

ANESTHESIA AND MANAGEMENT OF PERI-ANESTHETIC HYPOTENSION FOR CRITICAL PATIENTS

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General anesthesia involves the careful and judicious use of compounds that induce sensory deprivation to noxious stimuli, muscle relaxation, and in most cases, unconsciousness. In critically ill patients, there often is a delicate balance between loss of consciousness and cardiovascular and respiratory compromise, requiring careful monitoring techniques to ensure patient safety. Fortunately, many animals that present to you in an emergency setting will be young, healthy animals that may require anesthesia to repair minor trauma. Other cases, however, will present to you with potentially life-threatening critical illnesses, making anesthesia more challenging and somewhat risky. Many anesthetic agents induce some degree of cardiovascular and respiratory depression. The goal of this presentation is to describe anesthetic protocols for both healthy and unhealthy animals.

THE PHYSICAL EXAMINATION

The physical examination is one of the most important aspects of preparation prior to inducing anesthesia. In critically ill patients, a careful physical examination should be performed just prior to inducing anesthesia, as clinical status may have changed dramatically since initial presentation, often changing your choice of anesthetic protocols. Questions to ask yourself include: Is the patient's airway patent? Does the animal require mechanical or assisted ventilation? Is the animal morbidly obese or have an intraabdominal mass that will change efficacy of ventilation once the patient is placed in dorsal recumbency? Does the animal have a sucking chest wound, rib fractures, pleural effusion, or potential for pneumothorax? Are there pulmonary contusions that may be affected by large volumes of intravenous fluids? Are the animal's respirations effective or ineffective? Is the animal in a state of circulatory shock? Is there a normal circulating blood volume? Is the heart beating efficiently, or is there a cardiac murmur or dysrhythmia? What is the clinical status of the animal? Is there an adequate blood pressure? Is there any sign of ongoing hemorrhage or severe electrolyte loss? In most cases, the answers to these questions can be obtained from a thorough and systematic physical examination, starting with the basic ABC's of emergency medicine. The animal must have a patent **A**irway, to deliver oxygen into the lungs while **B**reathing, and the oxygen can be delivered to tissues during the process of normal **C**ardiac function and **C**irculation. Once the ABC's have been evaluated and stabilized, other diagnostics can then be performed.

BLOODWORK AND ELECTROLYTES ABNORMALITIES

Following physical examination, bloodwork should be performed to evaluate the patient's oxygen carrying capacity, renal and hepatic function, and coagulation status. Every effort should be made to normalize values prior to inducing anesthesia. However, in many cases, until the underlying problem is definitively addressed, patient clinical status may not improve despite very aggressive efforts. These types of cases present the most challenge for the veterinary practitioner in deciding how to induce general anesthesia without potentially doing more harm.

Patients with traumatic uroabdomen should be stabilized prior to inducing general anesthesia. Every effort should be made to decrease serum potassium to less than 7 mmol/L before any anesthesia is induced. Treatment protocols include administering regular insulin (0.25 units/kg IV) and dextrose (2 gm dextrose IV per unit of insulin, followed by 2.5 – 5% dextrose CRI to prevent hypoglycemia), intravenous sodium bicarbonate (0.25 – 1.0 mEq/kg), or calcium gluconate (0.5 – 1.0 ml/kg 10% solution IV). The electrocardiogram should be monitored closely for the appearance of atrial standstill and inappropriate bradycardia. Secondly, drainage of intraabdominal fluid can be accomplished by placement of an intraabdominal catheter attached to a closed collection system. A red rubber tube or an Argyle chest tube can be placed using a local anesthetic such as lidocaine (0.5 – 1.0 mg/kg). Once secured, the drain can be left in place until definitive repair of the urinary tract can be performed at the time of surgery. Anemic or hemorrhaging patients should have a combination of crystalloid and colloidal support. In cases of hemoabdomen and gastric dilation-volvulus, synthetic hemoglobin can be administered as a bolus or as a slow trickle (1 – 2 ml/kg/hour) to provide both colloidal support and improve oxygen carrying capacity.

Preanesthetic Agents

There are several rationales for using pre-anesthetic medications. One of the most important reasons for using premedications is to decrease the total amount of anesthesia required to induce and maintain general anesthesia. The use of a balanced anesthetic approach provides many benefits for the patient, particularly those that are critically ill. Anticholinergic drugs such as atropine and glycopyrrolate increase heart rate by inhibiting vagal stimulation. Glycopyrrolate though, has less of a chance of inducing tachyarrhythmias. Atropine reduces respiratory secretions and can cause second-degree heart block. Atropine crosses the blood-brain and placental barriers, while glycopyrrolate does not. This has important implications when providing anesthesia for the periparturient dam in need of a C-section, anesthesia that can potentially affect the outcome of the neonates.

Opioids, used in combination with a phenothiazine tranquilizer such as acepromazine, provide neuroleptanalgesia. Morphine provides excellent analgesia without inducing severe cardiovascular compromise. Potential complications of morphine and other opiate drugs include bradycardia (which can be reversed or prevented by using an anticholinergic agent), and hypoventilation. Morphine administration can also induce vomiting and ileus in ambulatory patients. In recumbent patients, though, the use of morphine is justified by decreasing doses of induction agents and inhalant drugs required to maintain general anesthesia. Butorphanol, a mu antagonist, kappa agonist, also can be used as a premedication when used in combination with a phenothiazine tranquilizer such as acepromazine. Used alone, however, butorphanol's sedative effects are fairly unreliable and short-lived. Additionally, due to its receptor affinity, using butorphanol early in the course of anesthesia may prevent more potent drugs such as morphine and fentanyl from providing adequate analgesia in the early post-operative time period, depending on the length of surgery. For these reasons, this author does not routinely use butorphanol, favoring more potent and more reliable opioids such as morphine and fentanyl. Fentanyl, a pure opioid agonist, is potent opioid with a very short duration of action. It should be used in very critical patients for analgesia, then as part of an induction protocol. When used as a premedication, induction of general anesthesia should occur shortly thereafter, within approximately 20 minutes, or the drug should be given as a constant rate infusion until general anesthesia is induced.

Phenothiazine tranquilizers, namely acepromazine, should be given to healthy animals as part of the premedication protocol. Acepromazine's antagonism of alpha-adrenergic activity can potentially induce vasodilation with subsequent hypotension, so should be used with caution. Other untoward side effects that have been reported include reduction of seizure threshold in predisposed animals. Thus, its use is relatively contraindicated in such patients. A potentially beneficial side effect of acepromazine is decreasing catecholamine-induced dysrhythmias. Alpha-2 agonists such as xylazine and medetomidine induce intense peripheral vasoconstriction, AV nodal block, bradycardia, and decrease in cardiac output. For these reasons, alpha-2 agonists should never be administered to emergency and critical care patients for absolutely any reason. The alpha-2 agonists may have their place in healthy animals, but should not be used in emergent settings.

ANESTHETIC INDUCTION

Anesthetic induction should occur rapidly. The most critically ill patients often will benefit from pre-oxygenation prior to induction. An intravenous catheter should be in place prior to induction, for maintenance of vascular access. Benzodiazepine tranquilizers such as diazepam (0.3 – 0.5 mg/kg IV) or midazolam can be used. Diazepam induces more reliable tranquilization and is less expensive than the more costly midazolam. If given alone, diazepam can potentially induce excitement; therefore, this drug is often used in combination with dissociative agents such as ketamine (5.5 mg/kg IV, 10 – 30 mg/kg IM), opioids such as fentanyl (10 mcg/kg IV), or in combination with etomidate (0.5 – 1.5 mg/kg IV). Ketamine is a dissociative anesthetic agent that will initially cause a catecholamine-induced increase in cardiac output. In critically ill patients that have maximized sympathetic tone, however, ketamine can decrease cardiac contractility; therefore, its use is relatively contraindicated. Ketamine, when used pre-intra- and post-operative, can decrease activation of NMDA receptor-mediated "wind-up" and decrease post-operative pain even days after surgery. Its use in combination with other analgesic agents is therefore beneficial, especially in controlling post-operative orthopedic pain. Propofol (4 – 7 mg/kg IV) is another drug that can be used to induce general anesthesia. Unrelated to other pharmacologic agents, propofol induces rapid anesthesia. Recovery from Propofol is also very rapid in most cases. Potential untoward effects of this drug include vasodilation and hypotension, and apnea. In cats, Propofol should not be used on consecutive days due to the potential for

development of Heinz body anemia. In the most critically ill patients, Etomidate can be administered along with Diazepam with minimal effects on cardiovascular status.

ANESTHESIA MAINTENANCE AND MONITORING

Immediately after successful induction of anesthesia, anesthesia should be maintained with an appropriate gas anesthetic agent. For short procedures in cardiovascularly stable patients, Propofol can be administered as a constant rate infusion (6 – 20 mg/kg/hour). It must be remembered, however, that Propofol has no analgesic properties; therefore, if a painful procedure is to be performed, appropriate analgesia should be administered prior to recovery from anesthesia. Proper anesthetic monitoring including pulse oximetry, electrocardiogram, temperature, capnography, and blood pressure should be performed and recorded for even “apparently routine” procedures. In many critical patients, pre-, intra- and post- anesthetic hypotension is a potential hazard that should be carefully addressed. First, the level of gas anesthesia should be decreased. Secondly, a fluid bolus (5 – 10 ml/kg) can be administered IV. All patients under general anesthesia should have vascular access. If a patient is hypotensive and hemodilution or true anemia is a concern, synthetic colloids such as Hydroxyethyl starch can be administered as an IV bolus (5 ml/kg). Alternatively, component blood products such as whole blood, packed red blood cells, or fresh frozen plasma can be administered depending on the primary problems at hand. If decreasing anesthetic depth and fluid bolus does not sufficiently increase blood pressure, use of a positive inotrope such as dobutamine (2 – 20 mcg/kg/min IV CRI) can be administered. Dopamine at lower doses (2 – 10 mcg/kg/min IV CRI) stimulates cardiac contractility through beta-adrenergic stimulation. Dobutamine, primarily a beta-agonist, stimulates cardiac contractility and as such, indirectly increases blood pressure. Dobutamine increases blood pressure more reliably than dopamine. Ephedrine is a synthetic sympathomimetic drug that stimulates both alpha- and beta-adrenergic receptors to stimulate catecholamine release. Bolus injection of ephedrine (0.1 – 0.25 mg/kg IV) has a longer duration of action than dobutamine, thus does not require administration as a constant rate infusion. If none of the above options are successful, vasopressor agents such as dopamine (> 10 mcg/kg/minute IV CRI), epinephrine (0.05 – 0.4 mcg/kg/min IV CRI), and norepinephrine (0.05 – 0.4 mcg/kg/min IV CRI) can also be administered. It is important to remember that agents that induce peripheral vasoconstriction may increase blood pressure but not necessarily improve renal, cerebral, and coronary blood flow.

In any patient with tachy- or bradyarrhythmias such as AV block, bradycardia, or sinus or ventricular tachycardia, attempts should be made to treat the dysrhythmia. Anticholinergic drugs such as atropine or glycopyrrolate should be administered to treat cardiovascularly unstable bradyarrhythmias. In some cases, if the heart rate is 50, and the animal’s blood pressure is stable and normal, treatment may not be necessary. However, if the animal is bradycardic and hypotensive, interventions should be implemented. Sinus tachycardia can adversely affect blood pressure by decreasing the amount of time the heart has to fill. Decrease in diastolic filling will result in a decreased cardiac wall stretch available for rebound, the force necessary for normal myocardial contraction. Therefore, filling the cardiovascular space with fluids, and in some cases, INCREASING anesthetic depth if the animal is actually feeling the procedure, may be necessary to decrease heart rate. Ventricular dysrhythmias should be treated with a combination of crystalloid/colloid therapy, oxygen, and drugs such as lidocaine (2 mg/kg IV bolus, followed by 50 – 100 mcg/kg/minute IV CRI) or procainamide. Procainamide can contribute to refractory hypotension, and is not the antiarrhythmic of choice in a patient with hypotension.

POST-OPERATIVE ANALGESIA

Post-operative analgesia should be performed with the thought that the patient should never ever be allowed to be painful. Constant rate infusions of fentanyl (1 – 7 mcg/kg/hour), morphine (0.1 mg/kg/hour in dogs, 0.01 mg/kg/hour in cats) can be administered with ease. Additionally, at the suggested doses, the drugs cause minimal cardiovascular depression or ileus. Intermittent bolus injections can also occur, provided that the drugs are administered according to an exact schedule, not given when the patient begins acting apparently painful or “PRN”. Local anesthetic agents can be placed in the wounds prior to wound closure for post-operative analgesia. Additionally, intrapleural lidocaine (1 mg/kg) or bupivacaine (0.5 – 1.0 mg/kg) can be administered via thoracostomy tubes for additional pain relief. Transdermal fentanyl patches are effective in controlling patient discomfort, but do not immediately take effect, thus requiring other types of analgesia until adequate blood levels of fentanyl are reached, usually 16 – 24 hours after placement of the patch. Some clinicians advocate placing the fentanyl patch on the evening prior to surgery, to ensure

adequate blood levels are obtained for the immediate post-operative period. Using combination multimodal approach to therapy such as a constant rate infusion of ketamine (0.5 mg/kg IV bolus at time of anesthetic induction, then 10 mcg/kg/minute intraoperatively, then 2 mcg/kg/minute post-operatively as a CRI), a non-steroidal anti-inflammatory drug such as carprofen or ketoprofen, epidural morphine, along with opioids helps to ensure that the patient never becomes painful. At the time of discharge, a combination of opioids and/or Nonsteroidal anti-inflammatory drugs should be considered for continued analgesia in the post-operative recovery period.

It is sometimes difficult to distinguish between pain, anxiety, and opioid dysphoria. Physical examination parameters such as heart and respiratory rate, pupil size and responsiveness, should all be checked, but are often indistinguishable from pain, anxiety, need to urinate or defecate, or attention seeking behavior. When I suspect an animal may be painful or dysphoric, I perform a thorough physical examination, including palpation of the surgical site. If the patient reacts to surgical site manipulation, I immediately give an additional dose of analgesia. If no apparent pain is present with surgical site manipulation, but the patient quiets when being handled, anxiety or attention-seeking behavior is diagnosed. I will add an anxiolytic agent to the treatment protocol, provided that hypotension is not a concern. If the patient neither responds to pain nor attention and anxiolytic agents, I make sure that the patient's urinary bladder is empty and there isn't a need to urinate or defecate. Only after all of these choices have failed will I consider reversing an opioid drug with naloxone.

CONCLUSIONS: "WHAT'S THE BOTTOM LINE?"

In the emergent situation, there may not be enough time to take a "wait and see if this works" kind of approach. One of the most important things to remember is that gas is poison. Many animals, particularly those that are critically ill, are exquisitely sensitive to the cardiorespiratory effects of inhalant anesthetic gases. For this reason, when an animal is hypotensive, one of the first things to consider is turning down the anesthetic vaporizer. If there is concern about an animal waking up during the anesthesia and surgery, balanced anesthesia with constant rate infusions of fentanyl or fentanyl and ketamine can be administered, to decrease the total amount of anesthetic gas required to maintain an adequate plane of anesthesia without causing hypotension and cardiovascular compromise. Next, (or sometimes simultaneously), a crystalloid (10 ml/kg) or colloid (5 ml/kg) fluid bolus can be administered, to fill up the vasodilated vascular beds. When a blood vessel dilates, a state of relative hypovolemia occurs, in which there is inadequate circulating volume to maintain vascular tone and cardiac preload. If there is insufficient myocardial stretch, the force of contraction is limited, and thus, can result in impaired cardiac output and a decrease in systemic blood pressure. Many anesthetic agents render the cardiovascular system incapable of compensatory changes such as vasoconstriction, so blood pressure and thus tissue perfusion and oxygen delivery become compromised. If decreasing the anesthetic depth and administration of fluids does not cause an increase in blood pressure, then positive inotropes (dobutamine and/or ephedrine) and vasopressors (dopamine) can be administered. Having an "anesthetic book" that contains charts of all of the necessary drugs, instructions on how to dilute each drug, resulting concentration, and volume of the diluted drug to administer to each patient based on body weight can save a lot of time and quick arithmetic in an emergent situation.

References available from author upon request.