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Topic Overview

Anesthesia and analgesia for veterinary patients with comorbidities can present unique challenges, requiring careful, tailored approaches for each patient. Risks can be mitigated and patient safety enhanced by use of modified anesthesia protocols, advanced monitoring techniques, and best practices in anesthesia recovery.

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ANESTHESIOLOGY

Anesthesia and Analgesia for Patients With Comorbidities

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The goal of safe and effective anesthesia for any patient is to maintain cardiac output and oxygen delivery (perfusion) to tissues. This goal is especially crucial for patients with comorbidities. Veterinary nurses can develop an individualized preanesthesia and analgesic care plan for each patient by integrating a variety of factors. For patients with comorbidities, key factors of the plan include the patient's history, signalment, and temperament; physical examination findings; diagnostic results; and the specific reason(s) for the procedure.

Achieving successful anesthesia outcomes for patients with various comorbidities necessitates a comprehensive understanding of physiology, meticulous anesthetic monitoring, and in-depth knowledge of pharmacology. Although mastery of

these elements is essential for ensuring patient safety and optimizing anesthesia management, detailed descriptions are beyond the scope of this article, which describes some of the more commonly encountered comorbidities relevant to anesthesia and management tips for before, during, and after administering anesthesia (**BOX 1**).

CONSIDERATIONS FOR ANESTHETIZING PATIENTS WITH COMORBIDITIES

The Preanesthesia Workup

Key to choosing the most appropriate anesthesia plan is the preanesthesia workup. A thorough history and signalment should be obtained from the patient's records and discussions with the

Learning Objectives

- Individualized preanesthesia and anesthesia plans are essential.
- For anesthetized patients, vital parameters should be closely monitored and adjusted as needed.
- During postanesthesia recovery, close monitoring and administration of appropriate stress and pain management interventions help prevent complications.



client. The patient's breed should be considered (e.g., anesthesia requirements for sighthounds and brachycephalic breeds are unique).

The preanesthesia physical examination should assess and address the patient's fear, anxiety, and stress (FAS) levels because if high, they can complicate the anesthesia procedure and recovery. Reducing FAS levels may involve gentle handling as well as pre- and postprocedure medication. Physical examination should include auscultation of heart and lungs and evaluation of pulse quality. Mucous membrane status and capillary refill time provide useful information about the patient's circulatory status.

The veterinary nurse should also complete a pain score assessment (e.g., Glasgow Composite Measure Pain Scale [CMPS] for dogs [go.navc.com/3RD3jNT], Feline Grimace Scale for cats [go.navc.com/44LJSdn]). Because the Glasgow CMPS can be lengthy, additional options, such as the Colorado State University Canine Acute Pain Scales, enable the anesthetist to obtain objective information that can inform drug selection. On the basis of these findings, the veterinary nurse can then assign the patient an

American Society of Anesthesiologists physical status classification, which helps prepare the team for the risks associated with anesthesia (go.navc.com/4cQWYBT). The classification (or score) does not indicate the risk resulting from the procedure itself.

For all patients with comorbidities, a standard diagnostic database should be collected for review (**BOX 2**). Additional parameters for patients with certain comorbidities are indicated under the respective conditions below.

Before Anesthesia Induction

Before anesthesia induction, most patients with comorbidities should be connected to monitoring equipment (e.g., blood pressure, electrocardiogram [ECG]) and oxygen.

During Anesthesia

During the anesthesia event, continuous monitoring of vital parameters such as blood pressure, ECG, oxygenation, and body temperature is crucial, especially for patients with comorbidities (e.g., cardiovascular, renal, hepatic, or endocrine disorders). Some patients may also require glucose monitoring, capnography, pulse oximetry, invasive blood pressure monitoring, and/or arterial blood gas analysis. Adjustments to the anesthesia protocol, such as drug dosages or fluid therapy, should be made promptly to maintain homeostasis and minimize risks.

BOX 1

Best Practices for Anesthetizing Patients With Comorbidities

- Preoxygenating the patient with a mask to maximize functional residual capacity in the lungs by increasing the amount of oxygen, which delays hypoxia
- Using Doppler ultrasonography with oscillometric blood pressure to confirm trends
- Attaching monitoring equipment before anesthesia induction (especially for blood pressure measurement and electrocardiography)
- Avoiding hypothermia
- Reducing stress and pain before the anesthesia event and during recovery
- Using multimodal anesthetics and analgesics with concurrent local anesthetics
- If available, using invasive blood pressure monitoring via arterial catheter provides the anesthetist with continuous and real-time updates on the patient's perfusion

BOX 2

Baseline Parameters to Collect Before Anesthetizing a Patient With Comorbidities

- Blood pressure
- Electrocardiogram tracing
- CBC
- Serum biochemistry
- Electrolytes
- PCV, total solids, glucose (collect the morning of the procedure if previous parameters were collected >24 hours earlier)
- Images (radiography, ultrasonography, computed tomography)

During Recovery

Postanesthesia recovery is a critical phase during which close monitoring and appropriate interventions can prevent complications. Complications induced by stress include but are not limited to increased oxygen demand, delayed healing, inflammatory cascade, and wind-up or maladaptive pain. For patients with comorbidities, ensuring a stress-free environment, maintaining normothermia, and managing pain during recovery are crucial.

COMMON COMORBIDITIES THAT AFFECT ANESTHESIA

Cardiovascular Diseases

The cardiovascular system is a complex network responsible for delivering oxygen and nutrients to tissues and removing waste products. At its core is the heart, which pumps blood through a series of blood vessels, ensuring proper perfusion of organs. Anesthetizing patients with cardiovascular disease can be challenging because most anesthetic drugs affect cardiovascular function. Understanding the mechanisms by which anesthetic drugs work, the underlying cardiovascular disease, and the effect on homeostasis helps the anesthetist develop an effective treatment plan that minimizes cardiovascular compromise and ensures optimal oxygen delivery.

For patients with heart disease, in addition to obtaining standard vital parameters, proBNP (B-type natriuretic peptide) testing, urinalysis, and preanesthetic ECG review are recommended.

Mitral Valve Prolapse

Mitral valve prolapse (also called myxomatous mitral valvular degeneration) is a progressive disease, and the anesthesia risks are closely tied to the stage of the disease. The condition involves loss of collagen and

other connective tissues within the valve leaflets, weakening and disrupting leaflet structure,¹ leading to blood regurgitation into the left atrium, dilation of the left atrium, and eccentric hypertrophy of the left ventricle (remodeling in response to volume overload).²

- **Preanesthesia planning:** Ensuring proper hydration status before inducing anesthesia helps avoid the detrimental effects of dehydration but also of fluid overload, which can exacerbate cardiac function and lead to congestive heart failure. **TABLE 1** lists some physical findings associated with dehydration.
- **During anesthesia:** Try to maintain homeostasis and maintain a heart rate within the normal to high-normal range while avoiding tachycardia as tachycardia increases myocardial oxygen consumption and workload.⁴ Bradycardia can be treated with anticholinergics to increase heart rate, which will maintain forward blood flow and minimize afterload.⁴ Use of anticholinergics to treat a normal/ideal heart rate can result in increased cardiac workload; however, if patients are hypotensive and bradycardic, use of anticholinergics is indicated.⁴ Maintaining normothermia throughout the procedure helps prevent hypothermia-induced bradycardia and supports stable cardiovascular function.² As the prolapse progresses, the patient's myocardial contractility worsens. To maintain contractility in the face of hypotension, the anesthetist should prepare a constant-rate infusion (CRI) of dobutamine or, if unavailable, dopamine. Although α_2 agonists are not contraindicated for all patients with heart disease, they should be avoided for patients with mitral valve prolapse to prevent increased systemic vascular resistance, which increases afterload, thus worsening the regurgitation.⁵

Hypertrophic Cardiomyopathy

Hypertrophic cardiomyopathy (HCM) affects mainly cats and is another progressive cardiac disease for which the anesthesia plan depends on the degree of disease.

TABLE 1 Tips for Monitoring Hydration Status of Dogs With Mitral Valve Disease³

DEHYDRATION, %	DRY MUCOUS MEMBRANES	TACHYCARDIA	DECREASED SKIN TURGOR	DECREASED PULSE PRESSURE	SHOCK
<5	–	–	–	–	–
5–6	+	–	–	–	–
7	+	+	+	–	–
10	+	+	+	+	–
12	+	+	+	+	+



Patients with HCM are prone to tachyarrhythmias.

- **Preanesthesia planning:** Patient stress or drugs that may demand more work on the heart or increase heart rate (e.g., anticholinergics, ketamine) should be avoided.⁶ Starting fluids before anesthesia induction, specifically for patients that are dehydrated, is ideal as increasing preload is beneficial but must be used cautiously. Also, the patient's heart rate before induction should be normal to slightly reduced,² which can be facilitated by having patients with HCM receive anxiolytics before coming to the clinic; however, controversy surrounds use of α_2 agonists in patients with HCM. For cats, other options are gabapentin or melatonin.⁷ Because patients with HCM are prone to tachyarrhythmias, ECG recordings and blood pressure should be obtained before induction, while the patient is sedated and relaxed. If arrhythmias are detected, the risks of moving forward should be discussed with the veterinarian and client.
- **During anesthesia:** Multimodal anesthesia is ideal for most anesthetized patients, and for patients with HCM it offers the added benefit of reducing the required doses of drugs that cause dose-dependent vasodilation (e.g., isoflurane, propofol, alfaxalone). Opioids and benzodiazepines are safe choices for the multimodal plan.² Use of an opioid (e.g., fentanyl) CRI can enable the anesthetist to limit the use of isoflurane while maintaining a surgical plane of anesthesia. Using balanced anesthesia techniques can help prevent hypotension, which is often challenging to manage in patients with HCM. Fluid therapy with a low sodium content is ideal.⁵ To avoid tachycardia and increased contractility, drugs used to treat hypotension are typically contraindicated. Anticholinergics and positive inotropes should also be avoided. Indicated options include cautious use of fluid therapy, low inhalant concentration, and use of a pure α_1 adrenoceptor agonist (e.g., phenylephrine). To ensure an ideal hypotension treatment plan, collaboration with a cardiologist and/or an anesthesiologist is recommended.
- **During recovery:** Anesthesia recovery is a high-risk time for patients with HCM. Among other things, postanesthesia decompensation can result from hypothermia, hypoventilation, or pain.⁸ Pulse oximeter, blood pressure, and temperature monitoring should be continued until the patient is alert, mobile, and maintaining appropriate oxygen saturation.

Dilated Cardiomyopathy

Dilated cardiomyopathy (DCM) is a progressive disease that reduces cardiac contractility due to eccentric hypertrophy of the left ventricular myocardial muscles.

- **Preanesthesia planning:** Patients should be connected to monitoring equipment and oxygen.
- **During anesthesia:** The goals associated with anesthetizing patients with DCM are to improve or maintain cardiac contractility and avoid increasing afterload. Vasoconstrictive drugs should be avoided because they will increase afterload.² The anesthetist should have a dobutamine (preferred)^{1,2} or dopamine CRI available. Dopamine at a higher dose ($> 10 \mu\text{g/kg/min}$) will have α_1 adrenergic effects that lead to vasoconstriction, which should be avoided. Stroke volume in patients with DCM can be minimally increased; therefore, avoiding bradycardia can help increase cardiac output. Fluid therapy should be chosen cautiously as a patient with DCM cannot handle an excessive fluid load. Fluid delivery rates should be low but balanced with hydration. Induction drug choice depends on the degree of disease. Patients with mild disease can tolerate induction with propofol or alfaxalone, but for patients with more severe disease, use of etomidate and a benzodiazepine or benzodiazepines and an opioid (e.g., fentanyl) should be considered.^{1,2}

Hepatic Disorders

The liver is responsible for producing clotting factors, plasma proteins, and bile; glucose storage; and metabolism. When anesthetizing patients with liver disorders, knowing the distinction between liver disease, liver dysfunction, and liver failure is crucial. *Liver disease* is an umbrella term for conditions that affect the liver. Patients with liver disease may exhibit vomiting/diarrhea, loss of appetite, seizures, and/or jaundice. Liver disease can lead to liver dysfunction (inflammation or damage that affects function) or liver failure (loss of partial or all functionality). Patients with liver dysfunction require anesthesia adjustments because the associated physiologic changes affect the pharmacokinetics of anesthetic drugs (**BOX 3**). However, patients with elevated liver enzymes (hepatocellular damage) but without signs of liver dysfunction do not necessarily require specific anesthesia adjustments because they can still metabolize anesthetic drugs effectively. Thus, anesthetizing patients with liver dysfunction focuses on drug choices. Patients with liver failure may exhibit neurologic signs and clotting abnormalities.⁹

BOX 3**Key Factors That Affect Pharmacokinetics of Anesthetic Drugs in the Liver**

- **Decreased albumin production:** Liver dysfunction often results in reduced albumin production.
 - **Decreased plasma binding:** Lower albumin levels lead to decreased plasma-binding capacity for certain anesthetic drugs.
 - **Increased circulating free drug:** With reduced protein binding, a higher proportion of the drug remains unbound or free in the bloodstream.
 - **Greater or prolonged effects:** Increased unbound drug leads to more pronounced or extended effects due to enhanced tissue uptake.
 - **Altered drug metabolism:** Hepatic dysfunction can hinder the metabolism of anesthetic drugs, potentially leading to prolonged effects and increased risk for toxicity.
 - **Reduced drug clearance:** Hepatic dysfunction may result in decreased clearance of anesthetic drugs from the body, extending their duration of action.
 - **Changes in drug distribution:** Liver disease can alter blood flow and tissue perfusion, impacting how anesthetic drugs are distributed within the body.
 - **Increased sensitivity to drugs:** Patients with liver dysfunction may be more sensitive to anesthetic drugs, necessitating careful dose adjustments.
- **Preanesthesia planning:** When selecting drugs, consider the extent of hepatic dysfunction, the patient's temperament, the adverse effects of each drug, and the specific purpose for anesthetizing the patient. Ideally, the selected drugs should be reversible and have a short half-life to minimize prolonged effects and potential toxicity. Avoid drugs that rely heavily on hepatic metabolism and elimination (e.g., benzodiazepines, certain opioids such as morphine). Instead, consider using drugs that are primarily metabolized through alternative pathways. For example, propofol is rapidly metabolized by the liver, but extrahepatic clearance makes it a relatively safe choice. The inhalant anesthetics isoflurane and sevoflurane are minimally metabolized in the liver, making them preferable for maintenance anesthesia. In addition, using

adjunctive medications such as dexmedetomidine can provide sedation and analgesia with minimal effect on liver function. Two beneficial parameters to assist drug metabolism for patients under anesthesia are normal blood pressure and normothermia.¹⁰ Patients in a high state of FAS before anesthesia should receive appropriate medications, which depend on the level of hepatocellular damage, disease, or dysfunction.

- **During anesthesia:** Anesthesia agents can alter hepatic perfusion, affecting blood flow through the hepatic artery, portal vein, or both. Hepatic bidirectional blood flow can also be affected by several diseases and factors, such as manual or mechanical intermittent positive-pressure ventilation, hypoxemia, hypercarbia or hypocarbia, α -adrenoceptor agonists, histamine-2 receptor antagonists, hypotension, cirrhosis or hepatitis, and excessive sympathetic nervous system stimulation (flight or fight response).

Hypoglycemia

Patients with liver disease can become hypoglycemic due to the liver's impaired ability to store and release glucose.

- **Preanesthesia planning:** Before inducing anesthesia, the patient's glucose level should be determined.
- **During anesthesia:** Blood glucose should be monitored every 30 to 60 minutes. The specific time interval should be based on the treatment administered for hypoglycemia, allowing for evaluation of treatment effectiveness versus baseline monitoring. If the veterinary team determines that glucose supplementation with dextrose is necessary, a 2.5% to 5% dextrose solution can be added to the maintenance fluids. However, if high fluid rates are required due to hypovolemia, it is advisable to supplement glucose with a separate dextrose CRI, which ensures proper glucose management without compromising fluid balance.

Hypoalbuminemia

Decreased colloid oncotic pressure can exacerbate hypotension in anesthetized patients. Albumin is responsible for approximately 80% of the colloid oncotic pressure in plasma.¹¹ Albumin levels below 1.5 g/dL can decrease colloid oncotic pressure, leading to edema (peripheral or pulmonary).¹²

- **Preanesthesia planning:** The anesthesia plan should include an option for natural oncotic support with



fresh frozen plasma, whole blood, or albumin. Veterinary research on the benefits and risks of using synthetic products is limited; therefore, synthetic colloids should be used cautiously until more comprehensive study results are available.¹¹ Ascites in patients with severe liver dysfunction can lead to anesthesia complications by affecting pulmonary expansion and function. Abdominal fluid removal must be done cautiously to prevent adverse effects, such as significant fluid shifts, which could result in profound hypovolemia or cardiovascular collapse.¹³

Coagulopathies

The liver plays a crucial role in producing most coagulation factors, with the exception of factor VIII and von Willebrand factor. When liver dysfunction is present, the metabolism of many coagulation cascade activators is impaired. In cases of liver failure, the patient may be at risk for disseminated intravascular coagulation due to the liver's decreased ability to manage coagulation activators.¹²

- **Preanesthesia planning:** When coagulation is prolonged, treatment with fresh frozen plasma is recommended to provide the necessary coagulation factors and help correct coagulopathies. If fresh frozen plasma is not available, delivery of whole blood will also provide the necessary clotting factors.
- **During anesthesia:** Hypothermia, common during anesthesia, can prolong coagulation times, making it essential to maintain normothermia during recovery.¹⁴

Renal Disorders

The kidneys receive approximately 20% of cardiac output and consume oxygen at a high rate to conduct their role in secretion, reabsorption, and filtration. In healthy patients, autoregulation of renal blood flow and glomerular filtration rate remains stable when mean arterial pressure (MAP) is maintained between 60 and 150 mm Hg; autoregulation (perfusion) is impaired if below 60 mm Hg. In patients with systemic hypertension, the autoregulatory range may differ. For patients with renal failure, MAP should be at least 80 mm Hg, which is the lower limit for renal blood flow autoregulation.¹⁵ Compromised renal blood flow, and consequently glomerular filtration rate, due to prolonged periods of hypotension under anesthesia can lead to an ischemic event. Even conditions before anesthesia (e.g., dehydration, stress, pain) can alter glomerular filtration rate.¹⁵ To avoid hypoventilation,

ventilation under anesthesia should be monitored by using capnography. Elevated carbon dioxide levels can lead to respiratory acidosis, which subsequently increases potassium levels by shifting potassium out of cells into the bloodstream.¹⁵ Conditions that can result from renal disease are azotemia, anemia, hypoproteinemia, and hyperkalemia.

Azotemia: If the patient has any level of azotemia (accumulation of nitrogenous waste products such as urea and creatinine in the blood), the level of azotemia should be reduced, if possible, before the anesthesia event.¹⁶ Euhydration and maintaining renal blood flow while the patient is anesthetized will help prevent further kidney injury.

Anemia: Patients with anemia tend to have lower cardiovascular reserves while anesthetized.¹⁶ For patients with a PCV lower than 20%, a blood transfusion before anesthesia should be considered due to the decreased oxygen-carrying capacity. Preoxygenation improves oxygen capacity and delays onset of hypoxemia. To optimize oxygen levels before anesthesia induction, administration with a tight-fitting mask for 3 to 5 minutes is recommended.¹⁷

Hypoproteinemia: Hypoproteinemia increases the amount of unbound drug in the bloodstream, thereby potentiating its effects. In uremic patients, potentiation is further exacerbated by increased permeability of the blood–brain barrier, which allows more drug to enter the central nervous system.¹⁸ For patients with hypoproteinemia, the anesthetist should consider decreasing doses of drugs that are highly protein bound (e.g., benzodiazepines, etomidate, thiopental, propofol).^{14,18}

Hyperkalemia: The most consequential disturbance in patients with end-stage chronic kidney disease or acute kidney injury is hyperkalemia (serum potassium level of 5.5 mEq/L or greater). Increased potassium levels result from the kidneys' inability to eliminate it. Efforts should be made to decrease potassium before the anesthesia event. Hyperkalemia can compromise cardiac stability as elevated potassium levels affect conduction and automaticity, leading to serious arrhythmias (progressing from atrial standstill to ventricular fibrillation and ultimately to asystole). Patients with renal dysfunction should undergo ECG monitoring before anesthesia induction, close monitoring throughout the procedure, and continuous observation during the recovery period.

Endocrine Disorders

Hypoadrenocorticism (Addison's Disease)

Impaired secretion of aldosterone and cortisol from the adrenal gland leads to a patient's inability to handle stress and causes electrolyte imbalances (e.g., hyponatremia, hyperkalemia) resulting from impaired fluid balance. Fluid imbalance can result in fluid loss and hypoperfusion, which may be exhibited as prerenal azotemia.¹⁹ Addisonian crisis, which can be caused by the stress of anesthesia and/or surgery itself,¹⁹ is a life-threatening condition that can end in cardiovascular collapse.

- **Peanesthesia planning:** Before anesthetizing a patient with hypoadrenocorticism, any abnormalities noted in the preanesthesia database should be corrected and stress should be minimized. Aldosterone plays a crucial role with regard to maintaining vascular volume, and aldosterone deficiency contributes to the challenges of managing patients with hypoadrenocorticism. Before anesthesia induction, glucocorticoids and mineralocorticoids should be supplemented as needed. Although careful drug selection is necessary for each patient, the primary drug that should be avoided in patients with hypoadrenocorticism is the induction agent etomidate because etomidate blocks endogenous cortisol synthesis for up to 24 hours.¹⁹ Although further research is warranted, administering a rectal dose of trazodone may be beneficial if the timing of the next dose coincides with the patient being under anesthesia.²⁰
- **During anesthesia:** After induction, vascular volume should be managed by administration of intravenous fluids. Monitoring arterial blood pressure is warranted, as is ECG monitoring due to the increased risk for hyperkalemia.
- **During recovery:** Recovery should be as stress-free as possible. Pain, shivering, hypothermia, and dysphoria are all stressful events that need to be managed carefully. Rectal trazodone can help facilitate a smoother recovery by minimizing stress and anxiety.²⁰

Hyperadrenocorticism (Cushing's Disease)

Hyperadrenocorticism is characterized by unregulated secretion of cortisol from the adrenal cortex. The condition can be caused by a pituitary tumor, adrenocortical tumor, or overadministration of supplemental glucocorticoids. Hepatomegaly in patients with hyperadrenocorticism does not indicate

liver dysfunction; rather, it indicates hepatic glycogen deposition resulting from steroid hepatopathy.

- **Peanesthesia planning:** In addition to presurgical CBC and blood chemistry, the preanesthesia database should include adrenocorticotrophic hormone stimulation test results. Before any anesthesia event, hyperadrenocorticism should be stabilized with pharmaceuticals that decrease cortisol production.²¹ Before anesthesia induction, blood pressure history should be evaluated and blood should be collected with minimal stress. Decreasing stress and pain before anesthesia induction aids patient handling, thus avoiding skin injury, common among patients with hyperadrenocorticism.
- **During anesthesia:** If the patient is chronically hypoxic because of obesity (Pickwickian syndrome), use of ketamine in the induction protocol has a benefit and a disadvantage. Although ketamine should be used with caution because it can increase oxygen demand, it is also a potent bronchodilator, which increases respiratory flow and decreases inspiratory work by relaxing smooth muscle in the airway.²² Preoxygenation should be initiated as decreased functional residual capacity (resulting from weakened musculature and abdominal distension) makes patients prone to hypoventilation and hypoxemia. The combination can be exacerbated by premedication.²² Invasive blood pressure and arterial blood gas monitoring is ideal. Ventilation should be closely monitored via capnography, and manual or mechanical ventilation should be initiated to maintain proper respiratory function as ventilatory function is often severely compromised. Patients with hyperadrenocorticism are often obese and may be prone to hyperthermia.
- **During recovery:** Reversible analgesics combined with local anesthetics help keep patients pain free, which promotes mobility, thus reducing risk for pulmonary thromboembolism during recovery.²¹ In addition, the anesthetic drug plan should be based on the patient's ideal body weight to ensure accurate dosing and minimize potential complications. Diligent monitoring of vital signs during the first few hours after anesthesia can help the veterinary nurse adjust sedation and pain management. If indicated, oxygen saturation levels should be continually monitored for hypoxemia, which can result from hypoventilation; oxygen supplementation during recovery is usually indicated.²³



Diabetes Mellitus

Diabetes mellitus is characterized by hyperglycemia resulting from an absolute or relative deficiency of insulin. In addition to hyperglycemia, hypercholesterolemia and increased liver enzyme levels are also common. In small animals, diabetes mellitus can be classified into 2 main types: type 1 is insulin dependent due to destruction of pancreatic β -cells, and type 2 is not insulin dependent and is often associated with insulin resistance. Use of glucocorticoids should be avoided as they can exacerbate hyperglycemia. If anti-inflammatory effects are needed, consider alternative medications that do not affect glucose metabolism as much.²⁴ Use of α_2 agonists (e.g., dexmedetomidine, xylazine) in patients with diabetes is controversial because they directly inhibit insulin release from pancreatic β -cells. However, they also decrease sympathetic tone, and the benefits of the decrease may counteract any hyperglycemia caused by insulin inhibition. Use of α_2 agonists can be used with caution in patients with diabetes mellitus, but careful monitoring of blood glucose levels is essential. If significant hyperglycemia occurs, alternative sedatives or analgesics may be preferable.²⁵

- **Preanesthesia planning:** The preanesthesia database for patients with regulated diabetes should include a urinalysis. For patients with unregulated diabetes, blood gases and urine or serum ketones should also be evaluated. Procedures requiring anesthesia should be scheduled as the first case(s) of the day to enable faster return to normal feeding and recovery from stress-induced fluctuations in glucose.²⁵ The 2020 AAHA Anesthesia and Monitoring Guidelines for Dogs and Cats provide fasting and insulin dosing information for patients with controlled diabetes mellitus (go.navc.com/4ja8AZh). For patients with uncontrolled diabetes or other comorbidities, consultation with a teaching hospital anesthesiologist is recommended.²⁶ Minimizing stress is crucial when anesthetizing patients with diabetes mellitus. At-home anxiolytics are recommended (if not contraindicated). As with other comorbidities, drugs that can be antagonized are often the best choice. Blood pressure should be taken before any handling and compared with historical blood pressure. Blood glucose levels should be checked and insulin dosage adjusted, if needed, before anesthesia. Dehydration should also be corrected before anesthesia as it can significantly affect the distribution and metabolism of anesthesia drugs. Preoxygenation will increase the patient's oxygen reserve, thus reducing the risk for hypoxia during anesthesia induction.

- **During anesthesia:** For induction, drugs such as propofol or alfaxalone are preferred due to their rapid clearance and minimal effect on blood glucose levels. Avoid drugs that may increase blood glucose levels, such as ketamine, which has been shown to cause hyperglycemia.²² For maintenance, inhalant anesthetics, such as isoflurane or sevoflurane, are preferred due to their minimal metabolic effects. Guidelines published by AAHA in 2019 recommend intraoperative blood glucose monitoring every 30 to 60 minutes, and dextrose should be administered if the patient becomes hypoglycemic.²⁷ Note that blood glucose meters with a veterinary-specific algorithm can provide more accurate readings than human-specific meters. Avoiding hypothermia is essential as it can alter insulin sensitivity and glucose metabolism. If regurgitation is a concern because of the patient's body condition score, esophageal suction before and after anesthesia is recommended. Adequate intraoperative analgesia can minimize sympathetic responses to surgical stimuli, thereby helping maintain glucose homeostasis. Use of locoregional blocks can be particularly effective for preventing a stress response; however, if patients have evidence of peripheral neuropathy, local blocks may exacerbate postoperative neurologic signs.²⁵
- **During recovery:** Ensuring a stress-free recovery environment is crucial to prevent the release of catecholamines, which can increase blood glucose levels. Offering small, frequent meals can help stabilize blood glucose levels and facilitate a return to normal feeding schedules. The timing of the patient's surgery can also help their recovery. Ideally, patients with diabetes mellitus are the first cases of the day with the goal of discharging them as soon as medically appropriate. Early discharge enables the patient and clients to return to their routine as quickly as possible. Last, the use of maropitant with an opioid premedication can help patients return to their normal feeding schedule faster than patients that do not receive it.²⁶

SUMMARY

The best way to achieve safe and effective anesthesia for patients with comorbidities is to focus on maintaining cardiac output and oxygen delivery. Knowing the pathophysiology of each disease and the pharmacology of anesthetic drugs and having appropriate diagnostic information enables veterinary nurses to provide the best care. **TVN**

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Heather Sidari

Heather Sidari has been a registered veterinary technician in North Carolina since 2006. She currently serves as the anesthesia supervisor at the North Carolina State University (NCSU) Veterinary Teaching Hospital and is a VTS in anesthesia and analgesia. In addition to her supervisory role, Heather is an active member of the Academy of Educators at NCSU and the Patient Safety Culture Committee. Heather has shared her knowledge and passion for veterinary anesthesia and analgesia at local and national conferences. She has also published articles, combining her love for teaching with her dedication to advancing veterinary medicine.



Heather R. Carter

Heather Carter has 15 years of experience in the veterinary industry on both the medical and leadership sides. She has achieved veterinary technician specialty (VTS) certification in anesthesia and analgesia, which she uses to train and mentor veterinary teams. She also holds a master's degree in industrial and organizational psychology from George Mason University, which enables her to ensure that hospitals have the infrastructure, culture, and workflows that support job satisfaction.



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CE QUESTIONS

1. **What is the primary goal of safe and effective anesthesia in patients with comorbidities?**
 - a. Reducing anesthesia costs
 - b. Maintaining cardiac output and oxygen delivery
 - c. Speeding up the anesthesia process
 - d. Eliminating the need for preanesthesia testing
2. **What are some of the best anesthesia practices for patients with cardiovascular disease?**
 - a. Preoxygenation and invasive blood pressure monitoring
 - b. Maintaining normothermia and avoiding stress and pain
 - c. Obtaining preinduction blood pressure and electrocardiogram tracings
 - d. All of the above
3. **Why is a low-stress environment crucial for patients with hypertrophic cardiomyopathy during anesthesia?**
 - a. To prevent increased heart rate and myocardial workload
 - b. To reduce the need for fluids
 - c. To eliminate the need for anxiolytics
 - d. To increase the time for diastolic filling
4. **At what range of mean arterial pressure does autoregulation of renal blood flow and glomerular filtration rate remain stable in healthy patients?**
 - a. 40–100 mm Hg
 - b. 60–150 mm Hg
 - c. 70–130 mm Hg
 - d. 80–160 mm Hg
5. **Which electrolyte imbalances are common in patients with hypoadrenocorticism?**
 - a. Hypernatremia, hypokalemia
 - b. Hyponatremia, hyperkalemia
 - c. Hypercalcemia, hypomagnesemia
 - d. Hypocalcemia, hypermagnesemia

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