**Balancing Anesthesia and Common Co-Morbidities**

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**Introduction**

When preparing to anesthetize patients with co-morbidities, it is of utmost importance to perform a thorough history and physical examination of the patient. When possible, the patient’s primary disease processes should be stabilized before performing elective procedures.

Understanding the primary disease process and how it could affect the patient’s performance under anesthesia is vital to minimize anesthetic complications. Vigilant monitoring throughout the entire peri-anesthetic period, reducing stress, and pre-oxygenating is important. Develop an individualized anesthetic drug protocol by selecting short acting, reversible drugs (when possible) and minimize anesthesia time.

**Cardiovascular Disease**

Most, if not all, anesthetics have dose-dependent cardiovascular side effects and are a result of changes in cardiac output, heart rate, and vascular tone. As a general principle, when anesthetizing patients with cardiovascular disease, we try to avoid or minimize any changes in cardiovascular parameters while maximizing perfusion. However, we need to recognize that anesthetic drug selection is a balancing act of choosing those with the least amount of cardiovascular effects while still obtaining optimal clinical effects, such as adequate sedation in a fractious patient.

Patients with cardiovascular disease have decreased reserve and ability to compensate for anesthetic related changes in heart rate, preload and afterload, cardiac output, and changes in vascular tone. When possible always stabilize the heart disease prior to anesthesia and surgery.

Many anesthetic drugs have an impact on the cardiovascular system. Increases in heart rate, with anticholinergics or dissociative anesthetics, either ketamine or tiletamine, will cause an increase in myocardial oxygen demand.  Many of our peri-anesthetic drugs can cause dose-dependent, decreased myocardial contractility and vasodilation.

*Premedication*

Opioids are rarely contraindicated and should be considered when analgesia is required; but opioids can produce bradycardia or worsen a pre-existing bradyarrhythmia. Their effect on heart rate is often dose dependent but is typically responsive to anticholinergic drug treatment. Depending on the dose and patient, opioids may also provide mild or moderate sedation.

It is common to administer a sedative with an opioid as part of a premedication plan. Benzodiazepines, diazepam and midazolam, have negligible cardiovascular effects and, when combined with an opioid, provide sedation in compromised patients. However, be mindful that benzodiazepines can also cause paradoxical excitation especially in younger already excitable patients.

Acepromazine and dexmedetomidine, while very different in their cardiovascular effects, should be used with caution in patients with cardiovascular disease. This does not mean that their benefits will never out weight their risks. Regardless of which drug is selected, using the lowest effective dose is recommended.

*Induction*

Dissociative anesthetics, including ketamine and tiletamine (sold in combination with zolazepam), should be used with caution in patients where an increase in heart rate, myocardial contractility and increased in myocardial oxygen demand are detrimental. Other more “cardiovascular friendly” induction drugs are available. Propofol and alfaxalone, as well as the human patient-labeled induction agent etomidate, can all provide a more ideal induction with better cardiovascular stability for these patients. A low dose of ketamine or a benzodiazepine can be used as a co-induction drug to lower the primary induction drug dose requirement.

*Maintenance*

Isofluraneand sevofluraneare appropriate for maintenance of anesthesia in patients with cardiovascular disease; however, both inhalants cause dose-dependent myocardial depression and hypotension. Use of partial intravenous anesthesia (PIVA) with constant rate infusions of opioids and other medications, ketamine or lidocaine, as well as loco-regional blocks, will help minimize inhalant anesthetic concentration requirements. Additionally, propofol and alfaxalone can be administered as both partial and or total intravenous anesthesia to further reduce, or even eliminate, inhalant anesthetic requirements.

**Respiratory Disease**

*Upper Airway Disease*

Common upper airway diseases include brachycephalic syndrome and laryngeal paralysis. The primary concern in a patient with upper airway disease is the ability to breathe and maintain ventilation and oxygenation. These patients may present to the clinic in respiratory distress. Every effort should be made to reduce stress or excitement and provide oxygen supplementation if needed.

Following appropriate premedication, an induction drug is administered IV to effect for easy intubation and control of the airway. Being familiar with the anatomy of the upper airway is important for rapid tracheal intubation, especially in a patient with an upper airway obstruction. Having various size endotracheal tubes, a stylet, and an operational laryngoscope available are recommended for all tracheal intubations. Be familiar with alternative intubation techniques, such as retrograde intubation. In extreme obstructive cases or where it is impossible to orally intubate, be prepared to perform an emergency tracheostomy.

The anesthetist should always be ready to reintubate the patient during recovery by having a variety of sizes of endotracheal tubes and additional injectable anesthetic drug readily available. Vigilantly monitor the patient with special attention to end-tidal CO2 and oxygen saturation throughout the entire peri-anesthetic period and well into recovery. Supplemental oxygenation may be required during the recovery period.

*Lower Airway Disease*

Lower airway and pulmonary parenchymal diseases, such as pulmonary edema or pneumonia, and reactive airway disease, such as feline asthma may require anesthesia for diagnostic procedures, such has bronchoalveolar lavage for sample collection, or for a procedure unrelated to their lower airway disease.

Lower airway disease precautions and drug selections are similar to that of upper airway disease. Provide sedation to reduce stress – such as a low dose acepromazine or dexmedetomidine. Butorphanol will provide mild to moderate analgesia and, as an antitussive, can help alleviate some airway irritation that can result from coughing. Bronchodilators (like terbutaline or albuterol) may be helpful but be mindful that they will also cause an increase in heart rate and myocardial oxygen demand. Supplemental oxygenation should be used prior to induction and throughout the recovery period.

*Space-Occupying Disease*

Patients with space occupying diseases, such as pneumothorax or diaphragmatic hernia, are at increased risk for complications during anesthesia. Therefore, their anesthetic management should be carefully planned. It is important to remember that the anesthetist should be prepared to provide ventilatory support immediately following induction of anesthesia.

Preanesthetic preparation of the patient may need to include thoracentesis to remove air or fluid from the chest prior to induction of anesthesia. This may require premedication depending on the patient’s tolerance to this procedure. Prior to induction of anesthesia, it is important to select premedication drugs that minimize stress and provide adequate analgesia. As always pre-oxygenation of the patient is recommended. The anesthetic induction drug that you select should be one that can be administered IV to effect with minimal respiratory depression that facilitates a rapid, easy intubation.

Inhalant anesthetic drugs can be used to maintain anesthesia. Adjunctive drugs, such as opioids or lidocaine, can provide additional analgesia and lower inhalant anesthetic drug requirements. Vigilant monitoring of the cardiovascular and respiratory system should be performed from premedication through complete recovery. Ability to support ventilation, either manually or with a mechanical ventilator, is recommended.

**Hepatic Disease**

The liver is responsible for protein synthesis, drug metabolism, glycogen storage, and production of clotting factors. Deficiencies in of these functions can lead to anesthetic complications. When developing the anesthetic plan, avoid long acting, non-reversible drugs heavily dependent on liver metabolism, such as acepromazine. Opioids can be used at the lowest effective dose for sedation and analgesia. Dexmedetomidine provides both sedation and analgesia, is reversible, and has a dose-sparing effect on other anesthetic drugs. However, dexmedetomidine may be associated with significant cardiovascular effects, including decreased cardiac output and should therefore be used with caution in patients with hepatic disease.

Propofol, alfaxalone, and dissociative agents are appropriate induction agents as they are administered IV to effect and are rapidly redistributed, metabolized, and cleared from circulation. Maintenance with an inhalant anesthetic is appropriate. However, due to their likelihood to cause dose-dependent hypotension, the use of partial intravenous anesthesia, or PIVA, can be used to reduce inhalant anesthetic drug requirements. PIVA can be accomplished with constant rate infusion of opioids, ketamine, lidocaine, alfaxalone or propofol. Lidocaine undergoes significant hepatic metabolism; therefore, doses should be monitored carefully to avoid toxicity.

**Renal Disease**

Assessment of renal function is vital prior to anesthesia. This is accomplished by performing a serum chemistry panel that includes BUN, creatinine, and electrolytes and a urinalysis. Identification of anemia and pre-operative arterial blood pressure will help to assess hydration status that can be used when making decisions regarding IV fluid selection and rate. It is important to maintain renal blood flow and adequate circulating blood volume with IV fluid therapy during the peri-anesthetic period.

For specific anesthetic drug recommendations for patients with renal disease, it is important to realize that many drugs rely on some degree of renal excretion, which vary between species. Most notably, ketamine primarily relies on renal excretion in cats. It is advised to avoid large doses of ketamine in cats with significant renal disease.

It is also advisable to avoid certain drugs or doses of drug that cause excessive vasodilation and hypotension. These include high doses of acepromazine, and mask or chamber inductions with inhalants. Inhalant MAC-sparing techniques such as local blocks and/or CRIs are highly encouraged.

**Endocrine Disease**

*Diabetes mellitus*

If possible, when a patient with diabetes requires anesthesia, efforts should be made have their diabetes well-regulated before the anesthetic event. Administration of insulin the morning of the procedure is generally at the discretion of the overseeing veterinarian familiar with the patient and its regulation status. It is ideal to obtain a blood glucose immediately before pre-medication to guide the administration of insulin or supplemental dextrose. The 2020 AAHA Anesthesia Guidelines fasting recommendations for diabetic patients is withhold food for 2-4 hours before the procedure and have water available until induction. They further suggest offering a small meal of wet food before this fasting period with administration of a half of their current insulin dose. Throughout the procedure, monitoring of blood glucose is recommended at a minimum every hour. The normal glucose range is generally between 80 and 120 mg/dL. Often in diabetic patients their “normal” could be higher. Understanding, the individual patient’s normal blood glucose range helps guide either supplementation with dextrose or administration of insulin. No specific peri-anesthetic drugs have direct contraindications for diabetic patients. Generally, short acting, reversible drugs are selected for use when possible so a rapid return to normal activity for the patient can be achieved.

*Hyperadrenocorticism (Cushing’s Disease)*

Patients with Cushing’s require even greater peri-anesthetic monitoring. Special attention needs to be paid to ventilation, arterial blood pressure and acid-base/electrolyte monitoring in these patients. When planning an opioid for your anesthetic protocol you have many choices and the one selected depends on the degree and duration of required analgesia. Often these patients do not require heavy sedation and an opioid alone may be all that is needed. For added sedation, a low dose of acepromazine or midazolam may produce sufficient sedation in the older, calmer Cushing’s disease patient. Alfaxalone or propofol is appropriate for induction of anesthesia in patients with hyperadrenocorticism and can be administered IV to effect to reduce the incidence of hypoventilation or apnea. Patients are then transitioned to inhalant anesthetic for maintenance of anesthesia.

*Hypoadrenocorticism (Addison’s Disease)*

Addison’s disease in dogs is a deficiency of aldosterone (a mineralocorticoid) and glucocorticoid secretion from the adrenal cortex. Electrolyte and fluid imbalances are common and, if severe, can result in cardiac bradyarrhythmias and hypotension. Medical management of this disease includes mineralocorticoid and glucocorticoid supplementation. An Addison’s disease patient should be stabilized before any procedure requiring anesthesia. Full blood work including a CBC and serum chemistry panel with electrolytes are recommended.

Because patients with Addison’s disease have a decreased ability to response appropriately to stress, glucocorticoid doses should be adjusted if surgery is planned. Typically, an extra dose of glucocorticoid, in addition to their normal daily dose, is administered prior to anesthesia. Dose and frequency of glucocorticoid supplementation will vary depending on if it is a major or minor surgical procedure and the perceived severity of the stress. Additional glucocorticoid can be administered postoperatively as needed.

Short acting, reversible anesthetic drugs are generally preferred for these patients. Premedication with an opioid often is sufficient for sedation as well as provides pre-emptive analgesia. Sedation should be included if required to minimize stress. Inducing anesthesia with a drug that can be administered IV to effect is recommended. Alfaxalone or propofol are both acceptable drug options. Vigilant monitoring of arterial blood pressure, total body water, electrolytes and acid-base parameters during anesthesia is required. Inhalant MAC-sparing techniques such as local blocks and/or CRIs are highly encouraged.

*Hyperthyroidism*

Patients with hyperthyroidism have excessive thyroid hormone resulting in a pathologically high overall metabolism. While relatively rare in dogs, this disease is common in the aging cat. As this disease progresses, multiorgan involvement develops resulting in cardiovascular and renal disease. These cats often have hypertension, tachycardia, gallop rhythm, and heart murmur. Their cardiac disease may require investigation to determine the degree of severity and degree of heart failure. In severe cases involving heart failure, cats can also have pulmonary edema or pleural effusion.

Opioids provide appropriate analgesia but do not always produce reliable sedation in the cat. In unmanageable patients, dexmedetomidine can be administered to provide more reliable sedation. Ketamine is generally avoided due to its undesirable cardiovascular effects. Alfaxalone is labeled for use in cats and poses no direct contraindication for patients with hyperthyroidism. Additionally, it is administered IV to effect for induction and can be continued for maintenance if desired. Midazolam can be used as a co-induction agent to reduce the total required dose of alfaxalone. Propofol is another suitable alternative for induction of anesthesia. Vigilant monitoring of arterial blood pressure, ECG to observe heart rate and rhythm, as well as pulse oximetry and ETCO2 are important considerations during anesthesia.

*Hypothyroidism*

Hypothyroidism is the deficiency of thyroid hormone and typically affects older dogs. Under anesthesia, common complications include hypoventilation due to obesity and patient positioning. Delayed gastric emptying can increase the likelihood of regurgitation and chance for aspiration pneumonia in recovery. Cardiac changes caused by hypothyroidism may be exacerbated by anesthetic drugs, predisposing these patients to further decreases in cardiac output, bradycardia, and hypotension.

In the stable hypothyroid patient, few modifications to the drug selection for the anesthetic period are required. No specific anesthetic drug is contraindicated. Due to the reduced metabolic state, reduced drug doses are recommended.

**Neurological Disease**

*Intracranial Disease*

In patients with intracranial disease and a suspected space-occupying mass, the focus should be on minimizing changes in intracranial pressure. Three essential parameters to monitor in these patients are oxygenation, ventilation, and arterial blood pressure as they have a direct influence on intracranial pressure. ETCO2 should be monitored closely during anesthesia. As ETCO2 increases, vasodilation occurs causing an increase in ICP. Maintaining a low normal ETCO2 between 35-40 mmHg is recommended for these patients. Finally, vigilant monitoring of arterial blood pressure is important. The brain autoregulates perfusion between mean arterial pressures of 50 and150 mmHg. Therefore avoid both hypotension and hypertension in patients with intracranial disease.

Analgesia and sedation should be provided to minimize stress and optimize the patient’s anesthetic experience. Vomiting has the potential to increase ICP, therefore avoid drugs for premedication that may cause vomiting such as morphine and intramuscular hydromorphone. Induction should be with an adequate dose of induction drug, administered IV to effect, until intubation can be performed without gagging and coughing. Maintenance of anesthesia can be provided with an inhalant anesthetic, along with analgesic adjunctive drugs, as required, to keep the inhalant drug requirements as low as possible.

*Seizure Disorders*

Patients that present to the clinic with a history of a seizure disorder, such as idiopathic epilepsy, can be anesthetized safely provided you have a good understanding of your chosen anesthetic drug’s effect on seizure threshold. Premedication with an appropriate sedative and opioid, in combination with either alfaxalone or propofol, both injectable, short acting induction drugs, is an acceptable protocol for these patients. Benzodiazepines should readily available to help control seizures should they occur in recovery. Patients receiving chronic anticonvulsant medications, anesthetic drug doses may be decreased and be mindful that recovery may be prolonged. Observe neurological status until the patient is fully recovered.

*Spinal Cord Injury*

For patients with spinal cord injuries or intravertebral disc disease, appropriately addressing their pain is important. Compression or damage to the spinal cord is extremely painful. If spinal fractures are present, adequate support and immobilization may be required to prevent destabilization and further injury. It is important to collect a thorough history with an emphasis on the onset of clinical signs (searching of a history of traumatic event) as well as the administration of any medications such as NSAIDs or corticosteroids.

No specific anesthetics are contraindicated in patients with spinal cord injuries. An appropriate anesthetic plan includes premedication with an opioid, consideration of adding a sedative, such as a benzodiazepine; a rapid, smooth induction with an injectable drug, such as alfaxalone or propofol, and maintenance of anesthesia can be with an inhalant anesthetic, along with analgesic adjunctive drugs, as needed.