Anesthetizing felines can pose unique challenges for the veterinary technician. In addition to the fact that cats can be difficult to monitor under anesthesia, their small size, interesting metabolism, variable temperament, and propensity toward particular health ailments can also prove problematic. Advanced preparation, skills, and knowledge will allow astute technicians to anticipate patient requirements under a variety of circumstances, thereby assuring a successful outcome.

**Patient Considerations**

Thorough patient assessment is paramount. Patient signalment and history typically include the patient name, species and breed, age, weight, sex (intact/pregnant vs. altered), as well as discovery of recent health issues, current medications, and details surrounding the presenting complaint. Other important factors may include diet and housing conditions (indoors vs. outdoors), preventative health status (e.g., date of last vaccine and fecal exam, prior FeLV test, etc.), and prior anesthetic episodes. Whenever possible, a good physical exam is essential; all abnormalities should be further investigated. Preoperative bloodwork, radiographs, and other diagnostic tests (e.g. blood pressure measurement, ECG rhythm strip, echocardiogram, and/or abdominal ultrasound) may be necessary to completely define common feline health problems such as obesity, diabetes, hyperthyroidism, renal insufficiency, hepatic lipidosis, hypertrophic cardiomyopathy (HCM), and asthma.

Although not always easy, every attempt should be made to minimize stress and avoid the release of catecholamines in the perioperative period. The utilization of pheromone products (e.g., Feliway diffusers and sprays in the exam room, in feline wards, and on the employee’s hands and clothing), and dedicated feline wards help to create a quiet, warm, clean, stress-free environment. Frequent tender loving care, especially during mealtime, can be of the utmost importance by reducing anxiety and promoting food intake. Conversely, minimize stress in aggressive felines by handling them as little as possible. When all else fails, it may become necessary to resort to chemical restraint. One sedation technique described for average-sized cats (3–4 kg) is to administer an oral dosage of ketamine (1 cc) into the cat’s mouth via a urinary catheter attached to the ketamine syringe by rapidly squirting the ketamine into the cat when it attempts to bite the catheter. This technique results in a salivating, slower-moving, recumbent, and somewhat catatonic patient.

**Preoperative Considerations**

Numerous factors should be considered prior to anesthetizing felines. The severity of preexisting health problems will guide the anesthetist in the selection of premedications, crystalloid fluid type and rate, and induction agents, as well as in the inhalant and analgesic choice. When multiple major health problems exist, the patient is usually treated for the most clinical or severe problem.

For example, consider the typical feline HCM patient: Intravenous fluid therapy must be carefully titrated (at ~5–10 ml/kg/hour) to prevent fluid overload and pulmonary edema. The primary objective of premeds is to reduce the overall dosage of induction and maintenance agents. Although high doses of acepromazine can cause peripheral vasodilation, hypotension, and decreased cardiac filling, low doses (0.03–0.05 mg/kg) used prudently in disease-stable HCM patients provide beneficial effects by decreasing cardiac afterload, reducing the incidence of catecholamine-induced arrhythmias, and decreasing myocardial oxygen consumption. The use of dissociative anesthetic agents (e.g., ketamine, tiletamine) should be avoided due to their deleterious sympathetic effects, which may include increased myocardial oxygen consumption due to an elevated heart rate and decreased diastolic filling time, thereby predisposing these patients to rapid cardiac decompensation and fatal arrhythmias. Likewise, barbiturates are contraindicated due to their propensity for elevating the heart rate and sensitizing the myocardium to catecholamine-induced arrhythmias.

Other preoperative considerations include the type of procedure being performed (elective vs. emergent, short vs. prolonged), possible adverse affects on the patient due to necessary surgical positioning (e.g., large abdominal masses or gross obesity compromising breathing efforts), as well as the expected level of discomfort associated with the procedure.
Monitoring and Equipment Considerations
Ensure that emergency drug dosages have been calculated, surgical supplies are ready, and additional trained staff is available to help should a crisis situation arise. Shocky feline patients may present with the following triad: bradycardia, hypothermia, and hypotension. Because there is speculation that felines down-regulate their adrenergic receptors when they become hypothermic, aggressive warming measures and small volume resuscitation are advised (to a systolic blood pressure of up to 60 mmHg) to prevent fluid overload once the patient becomes normothermic. Therefore, intravenous fluid doses should always be administered “to effect.” Volume overload is more widespread in small patients, and volume-overloaded anesthetized patients may manifest by serous nasal discharge, chemosis, pulmonary crackles, and, in severe cases, frothy fluid emanating from the endotracheal (ET) tube. Other alternative therapies for hypotensive patients include the use of hetastarch or positive inotropic drugs (e.g., dopamine, dobutamine). When greater than 20% of the patient’s blood volume is lost (or if the cat’s PCV is <20% and total solids are <4 g/dL), a whole blood transfusion should be considered. The patient should be blood-typed in advance, as fatal reactions may occur when feline patients are administered incompatible blood products. The most common sign of a transfusion reaction in an anesthetized patient is hypotension. If feline blood products are not available, Oxyglobin® (10.0 ml/kg) can be administered to cats at an infusion rate of <5.0 ml/kg/hour. Oxyglobin® should not be used in patients with pulmonary disease.

Patient induction can be achieved via induction chamber, mask, or chemical routes. Mask or induction chamber should be considered only if an injectable agent is not an option. Chamber and mask induction are least desirable for several reasons: 1) difficulty monitoring patients in an induction chamber; 2) exposure to high levels of waste anesthetic gases; 3) excessive stress being induced by inhalant agents, due to pungent odors and a prolonged induction period; and 4) severe stress-induced cardiac arrhythmias, causing increased morbidity and mortality. Furthermore, postoperative analgesia is not provided by inhalants alone. If chamber induction cannot be avoided, provide oxygen while allowing fractious cats to calm prior to starting the inhalant. During chamber induction, monitor the patient frequently to evaluate the level of sedation, and transfer the cat to a mask as soon as possible to better assess anesthetic depth.

Obtain a good light source or laryngoscope to ease visualization of the feline laryngeal area during intubation. If necessary, using a stylet will keep the ET tube more rigid during the intubation process. However, laryngeal tissue trauma and tracheal tears may occur if the end of the stylet extends past the end of the tube, or if the ET tube cuff is over-inflated. Never force intubation. When laryngeal spasm impedes intubation, lidocaine spray, 1% or 2% lidocaine solution drawn into a syringe, or a Q-tip impregnated with 2% lidocaine gel preparations can be applied to desensitize the arytenoids. Furthermore, be warned that the use of Cetacaine® (benzocaine) sprays to intubate cats can cause sudden death due to the development of methemoglobinemia.

Non-rebreathing circuits (e.g., Bain, Jackson-Reese) should be utilized for the maintenance of anesthesia in small patients (less than 7.0 kg.) This type of circuit is advantageous in small patients by decreasing resistance to breathing. In addition, most non-rebreathing apparatuses are simple, inexpensive, and lightweight. The caveats to non-rebreathing circuits include a dependence on high oxygen flow rates (200–300 ml/kg/min) to prevent rebreathing of carbon dioxide, increased cost of anesthetic agent(s) and oxygen, an accelerated onset of hypothermia due to high oxygen flow rates, and the potential for barotrauma if the pop-off is accidentally left closed.

Pulse palpation is useful in evaluating the heart rate (unless an arrhythmia is present), and is determined by the difference between the systolic and diastolic phase. The normal heart rate for anesthetized cats should be 100–220. Bradycardia in cats (defined as <100 beats per minute) should be avoided, as it can result in reduced cardiac output and hypotension. Similarly, tachycardia does not allow adequate time for cardiac filling, which also leads to decreased cardiac output. Moreover, tachycardic states can cause hypotension and increase the oxygen demand of the myocardium and induce arrhythmias.

The stethoscope is used to auscult the heart rate and rhythm. Although heart murmurs, arrhythmias, and other cardiac pathology (e.g., tamponade) can often be identified with a stethoscope, auscultation alone does not provide relevant information in regard to cardiac function or output. Hence, the information obtained from pulse quality and chest auscultation provides little information about anesthetic depth in the anesthetized patient. Alternatively, the use of an appropriately placed esophageal stethoscope can indirectly provide physiologically relevant information in regard to both respiratory and cardiovascular function by allowing evaluation of the intensity, duration, and quality
of both breath and heart sounds to suggest the adequacy of breathing and cardiac contractions. When used properly, breath and heart sound monitors can provide a good indication of cardiorespiratory function.

**Electrocardiography** monitoring is commonplace during general anesthesia. It is important to ensure good contact of leads to skin by either using ECG paste or alcohol when placing ECG leads. Avoid wetting large areas of the skin and direct contact with the table. Exact lead locations are not as important as ensuring that all waves are present (even if they are inverted). It is important to realize that an ECG tracing does not provide information about chamber size, or how efficiently the heart is ejecting blood. Therefore, the ECG should be used strictly for the detection of dysrhythmias during the perianesthetic period.

Bradycardia is commonplace in patients undergoing general anesthesia. It is important to realize that there are numerous causes for bradycardia, which may include drug side effects (e.g., opioids or α2-agonists), excessive vagal tone, hypertension, hyperkalemia (e.g., associated with blocked cats), uremia, hyperthermia, increased intracranial pressure (e.g., head trauma), profound hypoxemia, and deep-level inhalants, among others. Tachycardia is defined as >200 beats per minute in cats. There are many causes of tachycardia, which may include, but are not limited to, drugs (e.g., ketamine, thiobarbiturates, anticholinergics, positive inotropes such as dopamine, and sympathomimetics such as epinephrine), an inadequate plane of anesthesia, hyperthermia, anaphylactic reactions, hypovolemia, early-stage hypercarbia, and numerous disease states (e.g., hyperthyroidism, heart failure, central nervous system disease, anemia, and hypokalemia). Induction agents (e.g., barbiturates or α2-agonists) and disease processes (e.g., splenic disease) may predispose patients to cardiac arrhythmias.

**Blood pressure** is determined by cardiac output and total peripheral resistance. Total peripheral resistance (TPR) is defined as the resistance to blood flow created by the peripheral arterial system as well as capillary beds. Cardiac output is determined by a combination of the heart rate and stroke volume. It is important to realize that all patients will experience some degree of hypotension during general anesthesia. Normal arterial blood pressure values for cats are systolic 120–170 mmHg, and diastolic 70–120 mmHg.

There are 2 methods to measure blood pressure indirectly—either by using a Doppler or an oscillometric device (e.g., Dinamap, Cardell, petMAP, etc.) Regardless of the method used, selection of the correct sized blood pressure cuff is imperative for providing the most accurate results. Although in general the width of the cuff should extend 40%–60% around the circumference of the limb, in cats it is acceptable to use a cuff that is only 30% of the circumference of the limb. The cuff should be snug, but not too tight. Selection of an inappropriate cuff size is the most common source of errors. Acceptable cuff locations include the forelimb, tail, and hindlimbs; the areas proximal to the carpus and tarsus work best, but the ventral tail can also work well.

**Doppler methods** use a “return-to-flow” principle to detect the systolic blood pressure. Utilizing a Doppler device can prove advantageous to obtain periodic readings in anesthetized cats when oscillometric devices fail to record blood pressure readings in feline patients. In cats it is hypothesized that the resultant reading probably represents the mean arterial pressure (MAP). As such, a correction factor of 14 mmHg is added to the obtained reading to more accurately reflect the actual feline femoral systolic pressure. Perform several readings in a conscious patient and average the results.

**Oscillometric methods** detect intracuff changes caused by the pulse wave and calculate the heart rate, systolic, diastolic, and MAP. The author has had good experiences measuring blood pressure in cats while using a petMAP, and satisfactory results with other oscillometric devices by placing the cuff around the proximal tail, or over the distal humeral area, proximal to the elbow. Patient movement, smaller patient size (<5 kg), cold or vasoconstricted patients, or patients with short legs or excessive skin will all adversely affect results.

**Pulse oximeters** provide continuous and noninvasive monitoring of pulse and an estimate of arterial hemoglobin saturation (SpO2). Preoxygenating for ≥5 minutes increases the reservoir of the lungs and replaces the air with 100% oxygen. In the event of airway obstruction, difficult intubation, or apnea, preoxygenation permits a lapse of 3–4 minutes before the patient becomes hypoxic, as compared to the 90 seconds it will take a non-preoxygenated patient breathing room air to become hypoxic. Preoxygenation is especially valuable if a patient’s functional residual capacity is reduced (e.g., in pregnant females). Often following extended periods of use, pulse oximeter tongue-probe clips cause blanching of the local blood supply, thereby impeding accurate SpO2 readings. The author has had
success disarming the spring assembly of the clip and creating a modified clip that merely holds the probe ends opposed. This modification results in a clip incapable of producing pressure on the local blood supply.

End tidal carbon dioxide (ETCO₂) is the result of expired gases from the alveoli. An abrupt decrease in ETCO₂ can be an early and reliable indication of an impending cardiovascular collapse or cardiac arrest. Consequently, ETCO₂ production can be used to assess the effectiveness of cardio-pulmonary-cerebral-resuscitation (CPCR) techniques, since delivery of carbon dioxide from the lungs requires blood flow, cellular metabolism, and alveolar ventilation. Capnometers and capnographs monitor ETCO₂ by evaluating samples of the patient’s exhaled gases taken from the anesthetic circuit via an adapter placed on the end of the patient’s endotracheal tube. This adapter must be placed precisely at the end of the patient’s nose to eliminate excessive dead space and prevent rebreathing of carbon dioxide. Cutting the endotracheal tube to shorter lengths allows the adapter to be located at the end of the nose while still allowing the cuff to sit immediately distal to the larynx, but no further than the thoracic inlet. Furthermore, it may be advantageous to eliminate excessive dead space for smaller patients with side-stream ETCO₂ collection adapters by utilizing a special ETCO₂ adapter, which is a substitute for the connection of the endotracheal tube to Y-hose interface. Conversely, the sample collection tubing of side stream ETCO₂ devices can be attached to a 22-gauge needle that has been inserted directly into the lumen of the proximal section of the patient’s endotracheal tube. In the absence of intracranial pathology, normal ETCO₂ values are maintained between 35–45 mmHg. It is prudent to avoid hyperventilation (<20–25 mmHg), which can result in decreased cerebral blood flow and oxygen delivery to the brain. Elevated ETCO₂ levels may occur as a result of hypoventilation due to airway obstruction, pneumothorax, body positioning, lung disease, or during periods of acutely increased metabolism (e.g., “thyroid storm” associated with thyroid manipulation during thyroidectomy, or catecholamine release).

Hypothermia is one of the most common anesthetic complications. Almost all anesthetized or sedated patients will lose body heat under general anesthesia, but small patients are at the greatest risk, due in large part to their small body-surface-to-mass ratio. Hypothermia is exacerbated in prolonged surgical procedures, especially those that expose open body cavities or use cold irrigation solutions.

Hypothermia is considered a form of general anesthesia, as it increases the solubility of inhalants in the body, thereby effectively increasing the dose delivered. Critically ill or otherwise compromised patients may face adverse challenges when core body temperature decreases by as little as 2° F. Obviously, prevention is key when addressing hypothermia. It is important to maintain core body temperature in smaller patients centrally (focusing on the thoracic and abdominal cavities) versus peripheral methods. Warmed irrigation fluids can be used to help restore core body temperature. Furthermore, utilize thermometers carefully, as they may not always provide accurate results when used in close proximity to the surgical site. Rewarming should be considered when the patient’s temperature drops to ≤97.6° F. There are a variety of ways to maintain an envelope of warm air around perioperative patients. Convection-type warm air devices (e.g., BAIR Huggers®) are the most effective, followed by circulating warm water blankets. At least 60% of the body surface area must be in contact with the external heat source for rewarming efforts to be most effective. If latex gloves or bottles of warm water are to be used for smaller patients, it is essential that they be initially warmed to a temperature of ≤107° F and removed once they cool to the temperature of the patient, as at that point they contribute to heat loss rather than heat gain. Commercially available wire electric heating-pads and heat lamps have been associated with uneven heating, thermal injury, and electrocution and should be avoided.

Analgesic Options

Signs of pain in cats can be quite variable and at times, subtle—ranging from purring to self-mutilation, from fractiousness and hissing to withdrawal and silence. Confounding the interpretation of pain in cats are inconsistent observations regarding heart and respiratory rates, systolic blood pressure, and temperature. A better indication of adequate pain management in cats may be evidenced by the return of normal behaviors such as grooming and attention seeking, as well as a return of appetite.

Although somewhat historically controversial, pure μ-agonist opioid analgesics have been used with great success in cats. Paradoxical excitement (typically observed at higher opioid doses) can be averted by the addition of a sedative agent such as acepromazine. Pure μ-agonists opioids (e.g., morphine, oxymorphone, hydromorphone, and fentanyl) provide the most reliable forms of analgesia for severe pain in cats. Mild to moderate pain may be treated with butorphanol or, preferably, buprenorphine. Alternately, low doses of α₂-adrenergic agonists (e.g., medetomidine, xylazine) may combine with opioids in otherwise healthy patients. Ketamine (an NMDA receptor antagonist) may
be administered via continuous infusions in conjunction with opioids for adjunctive analgesic effects; however, lidocaine CRIs were not shown to be advantageous in cats.

Local anesthetics such as lidocaine and bupivacaine may be employed for local and incisional blocks as well as ring blocks during onychectomy (declaw). Epidural analgesia, pain catheters, as well as transdermal fentanyl and lidocaine are other pain management techniques that can be utilized in the perioperative period.

It is important to realize that pain management may be indicated after the patient has been discharged from the hospital. Due to the pH of the feline oral cavity, buprenorphine can be absorbed sublingually in cats, making it a good analgesic choice for acute or long-term use. Non-steroidal anti-inflammatory drugs (NSAIDs) are another excellent analgesic option for cats. Ketoprofen can be used in healthy cats for up to 3 treatment days, and meloxicam has been used for extended periods of time (7–10 days, or more), using a gradually tapering dosage.

Although anesthetizing cats can be somewhat difficult and challenging, it can be a very rewarding experience with a positive outcome!

References