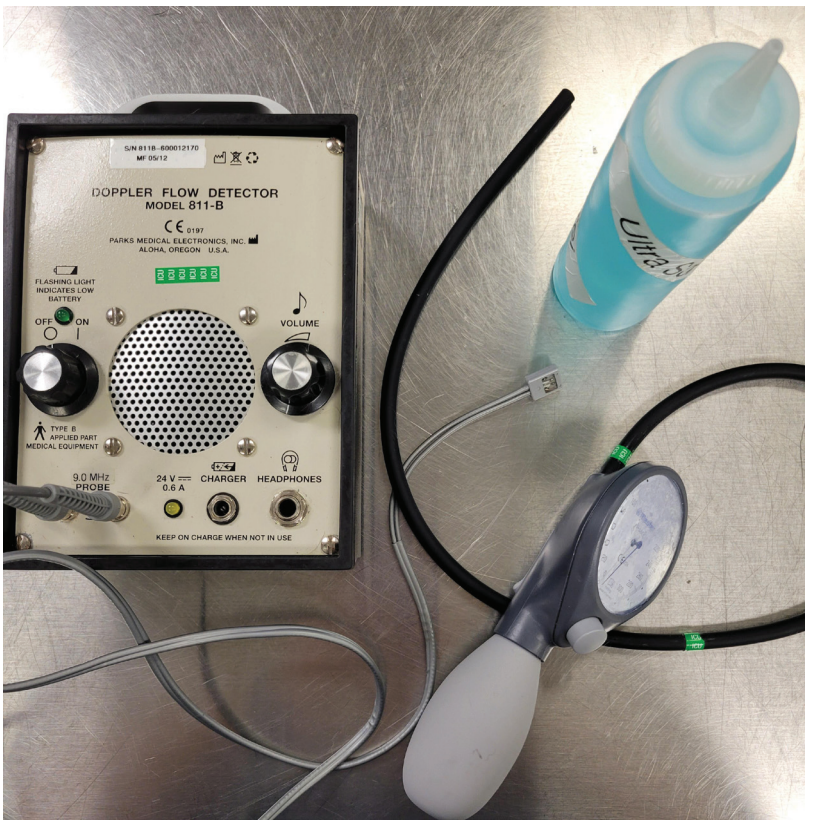


Figure 26.2 Doppler. *Source:* Rhonda South-Bodiford, LVT, VTS (SAIM).

Table 26.1 Normal systolic BP.

Hypotensive	<90
Normotensive	90–140
Hypertensive	>170–180

Hypertension is usually controlled with oral medication, and urinary protein loss may be treated with angiotensin converting enzyme (ACE) inhibitors. Anemia in a cat with CKD may be treated by erythropoietin replacement therapy that stimulates RBCs production. Cats with CKD may produce less erythropoietin, and there is some evidence that replacement therapy can increase the RBC count. Blood transfusions may be needed in some cases to help restore normal RBC concentrations.

Phosphate binders, potassium supplementation, antioxidant supplementation, and administration of intravenous or subcutaneous fluids are systemic therapies that have the potential to aid cats with CKD. Hemodialysis and kidney transplants may also be beneficial in some cats with CKD but are cost-prohibitive.

The earlier the diagnosis with initiation of treatment, the greater the outcome with respect to quality of life and survival will be for the patient. Unlike acute renal failure (ARF) or acute renal injury (AKI), cats with CKD have already sustained permanent damage to the kidneys due to exceeding the maximal capacity of compensatory glomerular hypertrophy. Renal function declines over several months to years as the kidney damage continues.

CKD clinical signs include weakness, weight loss, inappetence, depression, halitosis, diarrhea, vomiting, dehydration, hypertension, PU, and PD. There are many causes of CKD including genetics, congenital, urinary obstructions, autoimmune disease, cysts, toxins (e.g., lily toxicosis), and diseases like leptospirosis.

PU and PD normally exist concurrently. Normal urine output is 20–40 ml/kg/day for a cat. PU occurs when the urine output is greater than normal. PD is an increase in water intake > 80–100 ml/kg/day. Endocrine disorders and renal insufficiency are more common than primary PD conditions such as psychogenic PD [1]. Output that falls below the normal level (20–40 ml/kg/day) can be described as oliguria [1]. Anuria describes no urine output. CKD, AKI, ARF, bilateral ureteral obstruction, or urethra obstruction can cause oliguria and anuria.

Diagnostics include CBC, serum biochemistry panel, UA, symmetric dimethylarginine (SDMA), abdominal ultrasound, abdominal radiographs, and BP. Azotemia describes the blood work changes and elevations in BUN and creatinine. Clinical signs associated with declining renal function are described as uremia [1, 5, 6].

Often the initiating cause of CKD cannot be identified. However, potentially treatable diseases are pyelonephritis, obstructing kidney or ureteral stones, lymphoma, and glomerular disease. Therapy should be directed toward the underlying cause when possible. It may not reverse the existing damage, but it may help slow further kidney damage. The loss of capability to concentrate on urine occurs when more than 66% of the kidney function has been lost. BUN and creatinine will start to increase when 75% of the kidney function is lost.

The International Renal Interest Society (IRIS) (http://www.iris-kidney.com) has proposed a four-tiered system for staging CKD to better determine a cat's prognosis and treatment. Staging is determined by the level of kidney function, particularly creatinine and clinical status. Stage 1 includes PU and PD with normal creatinine and possible increased BP. Stage 2 includes PU and PD with mild changes in blood work and possible hypertension. Stage 3 includes weight loss, vomiting, anorexia, PU, PD, and hypertension. These signs improve with systematic treatment. Stage 4 includes difficulty controlling symptoms regardless of treatment. Hypertension should be monitored, and the cat observed for hyphemia, sudden blindness due to retinopathy and retinal detachments, lethargy, and weakness. These signs progress rapidly when a cat is in stage 4. Evaluating the quality of life in these cats is important. Gastric ulceration, vomiting, halitosis, diarrhea, intestinal bleeding, weight loss, muscle wasting, tremors, and hypothermia with advanced stages of CKD. Neurological signs of CKD may include difficulty walking, stumbling, altered mentation, lethargy, and seizures. Cats with hypokalemia due to their kidney disease may manifest cervical ventroflexion and plantigrade stance (Table 26.2).

Other clinical signs may include muscle tremors, cramps, weakness, and pain. If anemia occurs, the cat may exhibit pale gums, lethargy, and anorexia. Changes in the phosphorous and calcium balance can lead to renal secondary hyperparathyroidism, especially in young cats.

Hyperparathyroidism secondary to renal disease is caused by retained phosphorous in the blood as renal function declines because it induces the production of parathyroid hormone (PTH). It often starts before phosphorous levels rise outside of the normal range. PTH causes the release of calcium from the bone, aids in the reabsorption of calcium from the renal tubules, and increases the absorption of calcium from the intestines.

Declining calcitriol levels play a vital role in the development of impaired intestinal absorption. The combination of hyperphosphatemia and increased calcium absorption leads to the formation of calcium phosphorous crystals in soft tissues

Table 26.2 Kidney disease staging.

Stage	Blood Creatinine (μmol/L) (mg/dl)	SDMA (μg/dl)	Comments
At risk	<140 <1.6		Suggests the cat is at an increased risk of developing CKD in the future because of several factors (such as exposure to nephrotoxic drugs, breed, high prevalence of infectious disease, or old age).
1	<140 <1.6	<18	Nonazotemic. Some other renal abnormalities are present such as inadequate urinary concentrating ability without identifiable nonrenal cause, abnormal renal palpation or renal imaging findings, proteinuria of renal origin, abnormal renal biopsy results, and increasing blood creatinine concentrations.
2	140–250 1.6–2.8	18–25	Mild renal azotemia. Clinical signs are usually mild or absent.
3	251–440 2.9–5.0	26–38	Moderate renal azotemia. Many clinical signs may be present.
4	>440 >5.0	>38	Increasing risk of systemic clinical signs and uremic crises.

such as the liver and stomach, joints, and vessels. Uremic toxins accumulate as renal function declines. Uremic toxins limit the effectiveness of calcitriol to inhibit PTH secretion. The most active form of vitamin D is calcitriol in the renal tubular cells. PTH production promotes the formation of calcitriol, and in return, it reduces the PTH secretion through a negative feedback system. Increased phosphorous levels reduce the formation of calcitriol in the renal tubes. Without the negative feedback of calcitriol, PTH levels rise, leading to renal secondary hyperparathyroidism. As CKD progresses, there are fewer renal tubular cells to produce calcitriol leading to further increase in PTH.

Clinical signs include dullness, lethargy, weakness, anorexia, and impaired muscle function. This manifests more severely in younger cats. Changes in bone density are more frequently observed, and the bones of the skull and mandible are affected. This can lead to softening of the mandible causing freely moving teeth and rubber jaw. In severe cases, distortion of the face and jaw fractures may also be seen due to the growth of fibrous tissue where the bone has been reabsorbed [1, 6, 7].

26.5.2 Acute Renal Failure

ARF or AKI is the rapid loss of renal function leading to the accumulation of nitrogenous waste, fluid imbalances, and electrolyte disturbances. Important disruptions in kidney function may be signaled by even a mild elevation in creatinine. Unlike CKD, ARF is potentially reversible either by resolution of the injury, by adaptation of the kidney, or by both processes. Renal azotemia can be categorized as prerenal, renal, and post-renal. These categories can overlap in some cats.

Very concentrated urine and insufficient blood flow to the glomeruli prevent adequate filtering and removal of uremic toxins causing a rise in BUN and creatinine to occur with prerenal azotemia. A few disorders that can reduce perfusion to the kidneys are dehydration, hypotension, anesthesia, trauma, surgery, and shock. Perfusion is best restored by restoring normal BP and replenishing the fluid volume.

Injury to any part of the kidney results in renal azotemia. Most cases of renal azotemia are caused by decreased perfusion, medications, toxins, or infections [1]. Perfusion issues arise for the same reason as prerenal azotemia but are usually more severe and occur for a longer period. Toxins, including things like lilies and some medications, can accidentally injure the kidneys. The renal tubules are particularly sensitive to the adverse effects of medications, such as nonsteroidal anti-inflammatory drugs (NSAIDs), amikacin, chemotherapy drugs, gentamicin, and diuretics. Infectious causes include pyelonephritis, Lyme disease, and leptospirosis.

The bacteria *Leptospira interorgan* causes Leptospirosis, which has a proclivity for inducing hepatic and renal injury. It is acquired from slow-moving or standing water, wildlife such as raccoons, skunks, and opossums, carry the bacteria by shedding it in their urine, but food, soil, and bedding have also been shown to be a source of the disease. The bacteria induce kidney injury by colonizing and multiplying directly renal tubules and interstitium in addition to the direct toxic effect on the renal cell and secondary inflammation.

The most common postrenal azotemia is from obstruction or rupture of the urinary tract, uroliths are crystalline sludge, which may obstruct the urethra or ureters [1, 6]. This will cause backflow pressure on the kidneys, reducing glomerular filtration. If the obstruction is long-standing, then direct renal damage or renal azotemia may occur. Neoplasia, especially in the lower urinary tract, may also lead to obstruction. Rupture of the urinary tract permits the leakage of uremic toxins into the abdomen and surrounding tissues, quickly entering the bloodstream. Although glomerular filtration continues, treatment consists of relieving the obstruction or rectifying the rupture.

With the initial stages of ARF, the cat may seem completely normal and exhibit no clinical signs. The cat often becomes anorexic and begins to vomit as the injury and uremia progress. Lethargy, diarrhea, and weakness are common clinical signs noted at this time. The cat may initially be polyuric, but oliguria or anuria may develop as the severity of the insult increases. With toxic ingestion, neurological side effects such as seizures and confusion may also occur. Oral ulceration and halitosis are noted with severe azotemia. Renomegaly and kidney pain may be noted on abdominal palpation. Bradycardia occurs particularly with severe hyperkalemia; a large painful bladder may be present in case of obstruction.

26.5.3 Urinary Tract Infection

Urinary tract infections (UTIs) will generally arise from ascending bacteria and other organisms into the urinary tract from the skin or tissues surrounding the external urinary opening. UTIs are more frequently identified in females due to the urethra being shorter and predisposing the patient to ascending infections; the vestibule and the vagina also have a resident population of bacteria in proximity to the urethra. Cats greater than 10 years old are at a higher risk. Bacterial infections

are more common than viral or fungal organisms. Gram-negative organisms such as staphylococcus, streptococcus, and enterococcus are the most common cause of most UTIs [1, 6]. The normal defense averse to infections includes concentrated acidic urine, normal commensal bacterial population inhibiting the distal urinary tract, frequent normal volume urinations, complete bladder emptying, and antibacterial secretions known as defensins, in the urinary tract.

UTIs are categorized as complicated or uncomplicated. Uncomplicated UTIs occur in cats that lack structural, neurological, or functional abnormalities that may make them more susceptible to infections. The majority of uncomplicated UTIs can be successfully treated with 10–14 days of appropriate antibiotics [1, 8]. Improvement is usually seen within the first few days after starting antibiotics. Complicated UTIs occur in cats with underlying diseases that make them more predisposed to infections such as diabetes mellitus and CKD. Four–six weeks of antibiotic therapy is necessary and multiple antibiotics may be required.

A relapsed infection is a UTI caused by the same organism within days to weeks after finishing the antibiotics. Reinfection is another UTI following the initial infection but with a different organism. Superinfection occurs in cats that are already on antibiotics for a UTI when a second infection with a different organism occurs. Cats with indwelling urinary catheters are more prone to superinfections.

Symptoms of UTIs include pollakiuria, hematuria, stranguries, inappropriate urination, foul odor, or cloudy urine, and frequent liking of the perivuluar or prepuce area. Treatment for relapsed and superinfections can be the same as complicated UTIs.

26.5.4 Polycystic Kidney Disease

Polycystic kidney disease (PKD) is most common in Persian and Persian crossbred cats. It is an autosomal dominant condition, and afflicted cats develop fluid-filled cysts in the renal parenchyma; cysts compress the normal renal tissue as they enlarge. Continuous disease causes parenchymal compression and consequent interstitial nephritis eventually resulting in renal failure.

Clinical signs are due to renal failure and can take years to evolve. Cats with PKD are predisposed to develop UTIs because cysts can serve as a hotbed for bacterial growth. Clinical signs include PU, PD, inappetence, weight loss, vomiting, and weakness. Renomegaly and irregular surfaced kidneys in severely afflicted cats can feel like a cluster of small grapes. In the early stages, changes in the renal structure are likely to be the only abnormal physical examination finding, whereas a late stage may reveal signs consistent with chronic renal failure, poor body condition, pallor, dehydration, weakness, uremic breath, and oral ulceration consistent with decompensated renal failure. Retinal detachment or renal hemorrhage may be seen in cats with concurrent systemic arterial hypertension.

Diagnostically, there are no blood or urine abnormalities that are specific for PKD, serum biochemistry and UA are unremarkable in otherwise healthy cats before renal insufficiency occurs usually between the ages of 3 and 10 years old with an average onset of 7 years old. Cultures of the cyst fluid may be needed to confirm infection [1, 5]. Ultrasound examination of the kidneys can be used to detect PKD. Cats with kidneys that feel irregularly marginated on physical examination should be screened for PKD. Treatment for PKD includes treatment for renal insufficiency. Most cats will live a normal life until signs of renal failure develop.

26.5.5 Pyelonephritis

Pyelonephritis is an infection of the renal pelvis that results in more severe symptoms when compared to classic lower UTIs and treatment is often more complex. It results from ascending bacterial urinary bladder infection but hematogenous spread is possible, particularly in cats with concurrent diskospondylitis or sepsis. *Escherichia Coli* (*E. coli*) is the most common isolated bacteria causing pyelonephritis [1, 9].

Pyelonephritis can be acute or chronic. Acute symptoms include fever, hunched posture suggestive of abdominal pain or discomfort, lethargy, vomiting, malodorous urine, and inappropriate urination may be observed by the owner, PU, and PD. Chronic symptoms include oliguria or anuria suggestive of severe ARF, and large painful kidney(s) on abdominal palpation. Patients do not typically present to the hospital until clinical signs of chronic renal failure (vomiting, weight loss, poor hair coat, kidneys may palpate small and irregular) occur [9].

Diagnostics include a CBC, serum biochemistry panel, UA, urine culture, and sensitivity (MIC = minimum inhibitory concentration) especially if the USG is <1.035. This is important when trying to diagnose diseases and disorders of the upper and lower urinary tract. The normal feline kidney is 2.5–3.5 times the length of vertebrae L2 on a right lateral radiograph and

3–4.3 cm on an ultrasound. Pyelocentesis sample culture and histopathologic findings are necessary for a conclusive diagnosis of pyelonephritis. With ultrasound guidance, fine needle aspirates can be performed and may provide the ideal sample for the culture of the upper urinary tract but are contraindicated in any patient with a UTI, and azotemia or dilute urine should be assumed to have pyelonephritis [1, 9].

Treatment includes antibiotic administration based on culture and sensitivity results for a minimum of 6–8 weeks. *E. coli* is treated with amoxicillin combined with clavulanic acid, urine cultures should be performed every 7–14 days after treatment is initiated to determine antimicrobial efficacy and then re-culture 1 week after the therapeutic course has been completed, fluid therapy as needed, and systematic treatment. Cats should be monitored for relapse infections. Relapse infection will exhibit the same symptoms as the original infection.

26.5.6 Glomerulonephritis

Glomerulonephritis results from immune complex deposition, immunologic mechanisms, or formation of antibodies to glomerular basement membrane components causing glomerular cell proliferation and immunologic mechanisms, and glomerular capillary wall thickening with associated findings of cellular and mesangial matrix proliferation and glomerular basement membrane thickening. Proteinuria is the hallmark abnormality of glomerulonephritis. Progression of the disease and response to treatment can be monitored by serial measurements of the urine protein: creatinine ratio (UPC). Hypoalbuminemia and hypercholesterolemia may occur if nephrotic syndrome develops. Normal UPC ratio is <1 by some doctors and <0.5 by others. A moderately elevated UPC ratio (>1 : <20) is consistent with glomerulonephritis. Nonspecific clinical findings consistent with glomerulonephritis are anorexia, vomiting, weight loss, lethargy, edema, or ascites (rare) secondary to hypoalbuminemia, azotemia, PU, PD secondary to renal failure, hypertension, and hypercoagulability. Evidence of nephrotic syndrome – proteinuria, hypoalbuminemia, ascites or edema, hypercholesterolemia should signal the veterinary technician about the possibility of glomerulonephritis.

Glomerulonephritis is often secondary to another primary disease process, such as bacterial pyoderma or chronic skin inflammation, dental disease (chronic gingivitis), Dirofilariasis, *Ehrlichia* infections, endocarditis, feline leukemia virus, feline immunodeficiency virus, feline infectious peritonitis, and associated conditions such as lymphoma, immune-mediated diseases, neoplasia, pyometra, systemic lupus erythematosus, and pancreatitis. Nephrotic syndrome can alert you to the possibility of glomerulonephritis if proteinuria, hypoalbuminemia, ascites or edema, and hypercholesterolemia are noted [1, 10].

Diagnostics include CBC, serum biochemistry panel, UA, systemic BP, and UPC are recommended. Imaging such as thoracic and abdominal radiographs are used to evaluate for occult infections or neoplasia, and abdominal ultrasound can evaluate morphologic renal disease. Infectious disease testing includes feline leukemia virus, feline immunodeficiency virus, serum coronavirus antibody titers, *Ehrlichia* spp. antibody titers, and *Dirofilaria immitis* serum antibody and antigen testing are indicated.

Definitive diagnosis needs a histologic examination of renal biopsy specimens, renal tissue collection by ultrasound-guided or direct visualization should be used to obtain renal tissue samples. Complications from biopsy sites include excessive bleeding, assessment of platelet count, activated clotting times or other clotting factors, and assessment of arterial BP before the procedure is highly recommended. Without treatment, progression will lead to irreversible damage from fibrin deposition and glomerulosclerosis, and the loss of nephron function leads to renal insufficiency and failure [1, 10].

Treatment includes thromboxane synthetase inhibitors, ACE inhibitors, prostaglandin analogs, and leukotriene antagonists. Dietary omega fatty acid supplements have been used to reduce glomerular inflammation and associated symptoms such as proteinuria and hypertension. BP should be rechecked every 2–4 weeks at the start of therapy. Reduced sodium, protein-restricted diet, and treatment of severe hypertension (systolic pressure >170–180 mmHg). Amlodipine (0.625 mg/cat once daily) is a calcium antagonist and is the drug of choice, the ACE inhibitor, enalapril (0.25 mg/kg once daily) or a beta antagonist such as atenolol (6.25 mg/cat once daily) can be added if monotherapy is ineffective. Extreme caution and diligent follow-up are required to monitor for continuing azotemia and renal failure [11].

26.5.7 Feline Amyloidosis

Feline Amyloidosis is a deposition of fibrillar proteins in various tissues and is usually secondary to some infectious, inflammatory, or neoplastic disease process. This disease affects the medulla of the kidney, due to amyloid deposits in the kidney resulting in medullary fibrosis and papillary necrosis. Amyloid deposition is interstitial in the cat sparing the

glomeruli. Feline amyloidosis is considered rare in cats; however, Abyssinian, Siamese, and Oriental Shorthair breeds have increased incidences of amyloidosis. Diagnosis includes a renal biopsy, and treatment is typically systemic, as most cats are in renal failure by the time of diagnosis.

Cats are usually quite sick and are often uremic with nonregenerative anemia, hyperphosphatemia, metabolic acidosis, isosthenuric, and proteinuric. Siamese and Oriental Shorthair breeds with concurrent amyloid deposits in the liver may lead to rupture and severe acute hemorrhage. Amyloid deposits interfere with the blood supply (vasa recta) to the renal medulla resulting in papillary necrosis. The progressive loss of nephrons leads to renal failure and uremia [1, 12].

Cats with chronic protein-losing nephropathy (PLN) have weight loss, moderate to severe proteinuria, and hypertension. Thromboembolic disease or blood clots are the most life-threatening complication of this disease. Blood clots to the brain or lungs are a common cause of death in cats with PLN disease. Edema occurs when the albumin is less than 1.5 g/dl. Pitting edema may occur on the distal limbs, ascites, dull and thin hair coat, and muscle wasting, whereas weight loss, retinal detachment, and blindness can occur in the most severe cases. It carries a grave prognosis.

26.5.8 Lower Urinary Tract Disorders

Lower urinary tract disorders are often present with a combination of clinical signs including pollakiuria, stranguria, and dysuria. These clinical signs can be indicative of many disorders that affect the bladder and urethra, including lower UTIs, urethral obstruction, neoplasia, and feline idiopathic cystitis. Hematuria can develop from upper and lower urinary tract disorders.

26.5.8.1 Feline Idiopathic Cystitis

Feline idiopathic cystitis (FIC) is a feline lower urinary tract disease, a disorder of young to middle-aged cats that results in clinical signs of pollakiuria, dysuria, and stranguria; the etiology of this syndrome is not fully understood making it difficult to treat. Diagnostic testing includes a CBC, serum biochemistry panel, UA, culture, and sensitivity to rule out a UTI, abdominal radiographs, and ultrasound to rule out uroliths and neoplasia.

Treatments include feeding canned food to increase water intake and reducing stress by increasing water intake. The USG is decreased, potentially diluting noxious substances present in the urine. Reducing environmental stress and increasing water intake are two of the multimodal environmental modification strategies that decrease the recurrence of FIC [13]. See Chapter 5: "Client Education and Communication Topics for the Feline Owner," and Chapter 17: "Emergency and Critical Care," for further information on FIC.

26.5.8.2 Uroliths

Uroliths, calculi, or stones in the urinary tract result from the supersaturation of urine with stone-forming substances or crystalline components. The most common place for uroliths to form is in the bladder, since urine is stored there for a lengthy period. This gives the components more time to interact with one another. The kidneys are another frequent location for urolith formation. The higher the concentration of urolith components and the longer they are in contact with one another, the greater the risk of stone formation (Figure 26.3).

Uroliths form around a nidus, which can consist of white blood cells (WBCs), bacteria, organic matter, or crystals. The center of the urolith may be made up of different crystals than the rest of the stone. Uroliths can grow quickly layer by layer or rapidly when larger crystals come together and cluster together. Other factors of urolith formation are diet, frequency of urination, genetics, current medications, and the presence of a UTI. Crystals and uroliths can be prevented or dissolved by increasing urine flow and minimizing the components that form a urolith. Certain components of the urine inhibit the formation of crystals and uroliths such as organic proteins or

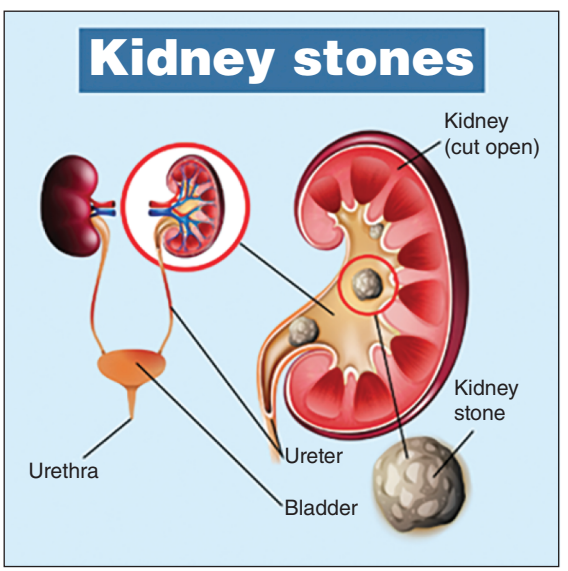


Figure 26.3 Kidney stones. *Source:* Wiley Media Manager.

inorganic minerals. Cats with bladder or urethral stones tend to manifest with signs of lower urinary tract disease, such as stranguria, pollakiuria, and dysuria. Hematuria, malodorous urine, and inappropriate urination may be signs seen by the owner.

Cats can present for a complete urinary obstruction (anuria) or bladder rupture, lethargy, vomiting, hematuria, and a bloated abdomen especially a urolith lodges in the urethra. Bladder and urethral obstruction symptoms can vary widely (Figure 26.4).



Figure 26.4 Urolith. *Source:* Wiley Media Manager, Steve Sant/Alamy Stock Photo.

Struvite uroliths are formed primarily of magnesium, ammonium phosphate, and smaller amounts of calcium phosphate. Bicarbonate increases the pH in the urine making struvite formation more likely to precipitate. Urease-producing bacteria have been long thought to be the source of struvite urolith formation because they can hydrolyze urea to form ammonia and bicarbonate. The ammonia precipitates with magnesium and phosphate to form a stone. Frequent use of struvite-preventing diets may be shifting the dynamics toward an increased formation of oxalate uroliths.

Calcium oxalate uroliths form primarily from calcium, oxalate, and varying amounts of calcium phosphate. These uroliths tend to form on the surface of cellular debris in the urine or on other crystals. Nephroliths and ureteroliths are mostly composed of calcium oxalate. Most calcium oxalate uroliths are radiopaque and can be seen in radiographs. Citrate and magnesium are important in the dietary management of calcium uroliths.

Urate uroliths are composed of uric acid and its principal salt, ammonia urate. Urate uroliths are common in the lower urinary tract and in young to middle-aged cats. They occur more frequently in male cats than female cats. They are radiolucent, so they are not readily seen on radiographs. Urate uroliths are not frequently associated with infections but urease-producing bacteria increase the incidence of urolith formation. A diet high in purine and acidic urine increases the formation of uroliths. Severe liver disease and cats with portosystemic shunts are at a higher risk. The liver is unable to convert ammonia to urea and uric acid leading to elevated levels of the substance in the stone.

Other uroliths such as cystine, calcium phosphate, and silica are exceedingly rare. Drugs such as tetracyclines and their metabolites have been known to cause uroliths. There is a strong link between silica uroliths and the consumption of specific dietary ingredients, such as substantial quantities of corn gluten feed, soybeans, intact grain hulls, and whole grains. Water in volcanic areas has also been implicated in the formation of silica uroliths. Feeding a low silica diet or canned food if needed to keep USG less than 1.030. Administration of potassium citrate if the urine pH is consistently less than 6.5 and providing distilled water for the cat to drink if living in areas with volcanic-rich soils.

Cystine uroliths can be found in the kidneys and the ureters in adult cats. They are seen in both male and female cats. The Siamese and domestic Shorthair cat breeds have the highest likelihood of cystine stone formation. Cystine is a nonessential sulfur containing amino acid normally present in low concentrations in plasma. Cystine uroliths are caused by impaired reabsorption of cystine and other amino acids by the renal tubules. Symptoms include hematuria, dysuria, pollakiuria, and/or urethral obstruction. Recommend evaluating urine amino acids.

Calcium phosphate (apatite) uroliths are uncommon in cats and are more often found in the kidneys than in the bladder. Calcium phosphate uroliths occur in cats with hypercalcemia, hyperparathyroidism, and dystrophic and ectopic mineralization of vital tissues (blood clots, urothelium). Monitoring therapy by repeating the UA every 3–6 months to adjust pH to 6.5–7.0, USG to <1.030, and abdominal radiographs every 6–12 months. Feeding a diet mildly reduced in protein and sodium that does not overly acidify the urine will correct the hypercalcemia caused by food. Other therapies, such as medication, prednisone, hydrochlorothiazide (1 mg/kg every 12–24 hours), or parathyroidectomy, may be indicated for highly recurrent stones [1, 7, 8]. See Chapter 17: "Emergency and Critical Care," for further information on lower urinary tract obstruction therapies.

26.6 Diagnostic Techniques

26.6.1 Complete Blood Count

CBC is used to assess for evidence of anemia, dehydration, and inflammation in cats with diseases that primarily or secondarily involve the kidneys or hematuria. It allows assessment of the degree of anemia in cats with severe hematuria or CKD. Nonregenerative, normocytic, normochromic anemia is common in cats with moderate to severe CKD (IRIS stage 3 or 4). Erythropoietin deficiency resulting from irreversible kidney damage, decreased erythrocyte lifespan due to

constant exposure to uremic toxins, circulating inhibitors of erythropoiesis caused by uremia, decreased erythropoiesis from iron deficiency or nutritional abnormalities, hemorrhage due to uremic gastritis, and increased bleeding tendency due to uremic thrombopathy are the principal causes of anemia [1].

Polycythemia can be detected on the CBC and may occur secondary to paraneoplastic syndromes associated with excessive erythropoietin secretion by certain renal neoplasia, such as lymphoma, fibroma, or renal carcinoma. Polycythemia can also be a result of sustained renal hypoxia such as unilateral renal thrombosis.

Leukocytosis, with or without a left shift, plus or minus toxic changes can be seen with infections of the kidneys, such as bacterial or fungal pyelonephritis, or the prostate. An inflammatory leukogram may also be observed with uroabdomen, neoplasia of the urogenital tract or lower urinary tract infections (bladder and urethra), though these conditions do not typically cause abnormalities on the CBC, except in rare cases like emphysematous cystitis with urinary bladder rupture.

Thrombocytopenia may be seen in septic cats, cats with certain infections that may involve the kidney such as leptospirosis, and in cats with renal neoplasia. A CBC is important in ruling out idiopathic or secondary immune-immediate thrombocytopenia as the cause of hematuria.

Supply List

1. Supplies of choice to perform venipuncture (needle or butterfly catheter and syringe)
2. Purple top tube (EDTA)
3. Assistant for handling and occlusion of the vein

Performing CBC

1. Obtain a sample of 3 ml of whole blood and place it in a purple top tube. It can be performed in-house or sent to a commercial laboratory.

26.6.2 Serum Biochemistry Panel

Serum biochemistry panels can be used to assess the degree of azotemia, hypoalbuminemia, and electrolyte imbalances that can occur with renal diseases. Azotemia is an elevation in serum urea and creatinine concentrations that can be used to clinically assess a crude estimate of renal glomerular filtration rate (GFR). Trends in serial BUN and creatinine valves are important in monitoring renal function. Greater than 75% of the kidneys' nephrons are lost or injured before bloodwork changes are seen.

In prerenal azotemia, kidney functions are completely normal. Prerenal azotemia is usually a consequence of reduced renal perfusion such as dehydration, hypovolemia, gastrointestinal tract fluid loss, high protein diets, extensive tissue necrosis, and the administration of certain medications like glucocorticoids. The degree of azotemia will only be mild to moderate in prerenal azotemia (creatinine < 4 mg/dl, BUN <80 mg/dl, and USG > 1.035). If the USG is >1.035 in a dehydrated cat, then it is suggestive of adequate kidney function. If severe prerenal azotemia is not corrected promptly, then decreased renal perfusion may give way to renal ischemia and lead to renal azotemia. ARF, AKI, and/or CKD lead to renal azotemia. It is possible to determine the underlying cause of azotemia by using the hydration status and the USG [1, 5, 6] (Table 26.3).

Table 26.3 Localization of azotemia.

Clinical feature	Prerenal azotemia	Renal azotemia	Postrenal azotemia
Azotemia	Mild to moderate	Mild to marked	Mild to marked
USG	>1.035	<1.035 Often 1.007–1.015	Variable
Physical signs of urinary tract obstruction and/or urinary tract rupture	Absent	Absent	Present
Response to fluid therapy	Azotemia resolves in 1–2 d	Partial or no resolution of azotemia	Complete, partial to no resolution of azotemia

Prerenal and postrenal azotemia may exist simultaneously. The key feature of renal azotemia is that it is accompanied by a USG that is <1.035, although the degree of azotemia can be variable. The USG can be in the isosthenuric range, 1.005–1.015 but not below 1.007. The exception to this includes any cat with a disease that impairs the ability of the kidneys to concentrate the urine leading to polyuria and polydipsia and is associated with diseases such as diabetes mellitus.

Postrenal azotemia occurs when there is interference with the body's excretion of urine because of an obstruction in the excretory pathway that affects both kidneys or a tear or rupture of the excretory pathway such as uroabdomen. If postrenal azotemia is not corrected, then renal damage can occur. Clinical findings typically include a distended turgid bladder, unproductive stranguria, hydronephrosis, or a fluid-filled abdomen [10, 12, 14].

Due to the kidneys' leading role in water balance and electrolyte homeostasis, electrolyte abnormalities are common with diseases that affect the kidneys. These abnormalities may result from gastrointestinal signs, such as vomiting and diarrhea associated with uremia, from the increased loss of electrolytes in the urine due to severe PU and PD, or from anuria that results in a decrease in renal excretion of electrolytes. Common electrolyte abnormalities seen with different disorders affecting the kidneys are hyperkalemia, hypokalemia, hypercalcemia, hypocalcemia, and hyperphosphatemia.

Hyperkalemia can be seen with ARF, AKI, CKD, uroabdomen, urethral obstruction from a tumor, uroliths, or a protein mucus plug. Moderate to severe hyperkalemia can lead to life-threatening cardiac arrhythmias (heart block, asystole, ventricular tachycardia, and ventricular fibrillation) [15].

Hypokalemia, which is common in CKD cats, results from inadequate water intake and increased renal loss resulting in muscle weakness, stiff gait, ventroflexion of the neck, decreased renal responsiveness to ADH, and the possibility of progression of kidney injury. Hypokalemia can also occur secondary to post-obstruction diuresis following the correction of a urethral obstruction. A polyuric response is initiated by the kidneys after the relief of a bladder outlet obstruction.

Hyperphosphatemia is seen with prerenal, renal, and postrenal azotemia and may predispose the cat to metastatic calcification of soft tissue when the product of the serum total calcium and phosphorous is greater than 60.

Severe hypocalcemia is characterized by low ionized calcium. It can be seen with acute renal failure. Mild hypocalcemia with normal, ionized calcium is common in cats with moderate to severe CKD. It can also occur in cats with complete urethral obstruction and may worsen the cardiac effects of hyperkalemia.

Mild hypercalcemia may be seen with prerenal azotemia resulting from dehydration and is also seen in a small portion of cats with CKD. An increase in the total calcium is seen but the ionized calcium is normal. Severe hypercalcemia from other causes can lead to acute or chronic kidney failure and can predispose a cat to calcium-based uroliths.

Hypoalbuminemia, hypercholesterolemia, and possible elevated triglycerides are seen in cats with glomerular disease. When peripheral edema or body cavity effusion accompanies these biochemical changes then nephrotic syndrome exists. Nephrotic syndrome can be seen in the later stages of glomerulonephritis.

It is common with ARF or CKD for a cat to have mild to severe metabolic acidosis. A low bicarbonate concentration on the serum biochemistry panel is expected with metabolic acidosis. The failing kidneys have a limited ability to secrete excess hydrogen ions caused by decreased tubular bicarbonate reclamation and disordered renal ammonia production in surviving nephrons. Chronic acidosis can promote nausea, anorexia, vomiting, weight loss, and protein malnutrition, all of which can be detrimental to the cat [1, 6, 12, 14, 16].

Supply list

1. Supplies of choice to perform venipuncture (needle or butterfly catheter and syringe)
2. Green top tube (lithium heparin) or red top tube
3. Assistant for handling and occlusion of the vein

Performing a Serum biochemistry panel

1. Obtain a sample of 3 ml of whole blood and place it in a green or red top tube depending on the analyzer being used. The sample may need to be spun down in a centrifuge depending on the analyzer or shipping guidelines of the laboratory.

26.6.3 Urine Collection Methods

26.6.3.1 Free Catch

Free-catch samples should be obtained mid-stream due to less bacterial contamination from the urogenital flora. The sample should be collected in a sterile container. False-positive can occur on a urine culture due to contamination from external hairs on the prepuce and vulva. Since mid-stream collection can be difficult on cats, the use of a litterbox with nonabsorbable litter is recommended when a culture is not needed.

26.6.3.2 Catheterization

Urinary catheterization will require sedation or anesthesia in both male and female cats. Discard the first few milliliters of urine when collecting the sample from a urinary catheter as it may be contaminated with debris carried into the bladder. Clip the hair around the prepuce or vulva and gently cleanse the area with a nonirritating surgical cleanser. Wash hands prior to the procedure and don sterile surgical gloves. Place a sterile drape over the genitals to allow for manipulation of the catheter without contaminating it against the cat's fur. The sterile urinary catheter previously selected should be used with a small amount of sterile lubricating gel applied to the tip of the catheter. Sterile lidocaine gel can be used as an alternative if available and may offer some local anesthetic benefits. Urinary catheters should be handled with clean exam gloves after placement to help decrease contamination.

Tom cat catheters are most commonly used to unblock male cats; however, red rubber catheters, small Foley catheters, or Slippery Sam™ catheters are recommended for indwelling urinary catheters. It is important to premeasure the indwelling urinary catheter length to prevent folding or knotting within the bladder.

The male cat is placed in lateral or dorsal recumbency and the prepuce is disinfected, and the penis is extruded and pushed dorsally to straighten the normal curvature of the penis. The catheter is lubricated and advanced into the urethral orifice until urine is obtained.

The female cat is positioned in dorsal recumbency, the tip of the catheter is lubricated and passed slightly dorsal along the ventral floor of the vestibule into the urethral orifice and advanced until urine is obtained. A sterile small cone from an otoscope can be used to help visualize the ureteral orifice [6, 7, 14].

26.6.3.3 Cystocentesis

An optimal, uncontaminated sample for urine culture and sensitivity studies can be obtained by cystocentesis and is considered the gold standard. The procedure is occasionally used as part of a stabilization technique in cats with lower urinary tract obstruction when emergency decompression of the bladder is required, and a catheter cannot be passed. This procedure can be performed on most awake feline patients, provided there are no contraindications such as coagulopathy, pyoderma on the skin of the ventral abdomen, bladder tumor, large uroliths, a suspected devitalized bladder wall secondary to prolonged urethral obstruction, and an uncooperative cat that cannot be manually restrained for the procedure, then sedation or anesthesia may be required.

Position the cat in dorsal or lateral recumbency, clip excess hair from the ventral abdomen, and use an aseptic technique to prepare the area. Use your nondominant hand to locate and isolate the bladder. Using your dominant hand to hold the syringe, insert the needle at an oblique angle directed dorso-caudal through the ventral abdominal wall into the bladder. This technique allows for the tip of the needle to remain in the bladder lumen and decreases the risk of distal aortic laceration. Aspirate 3–10 ml of urine (the preferred amount for testing), release pressure from the plunger on the syringe, and relax your nondominant hand before removing the needle to prevent aspiration of fat and abdominal contents.

Ultrasound-guided cystocentesis requires the cat to be in dorsal recumbency, identifying the probe marker on the screen that will reveal the cranial aspect of the bladder. Place the probe on the caudal portion of the abdomen. Once the urinary bladder is located, insert the needle at a 15° angle under the probe and in the bladder in line with the mark indicating the cranial aspect on the ultrasound probe. Watch the ultrasound screen to confirm that the needle is inserted into the urinary bladder and aspirate urine into the syringe. Stop aspirating before removing the needle from the abdomen.

If the cat begins to move at any time, stop, release pressure on the plunger of the syringe, and remove the needle to avoid complications. If urine cannot be aspirated at first angle of insertion, withdraw the needle. Obtain a new needle and syringe, then palpate and isolate the urinary bladder or locate it with the ultrasound again before inserting the needle. A new needle and syringe should be used with each attempt to minimize the risk of infection from the skin and intestinal bacteria. Always change your needle before placing urine sample into the collection tubes to help prevent any contamination from the collection needle [17].

26.6.4 Urinalysis

A UA is a valuable diagnostic tool that provides insight into the urine. It assesses the physical and chemical properties of urine and is primarily used to evaluate the health of the kidneys and urinary system. It can help to diagnose diabetes mellitus, renal disease, dehydration, hematuria, and UTIs. Urine may be collected in one of three ways mentioned in the previous section of this chapter. Cystocentesis is the gold standard method for collecting urine samples for culture because it prevents contamination of the sample from the urethra or genital tract. The ideal sample for analysis is a

fresh, within 3 hours old, and nonrefrigerated sample. The UA is divided into three parts: physical properties, chemical properties, and sediment.

26.6.4.1 Physical Properties

Normal urine is yellow because of the presence of urochrome pigment. Very concentrated urine may be deep amber in color, whereas very dilute urine may be almost colorless. A red or reddish-brown color usually is caused by RBCs, hemoglobin, or myoglobin, whereas a yellowish-brown to yellowish-green color may be caused by bilirubin; urine containing bilirubin appears concentrated. Normal urine is usually clear. Cloudy urine often contains increased cellular elements, crystals, or mucus. Urine has a normal mild odor due to the presence of volatile fatty acids. The most common abnormal odor is ammoniacal and is caused by the release of ammonia by urease-producing bacteria or a sweet odor caused by ketones.

USG reflects the total solute concentration of urine, and the amount of any substance in urine must be interpreted considering the specific gravity. For example, 4+ protein in 1.010 urine represents more severe proteinuria than 4+ protein in 1.045 urine. Refractometry is the best technique for the estimation of USG. Dipstick methods to estimate USG are unreliable and should not be used. USG should be determined before any treatment because fluids, diuretics, or glucocorticoids may alter the specific gravity (Figure 26.5). USG is defined as the weight of a solution compared with an equal volume of distilled water. It is dependent on the number and molecular weight of the solute particles but has the advantage of requiring only simple, inexpensive equipment for measurement such as a refractometer. Normally, urine is composed of solutes of relatively low molecular weight such as urea and electrolytes. If the urine contains appreciable amounts of larger molecular weight solutes, such as glucose, mannitol, or radiographic contrast agents, these substances will have a proportionally greater effect on specific gravity. The term *isosthenuria* (USG, 1.007–1.015) refers to urine of the same total solute concentration as unaltered glomerular filtrate. The term *hyposthenuria* refers to urine of a lower total solute concentration than glomerular filtrate (USG < 1.007). Although rarely used clinically, the term *hypersthenuria* (baruria) refers to urine of a higher total solute concentration than glomerular filtrate (USG > 1.015). The normal range of total urine solute concentration for cats is wide (USG, 1.001–1.080). Samples obtained in the morning have higher USG values than those obtained in the evening, and urine concentration decreases with age, but there is no effect of sex on USG (Figure 26.6).

26.6.4.2 Chemical Properties

The urine dipstick analysis is a convenient method of assessing several biochemical aspects of urine. The dipstick can be done on a fresh unspun urine sample. If the urine is turbid or bloody, then the sample can be centrifuged, and the supernatant can be used for the dipstick analysis.

Urine pH on the dipstick can measure urine pH in the 5–9 range. The normal cat urine pH is between 5.5 and 7.5. Diet, disease processes, and medications can affect urine pH, so it cannot be interpreted alone. Acidic urine, pH < 5.5, can be caused by a meat-based diet, metabolic or respiratory acidosis, catabolic state, and administration of acidifying drugs such as potassium phosphate. A pH of > 7.5 is caused by old, stored urine, a UTI caused by urease-producing bacteria, exclusive consumption of a vegetarian diet, metabolic and respiratory alkalosis, and medications such as bicarbonate. The pH can influence the solubility of various types of urinary crystals and influence their detection in urine sediment analysis.

Commonly used dipstick methods for protein determination are much more sensitive to albumin than to globulin. For the evaluation of proteinuria, it is critical to localize the origin of the protein loss by history, physical examination, and critical evaluation of the urine sediment. Persistent, moderate to heavy

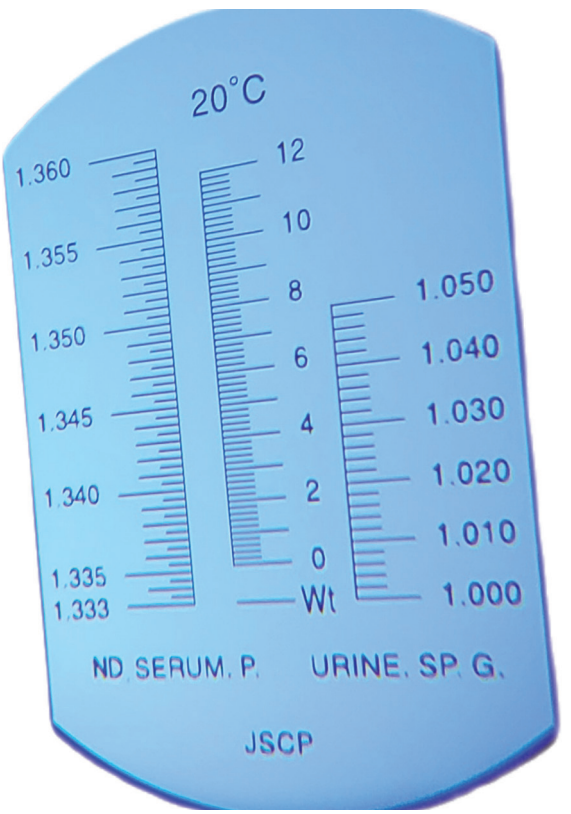


Figure 26.5 Refractometer measurements. *Source:* Rhonda South-Bodiford, LVT, VTS (SAIM).



Figure 26.6 Refractometer. *Source:* Rhonda South-Bodiford, LVT, VTS (SAIM).



Figure 26.7 Urine dipstick. *Source:* Rhonda South-Bodiford, LVT, VTS (SAIM).

proteinuria without urine sediment abnormalities is highly suggestive of glomerulonephritis and glomerular amyloidosis. If the sediment is active and proteinuria is mild to moderate, consider inflammatory renal disease or disease of the lower urinary or genital tract (Figure 26.7).

Glucose in the glomerular filtrate is almost completely resorbed in the proximal tubules and is not normally present in the urine of cats. Glucose will appear in the urine (glucosuria) if the blood glucose concentration exceeds the renal threshold (approximately 300 mg/dl in the cat). Most dip strip kits are a colorimetric test based on an enzymatic reaction (glucose oxidase) specific to glucose. The causes of glucosuria include diabetes mellitus, stress or excitement in cats, administration of glucose-containing fluids, and renal tubular diseases, such as primary renal glucosuria. Glucosuria also may be observed occasionally in cats with chronic renal disease, with tubular injury caused by nephrotoxins.

Ketones are made up of β-hydroxybutyrate, acetoacetate, and acetone, which are the products of exaggerated and incomplete oxidation of fatty acids. They are not normally present in cat urine and are found when there is an increased fatty acid catabolism due to a shift in energy production. The nitroprusside reagent present in dipstick tests reacts with acetone and acetoacetate but is much more reactive with acetoacetate. It does not react with β-hydroxybutyrate. Causes of ketonuria include diabetic ketoacidosis, starvation or prolonged fasting, glycogen storage disease, low-carbohydrate diet, persistent fever, and persistent hypoglycemia. Ketonuria occurs more readily in young cats and, of the causes listed, diabetic ketoacidosis is the most important cause in adult cats.

Cat urine should always be negative for bilirubin. It may occur whenever there is either excessive formation of bilirubin such as with immune-mediated hemolytic anemia (IMHA) or impaired hepatobiliary excretion of bilirubin such as with acute liver failure and biliary obstruction. Bilirubinuria usually occurs before clinical evidence of icterus is noted. Bilirubin is filtered by the glomerulus and the renal tubular threshold for reabsorption is easily overwhelmed leading to increased amounts of bilirubin in the urine.

The urobilinogen dipstick test has questionable value. In theory, complete biliary obstruction is reflected by a negative result but in reality, the dipstick test cannot detect the absence of urobilinogen. Increased amounts can be seen with liver disease or hemolytic anemia, but the correlation is poor.

Occult blood dipstick tests for blood are extremely sensitive but do not differentiate among erythrocytes, hemoglobin, and myoglobin. The test is more sensitive to hemoglobin than to intact erythrocytes. Hemoglobin causes a diffuse color change, whereas erythrocytes cause spotting of the reagent pad. A positive test must be interpreted considering the urine sediment. Most dipsticks can detect between 5 and 20 RBC/ml of urine. False-positive reactions can occur if the sample is contaminated with oxidizing agents such as disinfectants if the urine was collected from a tabletop or floor. A false-negative reaction can occur if the RBCs are lysed in dilute urine (USG < 1.008) or alkaline urine.

Pyuria is more reliable on sediment evaluation than the dipstick test. Active inflammation somewhere in the urinary tract or possibly in the genital tract is indicated by many WBCs in the urine. The test has a high rate of false positives in cats, so it is not considered diagnostically useful.

The nitrates dipstick test is not suitable for use in small animals and is not overly sensitive in cats for the detection of UTIs.

Dipstick USG is not particularly useful because it can only detect between 1.025 and 1.030, which is below the USG cutoff point for adequate renal concentrating ability in cats.

26.6.4.3 Urine Sediment

Urine sediment examination is always done with a centrifuged urine sample. The sample should be centrifuged at 1000–1500 rpm for 5 minutes. The supernatant is then decanted off the sediment. The sediment is resuspended in 0.5 ml of the spun urine. A drop of sediment is then placed on a clean microscope slide and a coverslip is applied over the sample. An unstained urine sample is preferred for examination, but one drop of a commercial sediment stain can be added to a drop of resuspended urine sediment. Both low and high-power fields are recommended for stained and unstained samples [1, 5].

Very few RBCs are in normal urine (0–5 RBCs/hpf) and an increased number indicates hematuria. Comparing samples collected by free catch and cystocentesis may be helpful in localizing the source of bleeding within the urinary tract. Cystocentesis can cause iatrogenic hematuria. A follow-up free-catch UA a few days later can clarify if the hematuria was from the cystocentesis.

Urine sediment normally contains sparse numbers of WBCs (<5 WBCs/hpf). Inflammation is suspected anywhere in the urinary tract when the sediment contains an increased number of WBCs (>5 WBCs/hpf) on a sample collected by cystocentesis. Free-catch samples with pyuria are indicative of inflammation anywhere in the urinary tract or genital tract. Sperm can be seen in the urine of intact male cats.

Normal urine is sterile. Both rods and cocci bacteria must be > 10^4/ml for it to be seen microscopically. The absence of bacteria does not rule out UTI. Bacteria in a free-catch sample or catheterization sample are more difficult to interpret because the bacteria can represent normal flora, but bacteria seen on a sample collected by cystocentesis are significant. To confirm bacteriuria, an air-dried sample of the urine sediment should be stained with a Gram or modified Wright's stain. These staining techniques are better for detecting bacteriuria compared to an unstained urine sediment sample. A sample should be collected by cystocentesis if a UTI is for a culture and sensitivity unless it is contraindicated for that patient.

Usually, contaminants, yeast, and fungi are occasionally seen during the urine sediment examination, especially in free-catch samples.

Supplies List

1. Supplies of choice to perform cystocentesis (3–10 ml syringe, 22–25 g, 0.75–1.5-inch needles depending on the size of the cat and bladder,
2. Supplies of choice for urinary catheter placement – Appropriately sized urinary catheter, 10 –60 ml syringe, sterile surgical gloves, sterile gloves, surgical cleanser, sterile lubricant, lidocaine gel if available, red top collection tubes, and sterile small otoscope cone.
3. Supplies for voided sample (litterbox, and nonabsorbable litter)
4. Clippers
5. Alcohol
6. Red top tubes and gray top tube (C&S Boric Acid Sodium Borate/Formate tube) (for MIC)
7. Urine multistick dipstick
8. Refractometer
9. Microscope, glass microscope slides, coverslips, and urine sedi stain
10. Assistant for handling patient
11. Ultrasound (if needed/available)

Performing a UA

1. Obtain a sample of 1.5–3 ml urine and place it in the red top tube, 4 ml in the gray top tube.
2. Perform urine multistick dipstick and record results.
3. Centrifuge the sample in a red top tube, decant the supernatant, and place the sample on two different glass slides.
4. Stain one sample.
5. Observe samples under 100× on the microscope and document findings.
6. Place 1 drop on the refractometer to obtain urine-specific gravity.
7. Send the gray top tube to the lab for MIC.

26.6.5 Urine Culture and Sensitivity

Normal urine is sterile. Both rods and cocci bacteria must be $>10^4$/ml for it to be seen microscopically. The absence of bacteria does not rule out UTI. Bacteria in a free-catch sample or catheterization sample are more difficult to interpret because the bacteria can represent normal flora, but bacteria seen on a sample collected by cystocentesis are significant. To confirm bacteriuria, an air-dried sample of the urine sediment should be stained with a Gram or modified Wright's stain. These staining techniques are better for detecting bacteriuria compared to an unstained urine sediment sample. A sample should be collected by cystocentesis if a UTI is suspected to submit the sample for a culture and sensitivity unless it is contraindicated. Usually, contaminants, yeast, and fungi are occasionally seen during the urine sediment examination, especially in free-catch samples.

Processing the urine for culture should begin as soon as possible, since bacterial death may occur within an hour of collection. If the sample cannot be cultured immediately, then the sample should be refrigerated at 39.2 °F (4 °C). The sample can be stored for up to 6–12 hours and freezing should be avoided. Mycoplasma requires a special culture media, consult the commercial laboratory of choice for recommendations.

In some cases, tissue biopsies from the urinary tract collected aseptically can be cultured. If the culture is positive, it is indicative of a UTI regardless of the number of bacteria. The center of an aseptically retrieved urolith can also be cultured for bacteria. This is important even in cats with previous negative cultures.

Quantitative and qualitative are the two different types of urine cultures. Quantitative urine culture is performed by inoculating a MacConkey (gram-negative) and/or a blood agar plate with the collected sample. Individual colonies are identified after incubation based on colony morphology. Gram staining and standard biochemical reactions allow the differentiation of uropathogens. The number of colony-forming units per milliliter is estimated in order to allow the differentiation of uropathogens from possible contaminates. A qualitative urine culture involves isolating and identifying bacteria in the urine. It does not include quantifying the number of bacteria after 48 hours (about 2 days) of growth and is recorded as either positive or negative.

A false-positive urine sediment finding of bacteriuria with a subsequent negative culture may be explained by misidentification of debris or small crystals that can resemble bacteria. Bacterial contamination during sampling, such as needle penetration of a loop of intestine during a cystocentesis, or before analysis such as contamination during transfer to culture media, can also result in a false-positive urine sediment and culture.

A false-negative urine sediment examination or culture can be a result of iatrogenic bactericidal events during collection, prolonged refrigeration, heating or freezing of the sample, or use of antibiotics prior to urine collection. Urine should be collected prior to antimicrobial therapy or antibiotics should be discontinued 3–5 days before collection of a urine sample for a culture and sensitivity.

Therapeutic urine cultures at strategic times during antibiotic therapy are an effective way of assessing therapeutic success. Benefits of these cultures include verification of proper antimicrobial administration, early detection of bacterial resistance to the antibiotic chosen, and detection of persistent infection. Negative cultures during antibiotic treatment are consistent with the successful eradication of infection. The persistence of clinical signs should prompt further evaluation, such as radiographs, ultrasound, and cystoscopy, for other nonbacterial disorders. Cultures that remain unchanged despite appropriate antibiotic therapy may indicate that the antimicrobial drug is not reaching the site of infection, that there is incomplete or infrequent administration of the antibiotics, or that the cat's unwillingness to accept the medication is preventing effective tissue delivery of the medication. Antacids containing aluminum, magnesium, and calcium can decrease the absorption of oral antibiotics.

A follow-up UA and MIC should be repeated in 3–5 days after the cat has completed antibiotics for simple cystitis. For complicated UTIs or pyelonephritis, a MIC should be completed 3–5 days after initiating therapy and again in 5–7 days after completion of therapy [1, 5].

26.6.6 Symmetric Dimethylarginine

SDMA is a sensitive biomarker for renal function detecting as little as 25–40% renal function loss. Creatinine only rises once 75% of the renal function is lost and USG is sensitive to around 66% renal function loss. An elevated SDMA concentration reflects impaired GFR. Both primary and secondary renal insult, such as concurrent disease, can cause an elevation in SDMA concentration. An SDMA of < 15 μg/dl is considered normal. A mildly elevated SDMA is 15–19, and > 20 μg/dl is indicative of renal disease [3, 4, 18, 19].

Upper and lower urinary tract disorders can have nonspecific clinical signs and are diagnosed by performing a CBC, biochemistry panel, UA, and BP. A biopsy of the kidneys may be needed for further diagnosis. The treatment of most upper and lower urinary tract disorders is symptomatic, and history plays an instrumental role in helping diagnose and treat the disorders.

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