

# 2020 AAHA Anesthesia and Monitoring Guidelines for Dogs and Cats\*

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## ABSTRACT

Risk for complications and even death is inherent to anesthesia. However, the use of guidelines, checklists, and training can decrease the risk of anesthesia-related adverse events. These tools should be used not only during the time the patient is unconscious but also before and after this phase. The framework for safe anesthesia delivered as a continuum of care from home to hospital and back to home is presented in these guidelines. The critical importance of client communication and staff training have been highlighted. The role of perioperative analgesia, anxiolytics, and proper handling of fractious/fearful/aggressive patients as components of anesthetic safety are stressed. Anesthesia equipment selection and care is detailed. The objective of these guidelines is to make the anesthesia period as safe as possible for dogs and cats while providing a practical framework for delivering anesthesia care. To meet this goal, tables, algorithms, figures, and “tip” boxes with critical information are included in the manuscript and an in-depth online resource center is available at [aaha.org/anesthesia](http://aaha.org/anesthesia). (*J Am Anim Hosp Assoc* 2020; 56:■■■-■■■. DOI 10.5326/JAAHA-MS-7055)

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These guidelines were prepared by a Task Force of experts convened by the American Animal Hospital Association. This document is intended as a guideline only, not an AAHA standard of care. These guidelines and recommendations should not be construed as dictating an exclusive protocol, course of treatment, or procedure. Variations in practice may be warranted based on the needs of the individual patient, resources, and limitations unique to each individual practice setting. Evidence-based support for specific recommendations has been cited whenever possible and appropriate.

Other recommendations are based on practical clinical experience and a consensus of expert opinion. Further research is needed to document some of these recommendations. Because each case is different, veterinarians must base their decisions on the best available scientific evidence in conjunction with their own knowledge and experience.

Note: When selecting products, veterinarians have a choice among those formulated for humans and those developed and approved by veterinary use. Manufacturers of veterinary-specific products spend resources to have their products reviewed and approved by the FDA for canine or feline use. These products are specifically designed and formulated for dogs and cats and have benefits for their use; they are not human generic products. AAHA suggests that veterinary professionals make every effort to use veterinary FDA-approved products and base their inventory-purchasing decisions on what product is most beneficial to the patient.

AAFP (American Association of Feline Practitioners); ASA (American Society of Anesthesiologists); BP (blood pressure); CRI (continuous rate infusion); ECG (electrocardiogram); ET<sub>CO<sub>2</sub></sub> (end-tidal carbon dioxide); ETT (endotracheal tube); GER (gastroesophageal reflux); HR (heart rate); IM (intramuscular); NSAID (nonsteroidal anti-inflammatory drug); NRC (nonbreathing circuit); PPV (positive pressure ventilation); RC (rebreathing circuit); RR (respiratory rate); SpO<sub>2</sub> (percentage of hemoglobin saturated with oxygen)

## Introduction

The statement “there are no safe anesthetic agents, there are no safe anesthetic procedures, there are only safe anesthetists” should be the dictum for the entire anesthetic process in every practice.<sup>1</sup> The anesthesia team has the crucial role of identifying patient comorbidities and procedure risks and minimizing the detrimental effects of perioperative pain and stress in order to provide safe and efficacious anesthesia for each patient. In addition, “anesthesia” is not limited to the period when the patient is unconscious but is a continuum of care that begins before the patient leaves home and ends when the patient is returned home with appropriate physiologic function and absent or minimal pain levels. At home, the continuum begins with the pet owner administering prophylactic drugs like analgesics and anxiolytics as well as fasting the pet. In the hospital, the anesthesia continuum includes all of the following four phases of anesthesia: preanesthesia, induction, maintenance, and recovery. Anesthesia starts with a preanesthetic evaluation and stabilization (if necessary) of the patient, preparation of all of the anesthetic equipment, and selection of appropriate drugs with precise calculation of drug dosages for all phases of anesthesia. Induction and careful intubation followed by intraoperative monitoring and physiologic support in the maintenance phase are the next steps, with continued monitoring and support into the recovery phase. Postanesthesia care, as communicated by the veterinary staff with the pet owner in the clinic and at home, completes the continuum. Provision of analgesia and client/staff communication and education are critical throughout the entire process.

The objective of these guidelines is to make the anesthesia period as safe as possible for dogs and cats while providing a practical framework for delivering anesthesia care before, during, and after the anesthetic procedure. The guidelines are intended to be comprehensive but neither all-inclusive nor a single source for information and clinical recommendations. More detailed references are available for pain management<sup>2</sup> and cat-specific anesthetic and analgesic needs,<sup>3</sup> and academic anesthesia textbooks address disease-, breed-, and procedure-specific anesthesia recommendations and outcomes. However, the guidelines are designed to be as actionable as possible. With that in mind, readers will find the guidelines’ visual

components to be particularly useful. Algorithms, figures, “tips” boxes, and tables provide quick access to the essential resources and methods associated with anesthesia. An online resources center ([aaha.org/anesthesia](http://aaha.org/anesthesia)) is also available for more detailed information.

## Phase 1: Preanesthesia Individualized Anesthetic/Analgesic Plan and Client Communication

An individualized anesthetic plan with specific and sequential steps ensures the continuum of care throughout the entire anesthetic process. A complete anesthetic plan must address all phases of anesthesia, with inclusion of perioperative analgesia throughout each phase. Although each patient should be treated as an individual, having a set of anesthesia plans that are used repeatedly is appropriate. This allows the anesthesia team a level of comfort with their anesthesia protocols while adjusting plans based on individual patient needs.

The preanesthesia phase includes not only the choice of preanesthetic sedatives and analgesics but also a full preanesthetic evaluation and stabilization of the patient, if necessary. Categorization of patients using the American Society of Anesthesiologists (ASA) Patient Status Scale (scoring of 1–5) provides a framework for evaluation of patient health and determination of stabilization requirements prior to anesthesia (available at [aaha.org/anesthesia](http://aaha.org/anesthesia)). An increase in ASA status from 1 or 2 to 3, or from 3 to 4 or 5, increased the odds of anesthesia-related death in dogs and cats.<sup>4</sup> In another study, an ASA status of  $\geq 3$  increased the odds of anesthesia-related death when compared with an ASA status of  $\leq 2$ , with cats having a higher odds ratio than dogs for anesthetic death.<sup>4,5</sup>

Risks specific to the patient’s size and age and the surgical or medical procedure need to be considered.<sup>4–6</sup> Disease-related risks should be corrected or minimized if possible (see textbox “Potential Anesthesia Risk Factors and Actions to Mitigate Risk”).<sup>6–8</sup>

Monitoring of physiologic parameters and provision of physiologic support are integral to the plan in order to reduce the likelihood of adverse events.<sup>4–6</sup> Also critical is a plan for anesthetic recovery and for postdischarge care.<sup>4–6</sup> Resources such as staffing,

### Recommended Resources

2015 AAHA/AAFP Pain Management Guidelines for Dogs and Cats ([aaha.org/pain-management-guidelines](http://aaha.org/pain-management-guidelines))

2018 AAFP Feline Anesthesia Guidelines ([catvets.com/guidelines/practice-guidelines/anesthesia-guidelines](http://catvets.com/guidelines/practice-guidelines/anesthesia-guidelines))

2013 AAHA/AAFP Fluid Therapy Guidelines for Dogs and Cats ([aaha.org/fluid-therapy-guidelines](http://aaha.org/fluid-therapy-guidelines))

### Related Resources

2015 AAHA Canine and Feline Behavior Management Guidelines ([aaha.org/behavior](http://aaha.org/behavior))

2019 AAHA Dental Care Guidelines for Dogs and Cats ([aaha.org/dentistry](http://aaha.org/dentistry))

2019 AAHA Canine ([aaha.org/caninelifestage](http://aaha.org/caninelifestage)) and 2010 Feline ([aaha.org/felinelifestage](http://aaha.org/felinelifestage)) Life Stage Guidelines

equipment, and drug availability should be considered throughout the entire anesthetic plan.

To further minimize patient risk, use of an anesthesia-surgery checklist (available at [aaha.org/anesthesia](http://aaha.org/anesthesia)) helps prevent practices from committing critical oversights and errors in the peri- and intraoperative periods. These patient safety checklists can be created for every sedation or general anesthesia procedure, as part of the patient's medical record.

## Step 1: Preanesthetic Evaluation and Plan Considerations

### Preanesthetic Evaluation

The preanesthetic patient evaluation is critical for patient safety as it promotes identification of individual risk factors and underlying physiologic changes or pathologic compromise that will impact the anesthetic plan. Factors to be evaluated include the following:

- **History:** Identify risk factors such as known medical conditions and previous adverse drug responses. Clarify the use of all prescribed and over-the-counter medications (e.g., aspirin, herbal products, cannabidiol, and supplements) to avoid adverse drug interactions.<sup>9</sup> Note any abnormal clinical signs, both acute and chronic, with individual questions specifically directed at the cardiovascular, respiratory, gastrointestinal, nervous, and musculoskeletal/mobility systems. Records should be evaluated for previous anesthetic events, and client communication should include specific questions regarding satisfaction with previous anesthetics and recoveries. A smooth recovery may be noted in the hospital, but the patient may go home and exhibit abnormal behaviors such as lethargy, nausea, vomiting, restlessness, and vocalization, which could indicate pain or other complications that need to be addressed.
- **Physical examination:** A thorough physical examination should be completed and documented within 12–24 hr previous to anesthesia and repeated just prior to anesthesia if acute clinical changes occur. Failure to record a physical exam was reported to increase the odds for death in dogs.<sup>4</sup>
- **Age:** Although age is not a disease, disease processes occur more commonly in aged patients, and physiologic systems can be immature in neonatal and pediatric patients. Advanced or very young age can increase anesthetic risk because of altered responses to drugs caused by changes or immaturity in cardiovascular, respiratory, renal, hepatic, and neurological systems.<sup>4–6</sup> Examples include the inability to mount a robust physiologic response to hypotension or hypothermia in these age groups. Neonatal and pediatric patients may also be impacted by hypoglycemia and geriatrics by impaired cognitive function. A fairly high percentage of health abnormalities, including those that might cause a cancellation of or change in anesthesia, have been identified during preanesthetic screening of geriatric dogs.<sup>10</sup>
- **Breed/Size:** Few breed-specific anesthesia “sensitivities” have been identified. Greyhounds may have prolonged recoveries after receiving some anesthetics such as barbiturates and may experience hyperkalemia associated with general anesthesia.<sup>11,12</sup> Breeds affected by the multiple drug resistance mutation 1 (now ABCB1 or adenosine triphosphate binding cassette subfamily B member 1) gene mutation should receive reduced dosages of acepromazine and potentially butorphanol.<sup>13</sup> Conversely, breed-specific anatomy or propensity for underlying conditions commonly impact anesthesia. For instance, brachycephalic dogs and cats are more prone to upper airway obstruction, and brachycephalic breeds have been shown to have higher airway-related anesthetic complication rates compared with nonbrachycephalic breeds.<sup>14</sup> Some breeds of dogs (e.g., Cavalier King Charles spaniel) and cats (e.g., Maine Coon) may be predisposed to cardiac disease.<sup>15</sup> Other breed-related diseases that may impact anesthesia, such as collapsing trachea in many small-breed dogs, breed-related renal or hepatic dysfunction, low intra-erythrocyte potassium concentrations in the Shiba Inu, and drug metabolism in cats, should also be considered.<sup>16</sup> Breed-related size can also impact anesthesia.<sup>6</sup> Very small/toy-breed dogs and all cats are at increased risk for anesthetic complications because they are more prone to hypothermia and may be more difficult to intubate and monitor. These patients may experience volume overload if a means to deliver precise fluid volume (e.g., syringe pumps, buretrols, etc.) is not instituted and are more easily overdosed if high-concentration drugs, high-volume syringes, or high-volume bags of fluid are used. Giant-breed dogs can be at increased risk because they are more commonly overdosed when milligram per kilogram dosing versus body surface area dosing is used.
- **Temperament:** Fear, anxiety, and stress can be exhibited in many ways, including aggression, hiding, fleeing, or freezing. When any of these behaviors are exhibited, the patient may benefit from medication administered at home to provide anxiolysis and reduce fear prior to travel to the hospital. An aggressive temperament can limit the preanesthetic evaluation or make examination prior to sedation impossible. This can impair the ability to detect abnormalities and may increase anesthetic risk. Anxious patients often require high doses of sedatives or tranquilizers, which may cause respiratory and cardiovascular depression. For elective procedures, consider rescheduling with a plan to manage anxiety before admission to the clinic. Conversely, a quiet or

### Potential Anesthesia Risk Factors and Actions to Mitigate Risk

#### Preanesthesia conditions for which corrective intervention is advisable to critical

Anxiety  
Pain  
Hypoglycemia BG <60 mg/dL  
Hypothermia <99°F  
Anemia (depending on severity and chronicity)  
Dehydration  
Life-threatening cardiac arrhythmias  
Electrolyte and acid–base dyscrasias (K >6.0 mEq/L, pH <7.2)  
Cyanosis  
Congestive heart failure  
Oliguria, anuria  
Pneumothorax

#### Actions to mitigate risk during anesthesia

Preanesthetic physical exam and documentation  
Premedication to reduce stress, decreased anesthetic requirements  
Dedicated anesthetist  
IV catheter to facilitate IV administration of medications  
Oxygen supplementation and monitoring of respiratory function (RR, ETCO<sub>2</sub>, SpO<sub>2</sub>)  
Monitoring of cardiovascular function (HR, BP)  
Assessing cardiac rhythm (ECG)  
Monitoring and support of normal body temperature  
Continued patient support and monitoring in recovery  
Documentation of patient parameters during anesthesia and recovery (anesthesia record)

BG, blood glucose; BP, blood pressure; ECG, electrocardiogram; ETCO<sub>2</sub>, end-tidal carbon dioxide; HR, heart rate; RR, respiratory rate; SpO<sub>2</sub>, percentage of hemoglobin saturated with oxygen.

depressed animal may require lower drug dosages for sedation or anesthesia.

- **Patient Diagnostics:** Risk factors and specific patient concerns provide a framework for developing individualized anesthesia plans and may indicate the need for additional diagnostic testing, stabilization before anesthesia, or adjustments in chronic medications (see textbox “Recommendations for Chronic

Medications the Day of Anesthesia”). Individual patient diagnostics may include a minimum database of laboratory analysis (complete blood count, chemistry panel, urinalysis) and could include other components such as blood pressure (BP), electrocardiogram (ECG), and imaging modalities like echocardiogram or ultrasound. For example, BP should be routinely measured in patients with renal, cardiovascular, and endocrine disorders. Currently, dogs eating a grain-free diet should undergo an echocardiogram to evaluate cardiac contractility as a result of the potential link between dilated cardiomyopathy and grain-free diets.<sup>17</sup> There is no evidence to indicate the minimum timeframe between laboratory analysis and anesthesia. A reasonable timeframe is ≤3–6 mo if values were normal and the patient is clinically healthy. If either lab values or the patient’s health is abnormal, repeat diagnostics should be performed immediately prior to anesthesia.

#### Other Plan Considerations

- **Type of Procedure:** In addition to patient temperament and comorbidities, consider the level of procedural invasiveness, duration of surgery, and anticipated pain level. General anesthesia

#### Recommendations for Chronic Medications the Day of Anesthesia\*

Continue medications as scheduled:

- Thyroid medication: thyroid supplement or methimazole
- Behavioral and analgesic medications: sudden withdrawal of these medications is not advised
- Oral anxiolytics: to reduce fear and anxiety
- Cardiac medications: pimobendan, furosemide
- Antibiotics
- Steroids: should not be abruptly stopped

Discontinue the day of anesthesia:

- Antihypertensive medication, especially ACE inhibitors: enalapril, benazepril<sup>8</sup>
- Anticoagulants: may need to be discontinued 2 wk prior to anesthesia based on risk of bleeding

Administer based on specific recommendations to owner:

- Insulin: full dose should not be administered to fasted patients because of risk of hypoglycemia

\*List is not all-inclusive but focuses on medications strongly recommended to either administer or cease.

ACE, angiotensin-converting enzyme.

with airway control is required for long, invasive, and/or potentially painful procedures (dentistry, elective ovariohysterectomy or castration, or orthopedic procedure) and for any patient with airway compromise or undergoing airway surgery. Sedation may be appropriate for shorter (<30 min) and less invasive procedures (e.g., diagnostic procedures, joint injections, suture removal, and minor wound management) in healthy patients. However, heavy sedation is not suitable for all patients and may actually increase the odds for anesthesia-related death.<sup>5</sup> For instance, in older, medically compromised patients, brief general anesthesia is preferable because it is less stressful and more controlled than sedation. Some procedures may limit physical access to the patient (e.g., oral or ophthalmic procedures), necessitating individualized plans for monitoring, catheter access, etc.

- **Clinical Staff Training:** Trained clinical staff are essential for safe anesthesia. The number of trained staff and the level at which they are trained will also impact efficiency and scheduling. In addition, staff training can positively impact specific areas of anesthesia; for instance, staff training in local and regional anesthesia techniques will help facilitate their perioperative use.
- **Time of Day:** Increased anesthetic risk has been documented for procedures occurring late in the day or after normal hours.<sup>4,6</sup> This is because of a combination of inadequate time for stabilization, limited staff availability, and staff fatigue. The fact that many procedures are also emergency or urgent, versus scheduled or elective, is also associated with an increase in the risk of anesthetic death.<sup>5,6</sup> Nonemergency procedures may be best performed during the next available regular clinic day when time for preparation and planning is adequate. When possible, critical patients should be anesthetized early in the day to allow adequate time for anesthetist-supported recovery.

### Step 2: Client Communication/Education

Once the initial plan is formulated, pertinent information regarding the anesthetic procedure and pet-specific risk factors should be discussed with the pet owner. Because of safety concerns, pet owners are sometimes hesitant to authorize discretionary procedures requiring general anesthesia, such as preventive dental care or diagnostic imaging. This concern is best alleviated with appropriate communication between the veterinary team and the pet owner, along with education of the pet owner regarding the entire anesthetic process. Additional resources are available at [aaha.org/anesthesia](http://aaha.org/anesthesia).

Communication with the pet owners should include a full description of the anesthetic procedure and a discussion of potential risks prior to obtaining written, preprocedural consent. In healthy dogs and cats, the risks of anesthesia-related death were estimated to

be 0.05% (1 in 1,849, 95% confidence interval [CI] 0.04–0.07%) in dogs and 0.11% (1 in 895, 95% CI 0.09–0.14%) in cats, with death most frequently occurring in the first 3 hr postoperative.<sup>6,18</sup> Although this can be concerning, fears can be alleviated with assurance that the anesthesia team will consider multiple factors including health status, breed, age, expected pain level, and surgical plan when making an individualized anesthesia plan for their pet. Tailoring each patient's anesthetic plan to their specific needs allows the anesthesia team to provide optimum care, including patient-specific anesthetic monitoring performed by a dedicated anesthetist. The anesthesia team should clearly communicate to the pet owner that these measures will decrease the likelihood of anesthetic complications both during the procedure and in the recovery period.

Pain management and patient comfort is generally very concerning to the pet owner and should be emphasized as an integral part of each patient's anesthetic plan. Pet owners should be reassured that multiple modalities will be used to minimize patient discomfort and stress level prior to leaving home, in hospital, and during recovery at home. The pet may require analgesics and anxiolytics administered at home, and the benefits of these drugs should be explained. The overarching goal for client communication is to ensure that the pet owner is confident that the anesthesia team has the compassion, skills, and technology to provide the safest possible anesthesia for their pet.

## Phase 2: Day of Anesthesia

### Step 1: Anesthesia Begins at Home

The pet owner begins the continuum of anesthesia with fasting the pet and administering medications as directed by the anesthesia team. Although not all evidence is in agreement, in general, the recommended fast duration for healthy adult patients has decreased. The change is based on clinical experience and experimental evidence of shorter fasting benefits, including a lower incidence of gastroesophageal reflux (GER). An abbreviated fast is particularly important for diabetic and neonatal patients (**Figure 1**). Most medications currently administered to the pet should be continued on the day of anesthesia, but there are exceptions, especially for some cardiac medications (see textbox "Recommendations for Chronic Medications the Day of Anesthesia"). Analgesic drugs (e.g., nonsteroidal anti-inflammatory drugs [NSAIDs]) may be among the drugs that the patient is already receiving or may be started immediately prior to the procedure. If the patient experiences motion sickness, maropitant should be considered for administration before the patient is transported to the hospital to prevent vomiting. Anxiolytic drugs should definitely be administered for all fractious/aggressive/fearful patients and should be strongly considered for patients that develop any level of fear, anxiety,



Patient Status	Withhold Water for ___ Hr		Withhold Food for ___ Hr				Feed Pâté-Consistency Wet Food	Treatments and Medications				Other
	0*	6–12	1–2	2–4	4–6	6–12		Monitor BG	Chronic Oral Meds†	Anti-emetic‡, Antacid, and Proton Pump Inhibitors	Insulin	
Healthy	✓				✓			✓				
<8 wks of age or <2 kg	✓		No longer than 1–2 hr				✓ In pre-op period	Before, during, and after induction	✓			Perform as first case of the day
Diabetic	✓			✓			½ meal 2–4 hr prior	Before, during, and after	✓		½ dose given 2–4 hr prior	Perform as the first case of the day
History of, or at risk for, regurgitation		✓				✓	Consider feeding 10%–25% of normal amount 4–6 hr prior to induction		✓	✓		
Emergent		ASAP								✓		Stabilize patient prior to induction

\* 0 hr = allow free access to water

† Oral medications may be administered with small amount (1–2 tbs) wet food or pills coated in an edible paste-like material.

‡ Anti-emetics are a valid addition to any anesthetic protocol due to the potential for increased patient comfort by decreasing vomiting secondary to pre-anesthetic medications.

Review textbox "Recommendations for Chronic Medications the Day of Anesthesia." Use clinical judgement in healthy patients to determine if giving a small amount of in-hospital treats to facilitate gentle handling or decreasing patient stress would be beneficial prior to anesthesia.

**FIGURE 1** Feeding and treatment recommendations for dogs and cats prior to anesthesia.















































or stress during a visit to the veterinary hospital. Gabapentin and trazodone are commonly used for this purpose. Dosages for these and other previsit pharmaceuticals are listed in **Figure 2**.

### Step 2: Equipment Preparation

Prior to the start of any general anesthesia or sedation-only procedure, it is critical to ensure that all equipment and monitors are turned on, are functioning, and have undergone appropriate safety checks. All necessary equipment, including the anesthesia machine, breathing circuit, endotracheal tube (ETT), intubation tools (e.g., laryngoscope), and anesthetic monitors, should be prepared. Anesthetic equipment is considered “life-critical” because the well-being of patients can be adversely affected if the equipment is not functioning optimally or is used incorrectly. Anesthesia machines, paired with breathing circuits (nonbreathing circuit [NRC] or rebreathing circuit [RC]), are designed to deliver oxygen (O<sub>2</sub>) and inhalant anesthetic to the patient and to prevent rebreathing of

carbon dioxide (CO<sub>2</sub>) by the patient. The machine and the breathing circuit become part of the patient’s respiratory system and can support, if working correctly, or impair, if working incorrectly, respiratory function. Two essential safety features to have on every anesthetic machine are (1) an in-circuit manometer and (2) a safety pop-off valve (see examples at [aaha.org/anesthesia](http://aaha.org/anesthesia)). A manometer allows safe delivery of manual and mechanical breaths, enables leak checking of the seal of the ETT cuff within the trachea, and allows for a visual indication of rise in airway pressure. Safety pop-off valves prevent excessively high airway pressure and potential barotrauma. These can be installed on most anesthesia machines for use with both types of breathing circuits.

Anesthesia personnel have a responsibility to understand the proper use and function of, and be able to set up, check, and troubleshoot, all necessary equipment prior to use. Equipment setup should be guided by checklists (found at [aaha.org/anesthesia](http://aaha.org/anesthesia)) that dictate general equipment preparation tasks for the day (e.g., fill the

Desired Effect	Drug Options	Healthy		Examples	Compromised/Sick	
<b>Low FAS</b> 	Gabapentin			50–150 mg/cat PO, 20–40 mg/kg PO (dog) 2–3 hr before visit		
	Trazodone			3–7.5 mg/kg PO (dog)		
	Alpha-2 agonist			Dexmedetomidine gel OTM. Use label dose for patient size**		
<b>Light sedation</b> 	Opioid			Butorphanol 0.2–0.4 mg/kg IV/IM		
	Benzodiazepine			Midazolam 0.2 mg/kg, IV/IM		
<b>Moderate sedation</b> 	Opioid			Butorphanol 0.4 mg/kg IM or Buprenorphine 0.02 mg/kg OTM (cat)		
	Tranquilizer			Acepromazine 0.01–0.03 mg/kg IM (dog)*, 0.025–0.1 mg/kg IM (cat)*		
	Benzodiazepine			Midazolam 0.2 mg/kg, IV/IM		
	Alpha-2 agonist			Dexmedetomidine 3–7 µg/kg IM (dog) or 3–10 µg/kg IM (cat) or 0.04 mg/kg OTM (cats)		
<b>Heavy sedation</b> 	Opioid			Butorphanol 0.2–0.4 mg/kg IM		
	Benzodiazepine			Midazolam 0.2 mg/kg, IV/IM		
	Alpha-2 agonist			Dexmedetomidine 7–15 µg/kg IM (dog) or 10–20 µg/kg IM (cat)		
	Neurosteroid			Alfaxalone 1–2 mg IM <sup>§</sup>		
	Dissociative			Ketamine 1–2 mg/kg IM		

**How to use this chart:**

- Select desired level of sedation.
- Consider the combinations available.
- Evaluate the health status of your canine or feline patient.
- Taking into consideration patient demeanor, the anticipated length of, and degree of pain caused by the procedure, and other factors, select a color combination that suits you and your patient's needs.
- Make appropriate combination choices, remembering to use the lower end of the drug dose when combining with other sedatives.

FAS, fear, anxiety, stress; OTM, oral transmucosal administration

\* Maximum 2-3 mg total dose  
 † Maximum 1 mg total dose  
 § Best used in small patients  
 \*\* Administer to fractious patients in parking lot

**FIGURE 2** Anxiolytic, sedation, and premedication medications.

CO<sub>2</sub> absorbent canisters) and specific preparation tasks for each patient (e.g., pressure check the anesthesia machine prior to each use).

**Step 2a**

Ensure that O<sub>2</sub> levels in the E-tank or hospital supply tank are >200 psi or that the oxygen generator is functioning properly. Fill the vaporizer with liquid inhalant. If the patient will be breathing through an RC, change the CO<sub>2</sub> absorbent after 8 hr of use, which

may be roughly daily or weekly, depending on the anesthesia case load.

**Step 2b**

Connect the breathing circuit to the machine. When choosing a breathing circuit, note that NRCs are commonly used for cats and small dogs (patients <3–5 kg [6.6–11 lbs]) because, compared with RCs, they cause less resistance to breathing and have low equipment

dead space, both of which are important considerations in small patients. Excessive equipment dead space leads to rebreathing of CO<sub>2</sub> and subsequent hypercarbia/hypercapnia. Dead space should be kept to a minimum and should be  $\leq 2\text{--}3$  mL/kg, which is  $\leq 20\%$  of total tidal volume. The patient end of breathing circuits (where mixing of inspired and expired gases occurs) is a common source of dead space. Pediatric circuits, which have low dead space, are recommended for use in smaller patients. Rebreathing of CO<sub>2</sub> in the NRC is prevented by high O<sub>2</sub> flow rates, which also allows for a faster turnover in the change of anesthetic depth when adjusting the vaporizer setting. Thus, the O<sub>2</sub> flow should be  $\sim 200\text{--}400$  mL/kg/min when using NRCs.<sup>19</sup> Flow adequacy should be monitored with a capnograph and adjusted to keep the inspired CO<sub>2</sub> to  $< 5$  mm Hg. If any occlusion occurs in the expiratory limb of the circuit, the relatively high oxygen flow rates used in NRCs will cause rapid pressurization of the entire system and can lead to airway damage and/or circulatory collapse within minutes. In addition, the oxygen flush valve should never be used in a patient breathing through an NRC because it directs a high-pressure flow directly into the patient's airway, potentiating barotrauma. The risk of high airway pressure damage is increased in cats and small dogs because of their small lung capacity ( $\sim 400$  mL per average cat). For safety, a high-pressure alarm can be inserted in the expiratory limb of the breathing circuit. This does not allow escape of gas but emits a loud noise if the pressure in the circuit rises. An example of this alarm can be found at [aaha.org/anesthesia](http://aaha.org/anesthesia).

Rebreathing circuits (i.e., circle systems) with lightweight plastic rebreathing hoses and minimal dead space are typically used in patients  $> 3\text{--}5$  kg (6.6–11 lbs). Pediatric RCs typically have lower equipment dead space compared with hoses for adult patients and can be used for patients  $< 3\text{--}5$  kg (6.6–11 lbs) if NRCs are not available. RCs depend on functional one-way valves to ensure unidirectional gas flow and on CO<sub>2</sub> absorbent to prevent rebreathing of CO<sub>2</sub>. Proper valve function can be assessed by breathing through the circuit while visualizing movement of the correct valve on inspiration and on expiration. During the maintenance phase, total O<sub>2</sub> flow rate should typically be  $20\text{--}40$  mL/kg/min, with a minimum 500 mL/min to ensure accurate vaporizer output. The benefits of lower flow rates include decreased environmental contamination and decreased consumption of O<sub>2</sub> and volatile anesthetic gases (i.e., inhalant anesthetic not inhaled by the patient). Lower flow rates also conserve moisture and heat. When using RCs, a minor disadvantage of lower flow rates is increased time to change anesthetic depth after changing the vaporizer setting.

#### **Step 2c**

Leak test the machine and circuit before anesthetizing each patient and after changing any breathing circuit components. This safety

measure ensures that oxygen is flowing to the patient and that there is minimal risk of inhalant leakage. For this step, the adjustable pressure limiting, also called the pop-off valve, must be closed. Occlude the end of the breathing circuit and increase the O<sub>2</sub> flow to raise the machine circuit pressure to  $20\text{--}30$  cm H<sub>2</sub>O on the manometer. The oxygen should be turned off, and the pressure manometer should remain steady. If no leak is detected, open the pop-off valve, and then release the breathing circuit occlusion. If a leak is detected, pull the machine from use and initiate troubleshooting procedures.

#### **Step 2d**

Ensure proper setup of the scavenging system to limit or eliminate personnel exposure to inhalant gases. The Occupational Safety and Health Administration provides advisory guidelines, although some US states have specific regulations regarding control of waste anesthetic gases. Active scavenging systems are far more effective than passive scavenging systems (e.g., activated charcoal canisters). More information on waste anesthetic gas is available through the American College of Veterinary Anesthesia and Analgesia.<sup>20</sup>

#### **Step 2e**

Prepare for airway management by choosing ETTs of appropriate sizes and intubation tools (e.g., stylets, laryngoscope), along with a face mask for preoxygenation prior to induction. Veterinarians have several options for intubation, including clear cuffed polyvinylchloride, silicone, and self-sealing baffled tubes. Supraglottic airway devices, which do not require intubation, are available for airway management in cats and rabbits. See [aaha.org/anesthesia](http://aaha.org/anesthesia) for advantages and disadvantages of the various

#### **Anesthesia Equipment Safety Tips**

- To improve anesthesia safety, include a manometer and a safety pop-off valve in the patient breathing circuit. The latter prevents a rapid increase in airway pressure due to a closed pop-off valve, thus decreasing the risk of barotrauma.
- Following the oxygen flow from the anesthesia source, through the anesthesia machine and breathing circuit, to the patient, then from the patient to the rebreathing bag (or reservoir bag on NRC) and finally to the scavenging system, is an effective way of learning the common components of the anesthesia machine and breathing circuit.



devices. ETT elbow and capnograph adapters are a source of dead space. To decrease dead space breathing without increasing airway resistance, the diameter of the capnograph and elbow adapters should always exceed the internal diameter of the ETT. A single elbow adapter may add up to 8 mL of dead space, which can be excessive in small patients. Low dead space adapters are recommended.

### Step 3: Patient Preparation

The patient should be stabilized before anesthesia as anesthesia and surgery can exacerbate pre-existing physiologic compromise. Stabilization is patient-specific and includes acute (e.g., immediate preoperative IV fluid administration and analgesia) and chronic (e.g., initiation of treatment for cardiac disease, with anesthesia rescheduled after 2–4 wk of therapy) stabilization.

An accurate patient weight should be obtained on the day of anesthesia. All drug doses should be based on the patient's lean bodyweight, as fat bodyweight contributes little to volume of distribution and hence should add little to the anesthesia dose. Preparation of an anesthesia record and patient-specific emergency drug calculations are important steps in preparing for potential anesthetic complications. In almost all situations, placement of an IV catheter is optimal anesthetic patient care as the catheter allows for administration of additional anesthetics, analgesic drugs, and fluids, along with administration of emergency medication drugs, if needed. Patients undergoing very short procedures do not necessarily require fluids yet still benefit from an IV catheter.

### Step 4: Anesthesia Protocol

#### Step 4a. Pain Management

Effective analgesia throughout the entire anesthesia continuum is an integral component of patient health and welfare. Analgesia has numerous advantages as a component of general anesthesia.<sup>21</sup> First, analgesia improves anesthetic safety by decreasing the dose of inhaled drugs required for anesthesia maintenance, thus decreasing the likelihood of inhaled-mediated, dose-dependent adverse effects such as hypotension and hypoventilation.<sup>22</sup> Second, provision of analgesia optimizes patient outcome with fewer pain-related adverse effects such as tachycardia, hypertension, slowed gastrointestinal motility, delayed wound healing, upregulation of pain, changes in behavior, etc.<sup>23,24</sup> Third, although not yet proved in animals, provision of perioperative analgesia may decrease the development of acute pain-related chronic pain.<sup>25</sup>

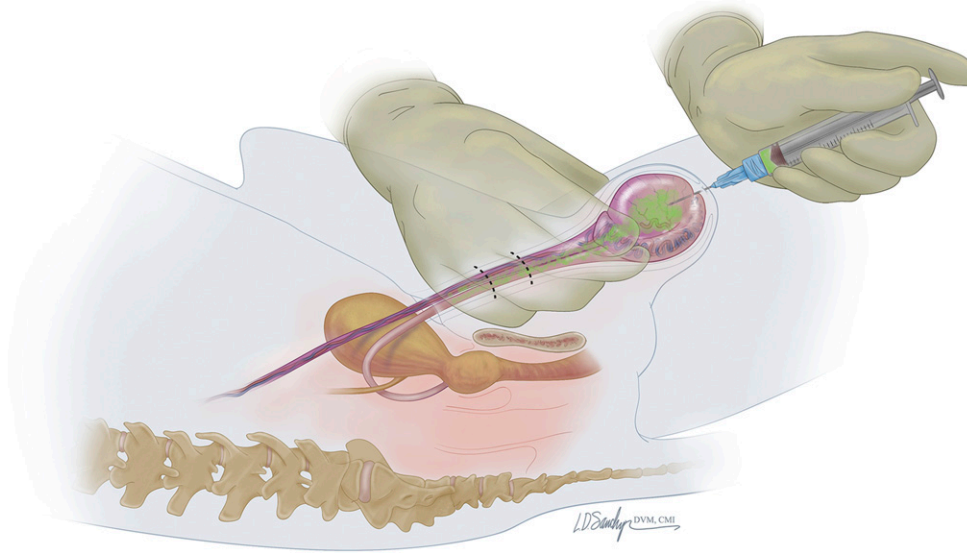
Pain is a complex multidimensional sensation with multiple sources. Using one drug or drug class for treatment of pain is unlikely to provide adequate pain relief, at least in moderate to severe pain states. Using multiple drugs and modalities, each with activity at

different sites of the pain pathway, alleviates or eliminates pain at multiple sites and from multiple sources. An example is the combination of an anti-inflammatory drug that decreases nociceptor activity and a local anesthetic that blocks pain signal transmission, plus an opioid or alpha-2 agonist to decrease receptor response in the central nervous system. This concept, known as multimodal or balanced analgesia, provides greater pain relief and promotes anesthetic safety by further decreasing required anesthetic drug dosages.<sup>23</sup> The use of multimodal analgesia also decreases the impact of drug unavailability, as with the recent opioid shortage. In addition, a balanced protocol includes preemptive, or preventive, analgesia and analgesia for a duration appropriate for the type/degree of pain. Preemptive administration of analgesic drugs decreases intra- and postoperative analgesic requirements.<sup>23</sup> Although not thoroughly researched in animals, the appropriate duration of analgesic therapy in animals can be extrapolated from the duration needed to control pain in humans suffering similar pain insults. Extrapolation is appropriate because of the similarities of the mammalian pain pathway across species.<sup>26</sup> Because animals conceal pain, treatment duration should be based on scientific knowledge of pain duration and not on presence/absence of pain signs.

**Building an Analgesic Protocol:** This is an overview of perioperative analgesia. For more in-depth information, see the *AAHA/American Association of Feline Practitioners (AAFP) Pain Management Guidelines* and *World Small Animal Veterinary Association Analgesia Guidelines*.<sup>2,27</sup> Analgesic drugs can be distributed into the four phases of anesthesia (preanesthesia, induction, maintenance, and recovery). Opioids are often the first class considered when designing protocols. Although this strategy is efficient for *anesthetic* plan development, when considering the sources of pain and the mechanisms of action of analgesic drugs, building an *analgesic* protocol is more effective if centered on anti-inflammatory and local anesthetic drugs. Inflammation is generally a major component of acute pain. Because inflammation is also the pathology that produces most acute pain syndromes, control of inflammation decreases further tissue damage and speeds healing. An anti-inflammatory drug (traditional NSAID or grapiprant) should be administered to all appropriate patients.

Local anesthetic drugs block sodium channels and provide complete pain relief from the nerves that are blocked. This fact led to the recommendation "...local anesthetics should be utilized, insofar as possible, with every surgical procedure."<sup>2</sup> The task force recommends the use of local anesthesia, including the simple techniques for common procedures in **Figures 3–5**.

Although opioids do not block pain at its source or stop the transmission of pain, they are potent and rapidly acting, making them excellent for acute pain relief. Full mu-opioid receptor agonists



**FIGURE 3** Feline or canine testicular block.

INDICATIONS: Feline and canine castrations.

INSTRUCTIONS:

1. Choose the desired local anesthetic.\* Calculate the low end of the dose of 1 mg/kg (cat)/ 2 mg/kg (dog) of bupivacaine, ropivacaine, or 4 mg/kg (cat), 6 mg/kg (dog) of lidocaine.
2. Complete a rough surgical scrub of the testicles and the incision site (scrotal [cat] or prescrotal [dog]).
3. Insert a 22-gauge needle into the center of the testicle with the tip of the needle pointed toward the spermatic cord.
  - a. Aspirate and inject  $\frac{1}{2}$  of the calculated volume into each testicle or inject until the testicle suddenly feels turgid, whichever occurs first.<sup>†</sup>
4. The drug migrates up the spermatic cord and provides pain relief from surgical crushing of the cord and associated vessels.
5. To provide pain relief from the incision:
  - a. Cats: Continue infiltrating as the needle exits the testicular body to block the skin and subcutaneous tissue.
  - b. Dogs: Inject local anesthetic in skin and subcutaneous tissue at the incision site.

\*Although bupivacaine or ropivacaine provide a longer duration than lidocaine, some clinicians are more comfortable with lidocaine because it has a higher safety margin if accidentally injected IV and the testicles are highly vascular. Thus, personal comfort with the drugs dictates final drug choice for this block.

<sup>†</sup>On removal, the testicle may appear hemorrhagic.

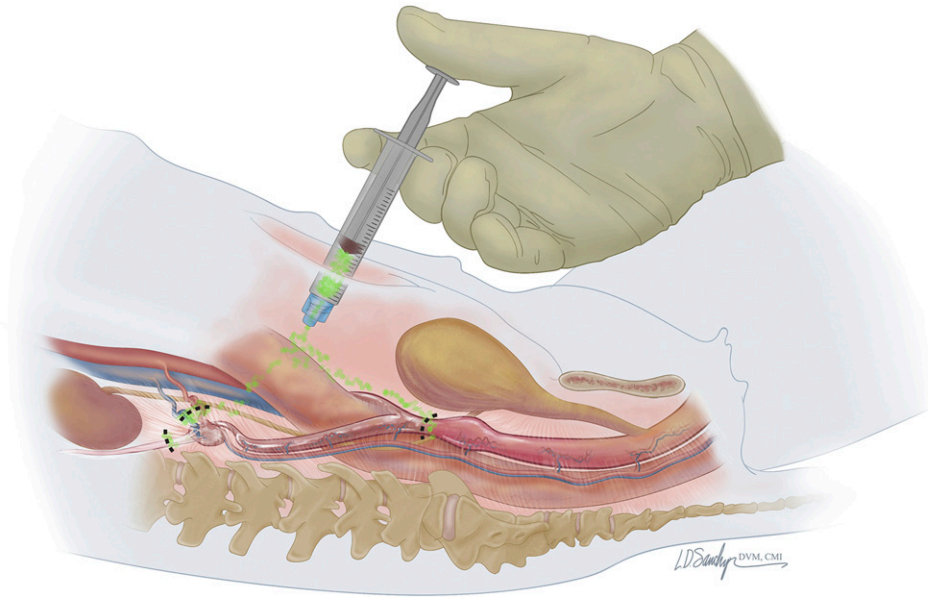
Artwork by Lauren D. Sawchyn, DVM, CMI.

(morphine, for example) are the most potent analgesics but also the most impacted by regulatory control. Buprenorphine is moderately potent but has a longer duration (4–6 hr) than most full mu-opioid agonists, with the FDA-approved buprenorphine for cats providing 24 hr of analgesia. Butorphanol is only mildly to moderately potent and has a short duration of action (<60 min in the dog and 90 min in the cat).<sup>27</sup> See **Figure 6** for opioid selection considerations.

After an anti-inflammatory drug, a local block, and an opioid have been chosen, adjunctive drugs should be added. Dexmedetomidine and medetomidine provide both sedation and analgesia, and their analgesic effects are synergistic with those of the

opioids, thus enhancing the effects of the less potent opioids.<sup>28</sup> Ketamine, administered as a subanesthetic dose infusion in a multimodal protocol, prevents or decreases the development of central sensitization, a condition that significantly amplifies pain intensity.<sup>27</sup>

Adjunctive drugs with less proof of efficacy include maropitant and gabapentin. Although minimum alveolar concentration reduction does not necessarily indicate analgesia,<sup>22</sup> maropitant decreased minimum alveolar concentration in cats (administered at label dose) and dogs (administered as infusion).<sup>29,30</sup> If not an analgesic, the potential for increased patient comfort secondary to decreased vomiting makes maropitant a



**FIGURE 4** *Intraperitoneal lavage technique for dogs and cats.*

**INDICATIONS:** Feline and canine ovariohysterectomies. (This technique may be more effective than mesovarium block because analgesia will be provided at both the ovarian and uterine surgical sites.)

**INSTRUCTIONS:**

1. Select and calculate the full dose of a local anesthetic, i.e., lidocaine (cats = 2–4 mg/kg, dogs = 4–6 mg/kg), bupivacaine (cats = 1 mg/kg, dogs = 2 mg/kg), or ropivacaine (cats = 1 mg/kg, dogs = 2 mg/kg). If necessary, dilute the drug with saline—the total volume needs to be a minimum of 0.4–0.6 mL/kg to lavage or bathe the entire abdominal cavity.
2. Immediately after making the incision or after completing the abdominal procedure but before closing the incision, “bathe” or “lavage” the peritoneal cavity with the local anesthetic by instilling it into the abdomen through the incision (literally just squirting it in the abdomen).\*
3. Close the incision as usual, leaving the local anesthetic in the abdomen.

\*Laving the abdomen right after the incision may be more effective (preemptive analgesia) but the local anesthetic could potentially be absorbed by sponges used to blot blood. The goal is to leave the drug in the abdomen. Thus, lavage just prior to closure may be more efficient.

Artwork by Lauren D. Sawchyn, DVM, CMI.

valid addition to an anesthetic protocol. Gabapentin is used for treatment of chronic neuropathic pain but is unlikely to provide analgesia for acute inflammatory pain. However, gabapentin might be appropriate in patients with pre-existing neuropathic pain if dosed at a minimum of 10 mg/kg *q* 8 hr.<sup>31,32</sup> Tramadol appears to provide minimal acute pain relief in dogs.<sup>33</sup> Although it is perhaps more efficacious in cats, especially used multimodally, cats are particularly averse to the drug’s taste.<sup>34,35</sup> Tramadol is controlled and linked to human diversion, so dispensing for home use should be limited. Other adjunctive drugs and nonpharmacologic therapy are covered in the 2015 AAHA/AAFP *Pain Management Guidelines for Dogs and Cats*.<sup>2</sup>

See [aaha.org/anesthesia](http://aaha.org/anesthesia) for additional resources on designing multimodal anesthesia and analgesia protocols.

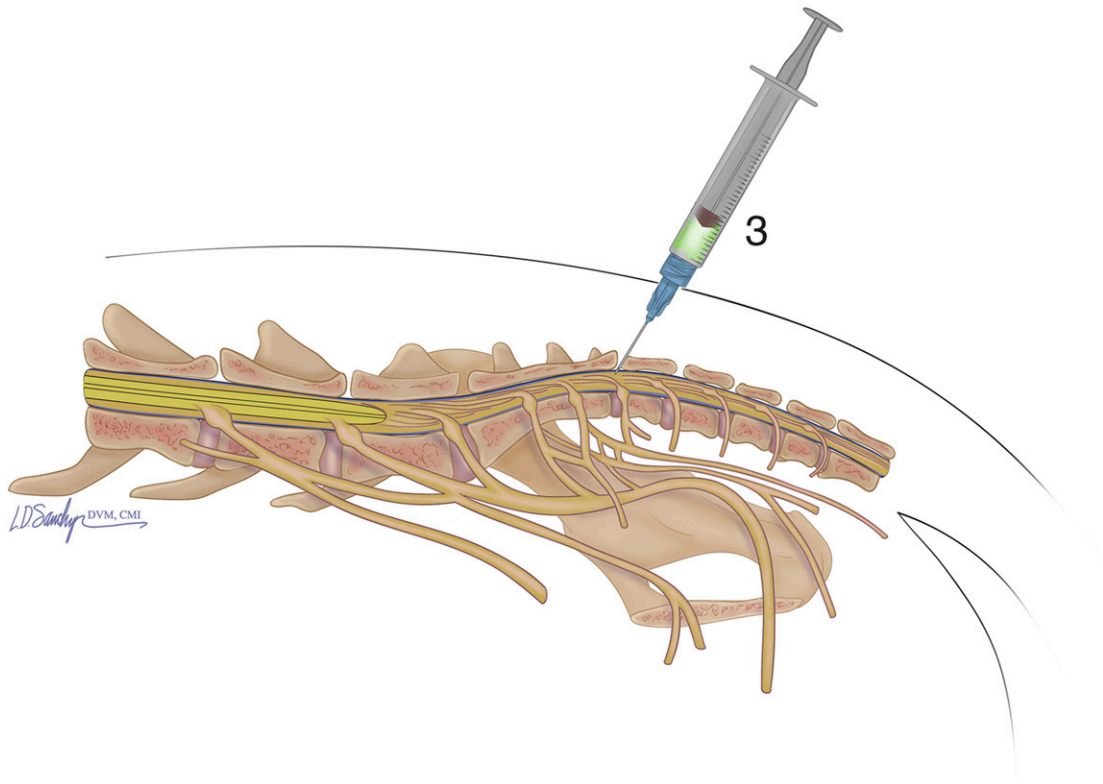
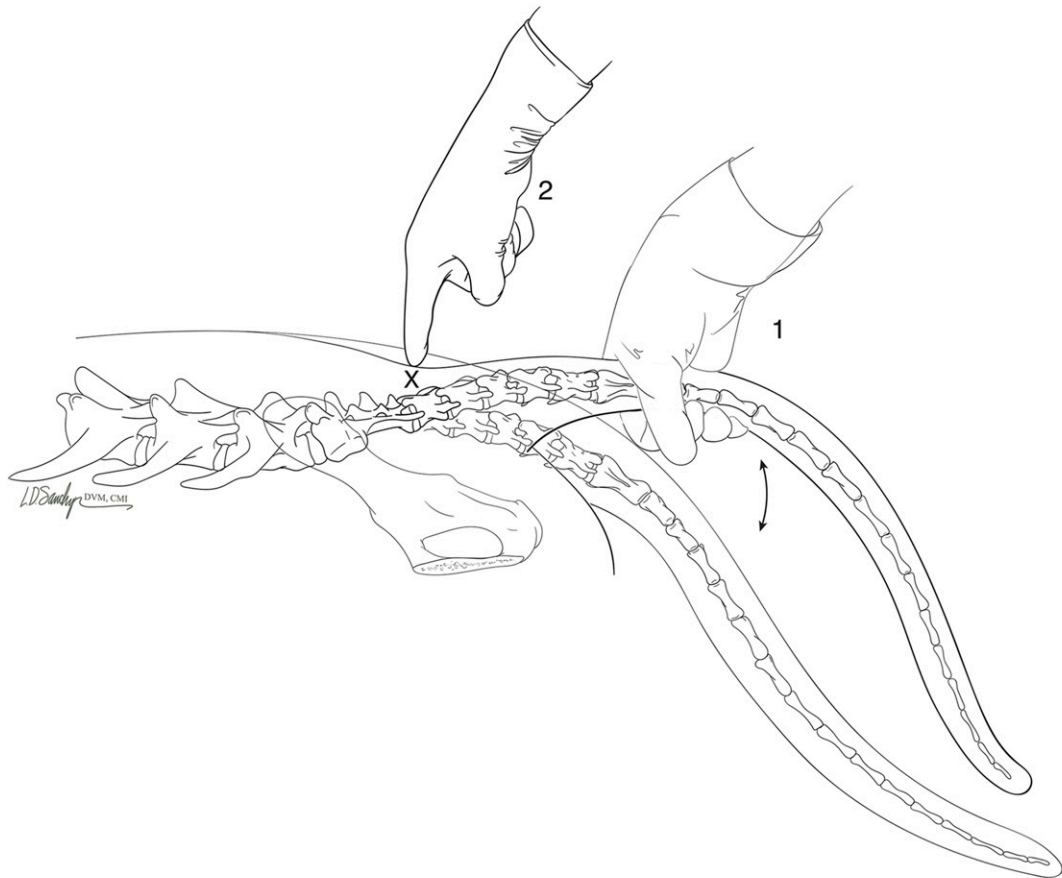
#### Multimodal Analgesic Drug Considerations for the Four Phases of Anesthesia

**Preanesthesia:** NSAIDs, opioids, alpha-2 agonists, ±maropitant, +/- gabapentin

**Induction:** Sometimes opioids, potentially ketamine (induction dose = loading dose for continuous rate infusion [CRI])

**Maintenance:** Local/regional blocks, CRI (opioid, lidocaine, ketamine, alpha-2 agonists, combinations), boluses of opioids or alpha-2 agonists

**Recovery:** NSAIDs, boluses of opioids or alpha-2 agonists, continue CRI, ±maropitant, ±gabapentin or other adjunctive drugs



**Step 4b. Preanesthetic Anxiolytics and Sedatives**

In addition to preanesthetic analgesic drugs, preanesthetic sedatives and anxiolytics are an important component of the continuum of anesthesia care. Benefits include decreased stress/anxiety and dose reduction of induction and maintenance drugs, which have dose-dependent adverse effects. Reduced patient stress can reduce risk of harm to staff members who are restraining/handling patients. As stated, providing appropriate oral medication at home can alleviate anxiety and pain prior to the pet's admission to the hospital.<sup>36,37</sup> In-hospital, preanesthetic medications can be administered by the intramuscular (IM) or subcutaneous route to achieve effects well in advance of anesthesia induction, or intravenously just prior to anesthesia for acute dose-sparing effects of induction drugs. Specific drugs/drug combinations should be chosen based on desired effects (e.g., reversible sedation) and individual patient needs (e.g., degree of analgesia; Figure 2). After premedication, physiologic monitoring and support (more information in the maintenance section) are conducted as indicated by the patient's health status. Early support of body temperature should be initiated in all patients. Thermal

supplementation is critical as hypothermia can cause numerous adverse events (more information in the Troubleshooting Anesthetic Complications section).

Premedication drugs listed in Figure 2 are also useful for sedation alone, remembering from previous information that greater patient safety is often achieved with general anesthesia, even for short

**Premedication Tips**

- Nonmedication strategies such as low-stress handling, pheromones, and environmental considerations (such as cat-only wards) play an important role in reducing patient fear and anxiety in the preanesthetic period.
- Fractious/fearful patients should be managed with appropriate preanesthetic anxiolytics and sedatives, generally at higher dosages than those required by calmer patients, to allow IV catheterization (if possible) and induction while ensuring staff safety.

←

**FIGURE 5** *Canine or feline sacrococcygeal or coccygeal epidural.*

INDICATIONS: Canine and feline tail amputations, perineal urethrostomies, anal sacculotomies, catheterization for relief of urethral obstruction, perineal relaxation for delivery of puppies/kittens, and other surgeries of the penis or perineal region.

## INSTRUCTIONS:

1. For either dogs or cats, use 0.1 mL/kg of either lidocaine, bupivacaine, mepivacaine, or ropivacaine.
  - a. A dose of 0.1 mL/kg is usually sufficient but up to 0.2 mL/kg is reported. The average volume in a cat or small dog is 0.5 mL.
2. To find the sacrococcygeal site, move the tail up and down in a “pumping” motion while palpating the sacrococcygeal region of the patient (1).
  - a. The first movable space at the caudal end of the sacrum is either the sacrococcygeal or intercoccygeal space (2). Either site is appropriate for injection and there is no need to differentiate what site is being palpated.
3. Insert a 25- or 22-gauge hypodermic needle through the skin ON MIDLINE at a ~45° angle to the skin surface. Proceed slowly until the needle enters the space (3).
  - a. If bone is encountered (it usually is), withdraw the needle a few millimeters, redirect slightly (steeper or flatter angle), and reinsert (“walking” off the bone).
  - b. Repeat this process until the needle is inserted between the vertebrae to enter the intervertebral space. A “pop” may be felt and there should be no resistance to injection.<sup>†</sup>

CONSIDERATIONS: (1) Pelvic limb motor function is not blocked unless the volume of local anesthetic is large, causing cranial spread to the motor nerves of the pelvic limbs. Stay at or below the 0.2 mL/kg volume. (2) If tail/anus relaxation does not occur within 5 min (within 8–10 min with bupivacaine or ropivacaine), the injection may have been made subcutaneously. Try again!

\*Opioids could be added as adjunct for perineural blocks, but they will not reach the receptors in the spinal cord and thus will not provide the long duration achieved with lumbosacral injection.

<sup>†</sup>There is generally no need for the saline test dose as is used for lumbosacral epidurals—just inject the drugs. Do not inject air; an air bubble may cause incomplete block because this is a very small space.

Artwork by Lauren D. Sawchyn, DVM, CMI.



Opioid	Analgesia	Onset (min)	Duration	Comments and Adverse Effects	Dose	Typical Starting Dose
					<i>in mg/kg unless otherwise indicated</i>	
<b>Fentanyl</b> 50 µg/mL DEA Class II	Profound analgesia Full mu and kappa agonists	<1–2	20–30 min	Less likely to cause adverse effects than other full opioid agonists; most commonly used as bolus for brief painful stimulus, as an infusion, or in a transdermal patch  More potent than the drugs listed below	<b>Dog and cat:</b> 0.001–0.005 IV, Can administer up to 0.02  Most commonly used as a CRI	<b>CRI, dog and cat:</b> Loading dose: 0.001–0.003 (mg/kg), Intra-op: 0.05–0.7 µg/kg/min, Post-op: 0.03–0.2 µg/kg/min
<b>Morphine</b> 10 mg/mL DEA Class II	Profound analgesia Full mu and kappa agonists	1–5 IV or 10–20 IM	2–4 hr	Adverse effects are minimal; may cause vomiting after IM injection, histamine release if administered fast IV, bradycardia and respiratory depression. Recommend co-administration with a tranquilizer to decrease excitement in cats.	<b>Dog:</b> 0.25–1.0 IM or slowly IV <b>Cat:</b> 0.1–0.3 IM or slowly IV	<b>Dog:</b> 0.5 (0.25 for geriatric and compromised patients) IM. <b>Cat:</b> 0.2 IM
<b>Hydromorphone</b> 2 mg/mL DEA Class II				Similar to morphine but no histamine release. May cause hyperthermia in cats, especially at doses >0.1 mg/kg	<b>Dog:</b> 0.1–0.2 IM or IV <b>Cat:</b> 0.1 IM or IV	<b>Dog and cat:</b> 0.1 IM, IV
<b>Methadone</b> 10 mg/mL DEA Class II				Similar to morphine but no histamine release and little to no vomiting; is also an N-methyl-D-aspartate antagonist but clinical significance is not known	<b>Dog and cat:</b> 0.2–0.4 IV; 0.2–0.6 (up to 1.0 in dogs) IM <b>Cat:</b> 0.6 OTM	<b>Dog and cat:</b> 0.4 IM, IV
<b>Buprenorphine</b> 0.3 mg/mL DEA Class III	Moderate analgesia Partial mu agonist	20–45	4–8 hr depending on pain intensity, concentration, and dose	Long duration of action but slow onset of action and minimal to no sedation; same adverse effects as other opioids but effects are generally mild	<b>Dog and cat:</b> 0.01–0.03 IM, IV  Commonly used in cats OTM to administer at home at 0.03–0.05 BID - TID	<b>Dog and cat:</b> 0.02 for IV, IM.
1.8 mg/ml DEA Class III			1 hr		24 hr	<b>Cat:</b> 0.24 mg/kg SQ
<b>Butorphanol</b> 10mg/mL DEA Class IV	Mild - moderate analgesia Kappa agonist, mu antagonist	3–5 IV or 5–15 IM	20–60 min (dog) 90 min (cat)	Decent sedative in both dogs and cats, especially if combined with a tranquilizer; same adverse effects as other opioids but effects are generally mild	<b>Dog and cat:</b> 0.2–0.4 mg/kg IM or IV	<b>Dog and cat:</b> 0.4 for surgery, 0.2 for sedation without surgery

Choose an opioid based on the anticipated level of pain that may be experienced by the patient based on comorbidities and surgical procedure.  
OTM, oral transmucosal

**FIGURE 6** Opioid selection considerations.

Drug	Dose* (mg/kg)	Caution	Comments	Dosing Example
Propofol	2–6	Causes dose-dependent cardiorespiratory depression	Fast onset, short duration, so easy to titrate to effect. Repeat dosing is safe in both cats and dogs	
Alfaxalone	1–3 (D) 2–5 (C)		Fast onset, short duration, easy to titrate to effect. Can be administered IM as a sedative (see sedation chart)	
Etomidate	1–3	Decrease dose by co-inducing with 0.2–0.4 mg/kg of midazolam or diazepam  Can cause myoclonus, paddling, and vocalization at induction but can be prevented with co-induction with a benzodiazepine. Etomidate with propylene glycol is an irritant to veins, causes pain on injection, and perivascular injections causes tissue necrosis/phlebitis. Can cause adrenocortical suppression—use in patients with adrenocortical insufficiency is controversial	Ideal choice for patients with significant cardiovascular disease. Causes minimal to no cardiovascular effects but some respiratory depression with rapid IV administration. Can dilute with fluids running to decrease injection pain and vascular effects	
Thiopental	5–15		Will cause tissue necrosis and phlebitis if extravasated; causes respiratory and cardiovascular depression	Currently unavailable in the US
Ketamine + Midazolam or Diazepam	2–5 0.1–0.4	Ketamine used alone causes muscle rigidity and could potentially exacerbate some types of seizures and tachyarrhythmias. These effects are alleviated with the addition of the benzodiazepine. Ketamine is cleared in part unchanged by the kidney in cats so use with caution in cats with renal failure	Most commonly administered as a 1:1 ratio by volume using 100 mg/ml ketamine and diazepam or midazolam (5 mg/ml) with an anticipated total dose of 2 ml/ 20 kg IV in a non- or lightly sedated patient and 1 ml/20 kg IV in a moderately sedated patient	A lightly sedated 20 kg patient would receive 1 ml diazepam + 1 ml ketamine combined in the same syringe for administration
Ketamine + Propofol	2–4 2–4	Same as each drug used individually. May decrease adverse effects of each drug (e.g., less propofol-induced respiratory depression, less ketamine-induced muscle rigidity)	Combine 2–4 mg/kg of each drug (ketamine 100 mg/ml + propofol 20mg/ml) in the same syringe and dose at 2–4 mg/kg of the COMBINATION	For a 20-kg dog, draw up 40 mg (2 mL) propofol and 40 mg (0.4 mL) ketamine. The combination concentration is 80 mg/mL
Tiletamine and Zolazepam	1–4	<b>Without the concurrent use of sedatives</b> , can cause prolonged, “rough,” or dysphoric recovery, especially in dogs. Tiletamine has the same cautions as ketamine and same alleviation of adverse effects because it is combined with a benzodiazepine	Physiologic effects similar to those of ketamine + midazolam or diazepam	These dosages are for a sedated patient. Dosages as high as 6–9 mg/kg may be necessary without sedation

Administer one of the drugs or drug combinations as deemed appropriate for any underlying comorbidity. After sedation is achieved, titrate induction drug “to effect,” anticipating use of the lower end of the dose range for moderately sedated animals or those with moderate systemic disease. A dose lower than that listed may be adequate for heavily sedated, obtunded, severely diseased patients, neonates and “true” geriatrics (i.e., those showing age-related changes). Use caution in patients with inadequate sedation, as this may necessitate a higher dose, which could lead to more physiologic complications.

\* Dosages are the same for both dogs (D) and cats (C) unless otherwise indicated.

**FIGURE 7** IV induction protocols for dogs and cats.

procedures, especially if they are painful (biopsy, laceration repair, etc.). A crucial point is that sedated patients, just as those under general anesthesia, require appropriate monitoring and supportive care. Administer supplemental oxygen to the deeply sedated patient using a facemask. The patient may require airway management, so be prepared to intubate if necessary.

#### Step 4c. Anesthetic Induction

Preoxygenation should be considered part of the preanesthetic/induction sequence. Delivery of 100% oxygen for only 3 min provides almost 6 min of adequate saturation of hemoglobin with oxygen.<sup>38</sup> This is especially critical in patients with airway disease (e.g., pneumonia, asthma) and breathing difficulty (e.g., upper

Drug Combinations	Dose (mg/kg)	Comments	Dosing Example
Dexmedetomidine* + Ketamine + Opioid of choice (see Figure 6)	0.005–0.01 + 3–10 + Drug specific	Most commonly used in cats but also acceptable for small dogs (the volume is fairly large for IM injection in medium-large dogs)  <b>Quick tip:</b> The combination is generally dosed as approximately 0.1–0.2 mL per <b>4.5 kg (10lb)</b> patient body weight of <b>each</b> drug. The low end of the dose is used for moderate sedation, the high end of the dose for deep sedation/ induction/light anesthesia. For use in dogs, the dexmedetomidine dose is sometimes decreased slightly and the opioid volume may increase, depending on drug selection	Induction for a 4.5 kg (10lb) cat would be: 0.2 mL of 0.5 mg/ml dexmedetomidine + 0.2 mL ketamine + 0.2 mL 10 mg/mL butorphanol or 0.3 mg/mL buprenorphine <sup>†</sup>
Tiletamine and Zolazepam	3–10	Administer with a sedative (e.g., dexmedetomidine) or in sedated patient to decrease the dose and the likelihood of rough recoveries  Cautions: Can cause prolonged, “rough,” or dysphoric recovery, especially in unsedated dogs. May sting on injection. Tiletamine has the same cautions as ketamine and same alleviation of adverse effects because it is combined with a benzodiazepine	Can be administered IM as a sedative (see Figure 2)
Dexmedetomidine + Tiletamine and Zolazepam + Butorphanol	See comments  Same dosages for dogs and cats	<b>Cautions:</b> Potent combination, dose carefully  <b>Note:</b> Butorphanol provides only mild analgesia, use multimodal analgesic protocols	Reconstitute tiletamine/zolazepam powder with 2.5 mL 0.5 mg/mL dexmedetomidine and 2.5 mL 10 mg/mL butorphanol for a final concentration of 100 mg of tiletamine-zolazepam, 0.25 mg dexmedetomidine and 5 mg of butorphanol, and per mL of mixture  Dose at 0.005 (light sedation to 0.04 (moderate plane of anesthesia) mL/kg
<p>The sedative and induction drugs can be combined in the same syringe and administered IM in healthy patients. Although these protocols are also acceptable for patients with mild disease, since the drugs cannot be titrated “to effect,” an IV induction protocol is preferred for patients with moderate disease, neonates and “true” geriatrics (i.e., those showing age-related changes). Conversely, an IM protocol is often preferred—and sometimes the only reasonable choice—for patients that are fractious and/or aggressive. Profound sedation can occur rapidly, so intubation tools and oxygen should be available. The low-end of the dosages is used for moderate sedation, the high end of the dosages for deep sedation/light anesthesia, which can be both anesthesia induction and maintenance for short procedures.</p> <p>* Medetomidine can be used at the same volumes as dexmedetomidine in the protocols listed as mL/kg but the mg/kg dose is double that of dexmedetomidine</p> <p><sup>†</sup> For other opioids, the volume must be calculated as the 0.1–0.2 mls may not be appropriate for all opioids.</p>			

**FIGURE 8** Intramuscular (IM) sedation/induction combination protocols for healthy dogs and cats.

airway dysfunction, limited thoracic movement [e.g., thoracic injury, impingement on diaphragm from dilated stomach or gravid uterus]) and in patients with expected difficult intubation (e.g., upper airway collapse or airway foreign body). All pregnant patients should be preoxygenated to ensure adequate fetal oxygen delivery.

A patient’s sedation level following preanesthetic drugs will influence the dose of induction drug, which should always be dosed “to effect.” Typically, appropriate premedication will result in lower doses of induction drugs. In addition, sick, debilitated, or depressed patients may require lower doses than healthy, alert patients. Anesthetic induction is most effectively and efficiently achieved by IV administration of fast-acting drugs (dosages and specific protocols in Figure 7),

such as propofol, alfaxalone, etomidate, diazepam- or midazolam-ketamine, or tiletamine-zolazepam. IV induction allows rapid airway control. IM administration (Figure 8) of a combination of a sedative and either ketamine or tiletamine-zolazepam combined in the same syringe can be used to both premedicate and induce patients whose venous access is limited by size (i.e., cats and very small dogs) or temperament (i.e., fractious or aggressive). This does not allow rapid control of the airway, and patients should be observed closely as they are becoming unconscious. Supplemental oxygen administration during this period should be considered in manageable (i.e., not fractious or aggressive) patients.

A patent airway should be secured using placement of an ETT or supraglottic device as soon after induction as possible. Tracheal

intubation is an essential part of maintaining an open and protected airway. The length of the tube should be assessed prior to intubation. The proper length will allow the proximal end of the tube to be at or just external to the incisors and the distal tip of the tube to lie midway between the larynx and the thoracic inlet. The largest-diameter ETT that will easily fit through the arytenoid cartilages without trauma should be used. This will minimize resistance and the work of breathing. Correct placement can be confirmed by direct visualization of the tube between the arytenoids, movement of the rebreathing bag, condensation in the ETT during exhalation, and/or observation of a definitive end-tidal carbon dioxide (ETCO<sub>2</sub>) tracing. A properly inflated cuff on a conventional ETT is necessary to create a seal for adequate positive pressure ventilation (PPV) and avoid inhalant leakage, being aware that overinflation may cause tracheal damage.<sup>39</sup> Applying a light coating of sterile lubricating jelly improves the cuff's ability to seal the airway.<sup>40</sup> Once the patient is intubated and connected to a breathing circuit, ensure that O<sub>2</sub> is flowing, close the pop-off valve or push down the button on the safety pop-off valve, and administer a manual breath to 15–20 cm H<sub>2</sub>O while listening at the patient's mouth for a slight hissing sound, audible if the cuff is under-deflated. If detected, slowly inflate the cuff while simultaneously administering a manual breath. Once the sound has disappeared, immediately open the pop-off valve or release the button on the safety pop-off valve and secure the ETT to the patient's head. Self-sealing baffled ETTs may be more leak resistant, but they do not allow air to escape around them if the airway pressure is excessive. When changing the patient's position after intubation, disconnect the ETT from the breathing tube so that the ETT does not rotate within the trachea as tube rotation may cause tracheal tears, especially if the cuff is relatively overinflated. Tracheal tears are a significant issue in anesthetized intubated cats.<sup>39,41</sup>

Final considerations: Padding and appropriate positioning (especially for cachectic, geriatric, or large patients) should be provided.

Apply corneal lubricant postinduction to protect the eyes from corneal ulceration after induction and every 2–4 hr.

#### Induction and Intubation Tips

- Mask or chamber inductions can cause stress, delayed airway control, and environmental contamination and are not recommended by the authors.
- Intubation tip: The capnograph adapter can be placed on the end of the ETT to confirm proper endotracheal tube placement during intubation.
- Cats can be particularly difficult to intubate. See tips in the *2018 AAEP Feline Anesthesia Guidelines*.<sup>3</sup>

#### Step 4d. Anesthetic Maintenance

Anesthesia is typically maintained using inhalant anesthetics delivered in O<sub>2</sub> and dosed “to effect.”<sup>19,38</sup> Maintenance can also be achieved using continuous infusions or intermittent doses of injectable agents, or a combination of injectable and inhalant drugs. Short-duration maintenance can be achieved with IM administration of sedatives plus ketamine or tiletamine/zolazepam. IM alfaxalone can be effective for short-duration, deep sedation in cats and small dogs, but the high dose required for anesthesia maintenance in healthy cats can cause excitement and hypermetria in recovery.<sup>42</sup>

- **Physiologic Monitoring:** Regardless of the drugs used for anesthesia maintenance (i.e., inhalant or injectable), vigilant monitoring, interpretation of physiologic changes, and response to patient physiologic status by well-trained and attentive staff are critical. Monitoring decreases the odds of anesthetic death,<sup>18</sup> whereas lack of monitoring increases the odds of anesthetic death by a factor of 5–35.<sup>5</sup> Both

Drug	IV Dose	Positive Inotrope (PI) or Vasoconstrictor (VC)	Administration
Ephedrine	0.1–0.2 mg/kg bolus	PI and VC	Indirect action causes release of norepinephrine at adrenergic receptors, Tachyphylaxis with repeated doses
Dopamine	1–15 µg/kg/min	PI	Given as a CRI
Dobutamine	1–10 µg/kg/min	PI	Given as a CRI
Phenylephrine	0.3–1 µg/kg/min or 1–3 µg/kg bolus	VC	Given as CRI or intermittent boluses
Norepinephrine	0.05–0.3 µg/kg/min	Mainly VC	Given as a CRI

**FIGURE 9** Drugs to support blood pressure in the anesthetized patient.

multiparameter electronic monitors and hands-on assessment of the patient by the anesthetist should be used. Treatment decisions should be made based on information from both the electronic monitors and the anesthetist's assessment. Monitoring respiratory function includes respiratory rate, oxygenation (percentage of hemoglobin saturated with oxygen [SpO<sub>2</sub>]), and ventilation (ETCO<sub>2</sub>). BP, heart rate (HR) and rhythm (ECG), capillary refill time, mucous membrane color, and pulse oximetry (SpO<sub>2</sub>) provide the best indices of cardiovascular function. Anesthetic depth is monitored, and a surgical plane of anesthesia is typically defined as a patient with absent palpebral reflex, mild jaw tone (i.e., muscle relaxation), and lack of purposeful movement. Body temperature monitoring is critical, with heat supplementation starting early; see section on anesthetic complications.

- **Physiologic Support:** Regardless of the drugs used for anesthesia maintenance (i.e., inhalant or injectable), O<sub>2</sub> should be delivered to the patient. The O<sub>2</sub> flow rates depend on the breathing circuit (see section on equipment preparation). For an RC, use a relatively high flow rate (2–3 L/min) when rapid changes in anesthetic depth are needed, such as during the transition from injectables to inhalants (induction) or when discontinuing inhalants at the end of the procedure. Because of the high oxygen flow, increased flow at induction and after discontinuing inhalants is not necessary when using an NRC. Increased inspired CO<sub>2</sub> suggests an inadequate O<sub>2</sub> flow rate. Following induction and intubation, the patient may be apneic or have a low or shallow respiratory rate, requiring intermittent (1–4 breaths/min) PPV breaths delivered by the anesthetist to maintain anesthesia until the respiratory depression of the induction drugs subsides. If PPV is excessive, ETCO<sub>2</sub> levels will decrease below the level that stimulates ventilation and the patient may not begin spontaneously breathing. Balanced crystalloid fluids should be administered for most patients undergoing anesthesia. The basal fluid rate for healthy dogs and cats is 5 mL/kg/hr and 3 mL/kg/hr, respectively. Additional volume should be added to the basal rate for correction of hypovolemia, including dehydration, and replacement of ongoing fluid losses. Fluid volume should increase or decrease depending on the patient's health status and fluid needs. See the *2013 AAHA/AAFP Fluid Therapy Guidelines for Dogs and Cats* for more information.<sup>43</sup>
- **Troubleshooting Anesthetic Complications:** Immediate and effective response to complications during anesthesia is critical. The most common complications are hypotension, hypoventilation, hypoxemia, hypothermia, and some arrhythmias like sinus tachycardia and bradycardia. Complications in the cardiovascular and respiratory systems are generally the most acutely life-threatening.

More detailed information for cats is available with the *2018 AAEP Feline Anesthesia Guidelines* and online at [aaha.org/anesthesia](http://aaha.org/anesthesia).<sup>3</sup>

#### o **Cardiovascular System Complications:**

- **Hypotension** is a common complication during anesthesia and is defined as BP values of systolic <80–90 mm Hg, mean <60–70 mm Hg, and diastolic <40 mm Hg.<sup>44</sup> Evaluation of other physiologic parameters (capillary refill time, peripheral pulse palpation) can be used to aid in the diagnosis of inadequate blood flow. Balanced anesthetic techniques such as additional opioid or a local block may permit a further decrease in inhalant dose, thus improving BP. Complete avoidance of the inhalant anesthetic-mediated dose-dependent vasodilatation can be achieved by application of partial or total intravenous anesthesia techniques (Figures 7 and 8). An IV crystalloid (5–20 mL/kg, depending on patient needs) and/or colloid (1–5 mL/kg) bolus can be administered IV. If the patient is also bradycardic, administer an anticholinergic (atropine, glycopyrrolate) or sympathomimetic (e.g., ephedrine). If decreased cardiac contractility or excessive vasodilation are causing hypotension, administer a positive inotrope or vasoconstrictor, respectively (Figure 9). If hypotension continues, ensure that the patient is not hypoglycemic, hypothermic, or anemic/hypoproteinemic and that there is no electrolyte imbalance. Initiate BP support and corrective therapy if these abnormalities are present.

- **Arrhythmias** commonly occurring perioperatively include sinus tachycardia, sinus bradycardia, atrioventricular block, and ventricular arrhythmias. Monitor using auscultation or ECG and/or by observing pulse–HR incongruity with Doppler ultrasound or SpO<sub>2</sub> waveform. The decision of whether to treat an arrhythmia should be based on the severity, the effect on other hemodynamic parameters (e.g., BP), and the likelihood of deterioration to a more significant arrhythmia. Examples of common arrhythmias and treatment considerations seen during anesthesia can be found at [aaha.org/anesthesia](http://aaha.org/anesthesia).

- **Tachycardia**, HR >180 bpm in cats<sup>3</sup> and HR >150–190 bpm for large and small dogs, respectively,<sup>44</sup> during anesthesia deserves special mention, because it should prompt the anesthetist to run through a list of rule-outs and not simply assume it is a response to inadequate anesthetic depth. Tachycardia can be secondary to a noxious stimulus, hypoxemia, hypercarbia, and hypovolemia. It can also occur secondary to administration of drugs such as alfaxalone, ketamine, atropine, and dopamine.

- **Hypertension**, defined as a mean arterial pressure >120–140 mm Hg or a systolic arterial pressure >160–180 mm Hg,<sup>44</sup> is uncommon in the adequately anesthetized patient, even in patients with primary hypertension, because of the negative cardiovascular effects of inhalant anesthetics. Again, rule out a response



to noxious stimulation, hypoxemia, hypercarbia, hypovolemia, and a light plane of anesthesia. The BP cuff should also be examined to ensure it has not slipped distally (e.g., around the carpus). BP can be verified with a second technique such as Doppler. Analgesics such as additional opioid should be provided to the patient who is consistently hypertensive. If hypertension persists but the patient appears to be adequately anesthetized and receiving appropriate analgesia, the increased BP may be tolerated. Increasing the vaporizer concentration in an attempt to decrease BP is not advised.

#### o Respiratory System Complications

- **Hypoventilation** can be estimated by observing respiratory rate and depth (very subjective) and can be quantified using capnometry. Hypoventilation can cause hypercarbia, with subsequent respiratory acidosis, and hypoxemia. Thus, hypoventilation should be corrected.  $\text{ETCO}_2$  is  $\sim 35\text{--}45$  mm Hg in awake patients and  $\sim 40\text{--}50$  (up to 55) mm Hg in patients in an appropriate surgical plane of anesthesia. To correct increasing  $\text{CO}_2$ , first ensure that the cause is not excessive anesthetic depth by checking the vaporizer setting and evaluating indicators of the patient's anesthetic plane. Initiate PPV if  $\text{ETCO}_2$  is  $>60$  mm Hg (hypercapnia). The anesthetist can deliver breaths by manually squeezing the reservoir bag while occluding the adjustable pressure limiting valve, taking great care to not leave the valve closed except when delivering a breath. A safety pop-off relief valve will prevent this complication. A mechanical ventilator can be used if the anesthetist is knowledgeable and comfortable with ventilator use. Visit [aaha.org/anesthesia](http://aaha.org/anesthesia) for more information on mechanical ventilation. Prior to instituting PPV, the hemodynamic status of the patient should be stable, if possible, as PPV can negatively affect cardiac output through impaired venous return. Recheck BP after starting PPV. If BP declines, decrease peak airway pressure and consider a fluid bolus (5–20 mL/kg) if there is the potential that the patient is hypovolemic. PPV can also cause barotrauma, so ventilator settings should start conservatively and be adjusted based on  $\text{ETCO}_2$ . If hypercapnia persists, investigate causes of increased inspired  $\text{CO}_2$  including excessive dead space, exhausted  $\text{CO}_2$  absorbent or one-way valves not functioning properly in an RC, or inadequate oxygen flow in an NRC. If machine malfunction is suspected, it may be prudent to quickly replace the machine with a different machine.

- **Hypoxemia** ( $\text{SpO}_2 < 95\%$ , severe  $\text{SpO}_2 < 90\%$ ) is uncommon when a patient is intubated and breathing 100% oxygen.<sup>44</sup> Observation of mucous membrane color is not a sensitive indicator of hypoxemia as cyanosis will likely not occur until hypoxemia is profound.<sup>45</sup> Continuous assessment of oxygenation is best accomplished with pulse oximetry. With low  $\text{SpO}_2$ , the anesthetist may be tempted to troubleshoot the pulse oximeter by repositioning the probe, moistening the mucous membranes, or trying a

different monitor. These measures may work if the issue is indeed the probe, but prior to troubleshooting the probe, verify that the patient is properly intubated and connected to the oxygen source and that the supply of oxygen is adequate. Hypoventilation can cause hypoxemia, so adequate ventilation should be ensured, as previously described. Insertion of the ETT past the thoracic inlet can cause one-lung intubation with decreased pulmonary surface area for gas exchange. If one-lung intubation is likely, the ETT can be pulled out slightly, with the goal to move the tip of the ETT into the trachea. Hypoxemia can be secondary to atelectasis, in patients with abdominal distention or obesity positioned in dorsal recumbency, or to primary pulmonary (e.g., pneumonia) or pleural (e.g., pleural effusion) disease. If this is expected, manual or mechanical ventilation should be instituted and a positive-end expiratory pressure (PEEP) valve (2.5–5 cm  $\text{H}_2\text{O}$ ) can be added to the expiratory limb of the circuit to open collapsed airways. Decreased oxygen delivery to the tissues from perfusion issues (rather than respiratory issues) can also cause decreased  $\text{SpO}_2$  readings. Treat indicators of poor perfusion such as slow capillary refill time, brady- or tachycardia, hypotension, and weak pulses (see section on cardiovascular complications). If no improvement occurs with these treatments, the patient should be positioned in sternal recumbency as soon as possible and recovered from anesthesia with continued oxygen support.

#### o Other Complications

- **Hypothermia**, core body temperature  $<98^\circ\text{F}$ , can result in a myriad of adverse effects, including delayed drug metabolism, cardiovascular dysfunction, impaired perfusion, respiratory compromise, cerebral depression, increased incidence of wound infection, etc., and is a very unpleasant sensation in conscious patients (as described by humans).<sup>44</sup> Delayed drug metabolism and cerebral depression can result in prolonged recovery.<sup>46</sup> The most effective heating methods are circulating warm-water blankets and warm air circulation systems. Other methods of supplemental heat that may be helpful in slowing heat loss include warm IV fluids, use of a fluid line warmer, and insulation on the patient's feet (bubble wrap, baby socks, etc.). Do not use supplemental heat sources that are not designed specifically for anesthetized patients as they can cause severe thermal injury.<sup>47</sup> Because shivering significantly increases oxygen consumption, continue to provide supplemental oxygen to shivering patients, especially those with respiratory or cardiovascular compromise.

- **GER and regurgitation** can cause esophagitis and aspiration pneumonia and can lead to esophageal stricture in extreme cases. When noted, suction of the esophagus is recommended followed by lavage with saline or tap water, with concurrent endotracheal tube protection of the airway. Diluted bicarbonate can be instilled

into the esophagus to increase pH.<sup>48</sup> Maropitant prevents vomiting, promotes more rapid return to normal feeding, and improves the quality of recovery from anesthesia but appears to have a lesser effect on the incidence of reflux or regurgitation.<sup>49</sup> Metoclopramide, ranitidine, and omeprazole plus maropitant also appear to have a minimal impact on regurgitation.<sup>50,51</sup> GER and regurgitation was minimized when cisapride 1 mg/kg was combined with omeprazole 1 mg/kg.<sup>52</sup> However, as GER and regurgitation cannot be consistently prevented, the use of gastroprotectants, such as omeprazole 1 mg/kg at least twice (evening prior and morning of anesthesia), can be considered for the neutralization GER pH in at-risk patients.<sup>50</sup>

#### **Step 4e. Recovery from Anesthesia**

Although many complications occur throughout anesthesia, between 47 and 60% of all anesthetic-related dog and cat deaths, respectively, occur during the postoperative period of anesthesia, with most occurring within the first 3 hr.<sup>4-6</sup> Thus, patient care and monitoring of the recovering patient by trained personnel is critical and should be maintained with the same vigilance as during the maintenance phase of anesthesia. The anesthetist should continue monitoring specific patient physiologic parameters such as HR/RR (respiratory rate), SpO<sub>2</sub>, BP, and body temperature. Patients should be closely observed until they are alert, normothermic, and ambulatory (unless nonambulatory preoperatively). An optimal recovery time (within 10–30 min of the end of anesthesia) for dogs and cats will depend on the patient health status, type of anesthetic technique used (i.e., inhalant versus injectable), duration of anesthesia, and body temperature.

In case sedatives, analgesics, or emergency resuscitative drugs are needed, intravenous catheters should be left in place until the patient is extubated and in sternal recumbency with physiologic parameters returned to normal. Extubate when the patient's RR and SpO<sub>2</sub> are within normal limits and the patient can adequately protect its airway by vigorously swallowing. Deflate the cuff immediately before removing the ETT. With patients who have undergone a dental procedure or rhinoscopy, it is beneficial to position the nose slightly lower than the back of the head and leave the ETT cuff slightly inflated during extubation. This will help clear blood clots and debris from the trachea and deposit any fluid or debris into the pharyngeal region where it can drain from the mouth or be swallowed, thereby reducing the risk of aspiration. Respiratory depression, potentially with resultant hypercapnia and hypoxemia, often persists during early recovery from anesthesia. Severe hypercapnia can lead to cerebral impairment and potentially to respiratory arrest. The capnograph adapter can remain on the end of the

ETT to assess ventilation until the patient is extubated.<sup>53</sup> In addition, a pulse oximeter should be used throughout recovery to assess the degree of oxygen saturation.

Numerous factors can impact the quality of recovery and should be addressed to aid the patient's smooth emergence from anesthesia. Environmental stress, bright lights, excessive noise, and a cold environment can attribute to the patient's discomfort following anesthesia. Bladder distension can be very uncomfortable. Express the bladder to minimize any discomfort, especially for those patients who may be nonambulatory and unable to urinate on their own in the immediate postoperative period.

Delayed recovery, dysphoria, and emergence delirium are common complications in the postoperative period. Delayed recovery can be caused by excessive anesthetic depth during the maintenance phase. This can not only prolong the recovery phase but also negatively impact the respiratory, cardiovascular, and thermoregulatory systems. Hypothermia (body temperature <98°F [36.7°C]) can lead to multiple physiologic complications, including delayed drug metabolism, further prolonging the patient's recovery.<sup>46</sup> Patient warming devices should be used throughout the recovery phase.<sup>46,53</sup> Certain drugs can cause peripheral vasoconstriction (e.g., alpha-2 agonists) or vasodilation (e.g., inhalants), modifying the heat loss from the patient and influencing the effectiveness of external warming devices.<sup>46,47</sup> Hypoglycemia, especially in small or neonatal patients, can lead to a prolonged recovery, so monitor blood glucose frequently. Judiciously titrated drug antagonism may be considered if the patient's recovery is concerningly prolonged. Alpha-2 agonists should be reversed only if the patient is excessively sedate or rapid recovery is needed. Opioid effects should be antagonized only if other analgesics have been administered; otherwise, the patient could experience intolerable pain.

Dysphoric recoveries and emergence delirium can often be difficult to differentiate. Emergence delirium often presents as an uncontrolled, uncoordinated thrashing of the patient, often encountered when the patient has regained partial consciousness quickly after the discontinuation from maintenance anesthetic drugs. Dysphoric recoveries can result from many issues, including uncontrolled pain, and hypoxemia due to airway obstruction. Administer an analgesic if pain is suspected. If pain management is adequate, administer an anxiolytic sedative, such as dexmedetomidine (which also provides analgesia), generally 0.001–0.005 mg/kg IV or IM (up to 0.01 mg/kg). If respiratory complications are the cause of the dysphoria/delirium, provide supplemental oxygen and assess the respiratory function of the patient. In some cases, the patient will need small doses of alfaxalone 1–2 mg/kg or propofol 1–2 mg/kg IV administered slowly until calm. Be prepared to reintubate if necessary.

Final considerations: Provide adequate padding for nonambulatory patients. Reapply eye ointment every 2–4 hr during the recovery period until an adequate blink reflex is present.

### Phase 3: Return Home

Once the patient has been discharged, the anesthesia continuum comes full circle. Pet owners can benefit from receiving anesthetic discharge instructions, in addition to a surgical discharge form. This guides postoperative care by the pet owner and alleviates their concerns, addressing possible complications that could be encountered and outlining when the veterinary team should be contacted.

#### Example of Information Included in an Anesthesia Discharge Form

Pets may experience some sedation for the first 12–24 hr following hospital discharge but should be easily awakened and able to perform normal functions. Pets may have a decreased appetite for 12–24 hr following anesthesia. This time frame may be longer dependent on the type of surgical procedure performed. Pets may experience a slight cough for 1–2 days from mild irritation from the breathing tube used during anesthesia.

Call the veterinary team if:

- Your pet's appetite or activity level does not return to normal within 24 hr
- Your pet's cough is moist, progressive, or productive
- Your pet experiences any concerning changes in behavior or mentation.

Anesthesia-related drugs for discharge generally include analgesics, primarily NSAIDs for most patients, and may include anxiolytics and maropitant. Antibiotics are a component of surgical care and outside the scope of this document. Because opioids are DEA controlled and subject to diversion, they should be provided only to patients predicted to otherwise experience substantial pain and only after careful study of the DEA, FDA, and individual state guidelines. Links to regulatory information and opioid alternatives are available through the International Veterinary Academy of Pain Management.<sup>54</sup>

### Special Focus: Staff Education and Safety Training

Staff training is critical for anesthetic safety. Although this is actually the first step in anesthesia, this section has been placed separately in order to emphasize its importance.

#### Postoperative Pain Assessment

Regardless of the perceived efficacy of the analgesic protocol, assessment of the patient's pain level during recovery from anesthesia is imperative as adequate pain relief is unlikely to be achieved in all patients. Using pain scoring systems, although not perfect, increases the likelihood that pain will be recognized and treated appropriately. Pain scoring resources are available online.

Providing quality patient care through scientific and knowledge-based practice is the mission of veterinary medicine. A cornerstone of the implementation and success of this objective is the veterinary staff, from the veterinarians, technicians, and assistants to the receptionist/office personnel. Creating a cohesive team and providing the educational training resources for the staff is key to patient and personnel safety. Untrained staff can lead to unhappy, unproductive employees who are inefficient and could compromise patient care with procedural mistakes. This can lead to a decline in customer service, ultimately leading to a decrease in practice revenue as a result of the loss of clients.

A successful training program begins with the active participation of the employee. Taking the time to introduce staff to hospital policies and procedures will result in a more efficient workflow. Training can be performed by all members of the team in various capacities; for example, an experienced nurse can teach clinical skills, the veterinarian can teach science, and the patient care representative or receptionist can help with effective client communication. This allows for all practice team members to become engaged in the success of individual employees.

First, create a plan for training by determining the practice goals. Be specific in those expectations. A comprehensive staff training program is outlined at [aaha.org/anesthesia](http://aaha.org/anesthesia), organized into weekly training sessions over a 12 wk period. Assign each department into an individual training objective, an approach that minimizes the ambiguity of trying to “learn everything.” List the tasks you need each employee to learn weekly and monthly as well as the resources available to support these skills. Regularly test your new employees to ensure retention of material. Use the full spectrum of educational resources, including handouts, in-house presentations, checklists, and online courses.

Anesthesia-based training programs should start with the anesthesia machine. Employees should not attempt to use anesthetic equipment before being properly trained and qualified to troubleshoot problems.<sup>55</sup> Checklists for daily anesthesia machine function, case preparation, and preventive maintenance should be readily available to the employee. A reliable way to prevent equipment failure is to inspect each part of the machine daily and before use.<sup>56</sup> Once a technician has been trained how to set up, operate, and disassemble

the anesthesia machine, the primary focus should center on the proper use of breathing circuits, rebreathing bags, and appropriate endotracheal tube selection. AAHA.org/anesthesia provides an anesthesia machine readiness checklist. A properly working anesthesia machine is critical to not only patient safety but also operator safety. Exposure to volatile anesthetic agents, including nitrous oxide and halogenated gases, is hazardous. Although the full risks associated with anesthesia exposure are unknown, exposure should be minimized. Retrospective studies have indicated, although specific incidence is unknown, that exposure to these hazardous chemicals can result in headaches, nausea, early pregnancy loss, and reduced sperm count in humans.<sup>57</sup> A properly sealed (i.e., not leaking) machine and ETT cuff, avoidance of mask and chamber inductions, and the proper use of the scavenging systems will limit exposure to anesthesia gases.

Once an employee is comfortable operating the anesthesia machine, training should shift to include anesthetic monitoring. Most patient complications will first be detected through use of an anesthetic monitor. For that reason, the anesthetist should be comfortable interpreting patient parameters such as ECG, ETCO<sub>2</sub>, BP, SpO<sub>2</sub>, and body temperature.

Anesthesia is pharmacologically based. Thus, specific training should be conducted on the various drug classes, along with a “what to expect” guideline. Emphasis can be placed on the medications used for sedation, pain management, and general anesthesia (see the sections on Anesthesia Protocol).

All clinical personnel should be trained in emergency resuscitation, with a review session repeated every 6–12 mo. The new Reassessment Campaign on Veterinary Resuscitation (RECOVER) initiative uses a combination of online and hands-on training.<sup>58</sup> Studies show that cardiopulmonary resuscitation outcomes are affected, not only by the availability of emergency carts, drugs, and equipment but also by the level of training within the hospital. The recognition of an emergent situation is almost as critical as the response itself.

## Summary

Anesthesia, which is an integral part of daily care in veterinary hospitals, cannot be defined merely by the time that the patient is unconscious, but rather by a continuum of care that begins at home with the owner and does not end until the patient returns home to the owner for follow-up care. Anesthesia is a multidimensional procedure involving not only the patient's individual characteristics but also specific and critical equipment, appropriate drugs and drug dosages, diligent physiologic monitoring and support, thorough client communication, and highly trained staff. Using this information, a template for standardized procedures structured in a systematic, stepwise approach is described in the guidelines. This is analogous to the growing emphasis on checklists as error-prevention

and organizing tools in human medicine. Standardized methods that use medical-specific checklists have been shown to improve the quality and consistency of healthcare delivery in a variety of clinical settings.<sup>59</sup> There is an inherent risk of morbidity or mortality associated with anesthesia, but by following the continuum of anesthesia as described in the guidelines, the risk for anesthetic complications is greatly minimized. In fact, patient health can potentially be improved by increased oxygen delivery via support of both cardiovascular and respiratory systems and by alleviation or elimination of pain.

Some details from these guidelines that warrant special mention are equipment selection/maintenance, pain management, staff training, and client education. Anesthesia is equipment intensive, more so than many other medical disciplines. The best staff training and anesthesia protocols will be nullified if a faulty breathing circuit or malfunctioning valve causes anesthetic complications. Thus, regular equipment maintenance and staff proficiency in its operation are not afterthoughts, but essential, first-line aspects of anesthesia care, as presented here.

Pain management, which is highlighted in these guidelines, is integral to optimal anesthesia and recovery from surgical procedures. The patient's level of postprocedural discomfort should be evaluated by both the veterinary team and, with guidance from the team, its owner. Proactive use of pain management protocols will enhance the quality of care, patient healing, and owner satisfaction.

Communication with and education of the pet owner are important and necessary aspects of the anesthetic process. All members of the practice team should assume responsibility for conducting an informed dialog with clients about the risks of anesthesia and the commitment of the anesthesia team to decreasing those risks. Staff education equips the practice team to both decrease anesthetic risks and properly educate pet owners about general anesthesia. No aspect of veterinary practice is more dependent on staff education than anesthesia, and detailed anesthesia training protocols are a feature of the guidelines. Training sessions should preferably be accompanied by periodic refresher training and a best-practices approach. If done regularly and purposefully, staff education also creates a continuous improvement culture within the practice and fosters a teamwork environment.

The objective of these guidelines was to make the anesthesia period as safe as possible for dogs and cats while providing a practical framework for delivering anesthesia care before, during, and after the anesthetic procedure. We are confident that using the guidelines, along with supplemental information from suggested references and the online resource center at [aaha.org/anesthesia](http://aaha.org/anesthesia), will allow the anesthetist to meet that objective. ■



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