

Anesthesia and Anesthetic Concerns for the Critically Ill or Traumatized Dog and Cat

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KEY WORDS

- cardiac compromise
- hyperventilation
- blood substitutes
- cerebral blood flow
- preemptive analgesia

The ideal anesthetic technique in the critically ill or traumatized patient should provide adequate hypnosis, muscle relaxation, and analgesia and should minimize stress during and after the medical or surgical procedures performed (Tables 1 through 3). The most common abnormality encountered in these patients is circulatory shock, a generalized condition in which the effective circulating blood volume is insufficient to deliver oxygen to and remove metabolic waste products from the cells. This results in stupor, coma, and other classic signs attributable to circulatory shock. Its etiology is varied. Clinically, shock can be classified according to three basic hemodynamic defects (hypovolemic, cardiogenic, distributive), each of which can result from a variety of causes. Anesthetic management of the shock or trauma patient requires assessment of the severity of shock as well as determination of the etiology. For example, the patient with cardiogenic shock due to severe ventricular arrhythmias will be managed differently than the patient with hypovolemic shock due to severe blood loss. Basic patient monitoring is important in determining the etiology of shock as well as in assessing the response to therapy. Patient monitoring and the treatment of fluid imbalance and cardiovascular emergencies are covered elsewhere in this Proceedings (see the article by Dr. Kirby on pp. 44). Anesthesia should rarely if ever be initiated until measures to assess shock and stabilize the patient are in progress.

Regardless of the underlying cause of circulatory shock, some generalizations regarding anesthetic drug selection can be made. Extremely depressed or quiet

animals with superficial wounds can often be managed with infiltration of local anesthesia at the wound site. Fractious animals or those in need of major surgery require general anesthesia. Most anesthetic drugs depress cardiovascular and respiratory function in a dose-related manner. Therefore drugs with minimal depressant effects should be used and, more importantly, *used in relatively low doses*. Several drugs that have minor depressant effects at low doses can be combined to provide general anesthesia (balanced anesthesia). Mask induction with halothane or isoflurane is not recommended unless the patient is very depressed and low vaporizer settings can result in quick, quiet induction. In alert patients, mask induction can lead to excitement and struggling, which elevate myocardial oxygen consumption and worsen myocardial function. The diazepam-ketamine combination maintains cardiac function and allows for intubation and subsequent administration of inhalation anesthesia. Very depressed dogs can often be intubated with a total of 5 to 10 mg of intravenous diazepam or midazolam. Similarly, intravenous oxymorphone or a diazepam-oxymorphone combination can be used to induce anesthesia in depressed animals. During surgery, intravenous fentanyl is useful for supplementation of halothane or isoflurane anesthesia. Fentanyl allows less inhalation anesthetic to be used, thereby minimizing cardiovascular depression.

The development of cardiac arrhythmias during anesthesia decreases cardiac output by disrupting the normal sequence of cardiac filling and ejection. Therefore drugs with minimal potential for producing cardiac arrhythmias should be selected for patients experiencing arrhythmia or those prone to its development. Atrial or ventricular arrhythmias that develop during anesthesia are treated according to guidelines used in awake dogs and cats and are generally managed by acute intravenous bolus or infusion of lidocaine.

During the immediate recovery period, oxygen should be supplemented through the endotracheal tube or by mask. Hypoventilation due to residual anesthetic-induced respiratory depression, as well as shivering (which dramatically increases whole body oxygen consumption), can lead to reduced myocardial oxygen delivery and subsequent myocardial decompensation. Oxygen can be discontinued when ventila-

Table 1
Anesthetic Drugs Commonly Used for
Premedication in Critically Ill Patients

Drug	Dosage (mg/kg)	Comments
Anticholinergics		
Atropine	0.02–0.04 IM, SC, IV	
Glycopyrrolate	0.01 IM, SC, IV	
Benzodiazepines		
Diazepam	0.2–0.3 IV	
Midazolam	0.2–0.3 IM, IV	
Opioids		
Oxymorphone	0.05–0.1 IM	Bradycardia should be anticipated
Butorphanol	0.2–0.4 IM	
Morphine	0.2–0.4 IM	Bradycardia should be anticipated
Alpha-2 Agonists		
Xylazine	0.1–0.2 IV	Bradycardia should be anticipated
Medetomidine	2–10 µg IV	Bradycardia should be anticipated
Neuroleptanalgesics		
Midazolam and oxymorphone	0.03 IM 0.05 IM	Can combine in same syringe
Midazolam and butorphanol	0.3 IM 0.2 IM	Can combine in same syringe
Dissociatives		
Ketamine	2.0–4.0 IM	Cats only

tion returns to normal and shivering stops. If opioids were used as part of the anesthetic regimen, postoperative respiratory depression should be anticipated; reversal using an opioid antagonist should be considered when respiratory depression is significant.

Cardiac contusion is a relatively common complication associated with severe traumatic events. Cardiac

arrhythmias and cardiogenic shock can be consequences of myocardial contusion and may result in both systolic and diastolic dysfunction. Contractility is reduced, and cardiac output becomes heart rate dependent. Anesthetic management involves selecting drugs that minimally depress contractile function, maintain heart rate, and prevent development of arrhythmias. A combination of drugs as described above should be selected. If opioids are a part of the anesthetic regimen, they should be accompanied by an anticholinergic to prevent bradycardia. Drugs that induce tachycardia or predispose to arrhythmias should be avoided so that ventricular filling is optimized. Drugs that can induce tachycardia include ketamine and isoflurane. Opioids that reduce heart rate can be beneficial.

ACUTE ABDOMEN

Acute abdomen refers to any condition of the abdomen that results in cardiovascular decompensation or a sudden onset of pain. This includes conditions as diverse as gastric dilatation and displacement, diaphragmatic hernia, blunt or penetrating trauma, tumor-induced gastrointestinal obstruction, and pyometra. Because of the cardiovascular decompensation common to these diverse conditions, many of the anesthetic considerations are the same as those described for the shock patient. Additional concerns are referable to the specific disease or condition present. For example, patients with diaphragmatic hernia or severe gastric dilation and displacement can have significant respiratory compromise due to a distended abdomen. Anesthetic management involves maintenance of ventilation. Preanesthetic opioids should be

Table 2
Parenteral Anesthetic Drugs

Drug	Dosage (mg/kg IV)	Comments
Barbiturates		
Thiopental	8–15	
Lidocaine/Thiopental	4 of each in succession	Do not mix in same syringe
Methohexital	3–5	Should be preceded by a sedative, tranquilizer, or narcotic
Dissociative Combinations		
Ketamine/diazepam	1 ml/9 kg of a 1:1 volume/volume mixture	
Ketamine/midazolam	1 ml/9 kg of a 1:1 volume/volume mixture	
Ketamine	2–6	Cats only
Opioids and Neuroleptanalgesics		
Oxymorphone	0.05–0.1	Will induce anesthesia only in very sedate or depressed patients
Fentanyl	0.002–0.004	Used intraoperatively to supplement inhalation anesthesia
Midazolam/Oxymorphone	0.05 midazolam followed by 0.05–0.2 oxymorphone	
Others		
Etomidate	1.0–2.0	Precede with tranquilizer, sedative, or narcotic
Propofol	4–6	Similar to thiobarbiturates
	200–400 µg/kg/min	

Table 3
Volatile Inhalation Anesthetics

Drug	Approximate Vaporizer Setting ^a	
	Induction (%)	Maintenance (%)
Halothane	1–3	0.5–1.5
Enflurane	2–4	1.5–3.0
Isoflurane	1–3	0.5–2.0
Sevoflurane	3–5	1.5–2.5

^aAssumes fresh gas flow rate of 20–40 ml/kg/min oxygen. If nitrous oxide is added to the fresh gas flow rate, decrease vaporizer setting by approximately 0.25–0.5. These settings are for a precision vaporizer located outside the anesthetic circle. Settings for precision vaporizers in the circle are not listed.

used cautiously until ventilation can be supported or controlled because of the attendant respiratory depression. Further, ventilation should be assisted during surgical correction.

Blood loss commonly results from blunt or penetrating abdominal trauma. Anesthesia should be delayed until transfusion returns the packed cell volume to at least 18% to 20%. Blood substitutes^a (15 to 30 ml/kg IV) are extremely helpful in restoring vascular volume and blood oxygen-carrying capacity following acute blood loss.

Acid-base and electrolyte abnormalities are common in acute abdomen patients. Unless electrolyte and acid-base imbalances are extreme, they are not contraindications for anesthesia; however, their presence should be noted since cardiac arrhythmias and muscle weakness can result. The electrolyte that most affects anesthetic management is potassium, and concentrations less than 2.5 to 3 mEq/L or greater than 6.0 to 7.0 mEq/L can result in muscle weakness and cardiac arrhythmias. Acidosis with pH less than 7.10 results in myocardial dysfunction. Bicarbonate should be administered to increase the pH to greater than 7.20. Bicarbonate should not be administered in the face of respiratory depression as the resulting increase in blood CO₂ can aggravate the acidosis.

AIRWAY OBSTRUCTION

Airway obstruction can result from trauma, foreign body aspiration, organic disease such as arytenoid paralysis, and tracheal collapse. These patients should be handled in a way to minimize stress. Preanesthetic sedation is beneficial to decrease patient apprehension. Agents such as acepromazine (0.01 to 0.05 mg/kg IM) or acepromazine-oxy-morphone are suitable because they are easily administered and decrease the patient's apprehension. Mask induction should be avoided to prevent excessive struggling. Rapid sequence induction using lidocaine (2 mg/kg IV) followed by reduced dosages of thiopental (1 to 3

^aOxyglobin®—Biopure Veterinary Division.

mg/kg IV) or propofol (1 to 3 mg/kg IV) is preferred so a patent airway can be rapidly secured. A laryngoscope or other bright light source should be available to facilitate intubation. An endotracheal tube that is smaller in diameter than indicated for the animal's size and breed should be available to bypass an anticipated obstruction. The cuff of the endotracheal tube should be inflated to seal the airway (distal to the obstruction) from surgically induced secretions and flush solutions. Prior to induction, preoxygenation with 100% oxygen is desirable in the event intubation is prolonged and resumption of ventilation is delayed. If the obstruction precludes oral tracheal intubation, elective tracheotomy should be performed following anesthetic induction to ensure airway patency throughout the perianesthetic period. If there is any doubt about airway patency following surgery and extubation, a tracheostomy should be performed prior to the termination of anesthesia.

HEAD TRAUMA AND CENTRAL NERVOUS SYSTEM DISEASE

Increases in intracranial pressure can result from space-occupying lesions within the cranial vault. Anesthetic management of these patients requires familiarity with the dynamics of intracranial pressure and prevention of any further increase in intracranial pressure through proper drug selection and anesthetic technique. The use of preanesthetic drugs that induce respiratory depression (such as the opioids) should be avoided because respiratory depression causes arterial CO₂ to rise. Cerebral blood flow and intracranial pressure vary directly with concentrations of arterial CO₂ between 25 and 100 mmHg. The dissociative anesthetics directly increase intracranial pressure and should be avoided. Benzodiazepines and phenothiazines minimally affect intracranial pressure. Anesthetic induction is best accomplished with the barbiturates. These drugs directly decrease intracranial pressure and allow for rapid, struggle-free intubation. Because hypoxia, coughing, gagging, and/or retching increases intracranial pressure, a sufficient barbiturate dose should be administered to allow for smooth, easy intubation. Once the airway is secured, hyperventilation should be induced to lower the PaCO₂ to the range of 28 to 30 mmHg. All inhalation anesthetics increase intracranial pressure through increases in cerebral blood flow and intracranial cerebral-spinal fluid volume; if hyperventilation is induced prior to their use, however, intracranial pressure does not rise above prehyperventilation values. Isoflurane maintains the lowest intracranial pressure in the face of hyperventilation. Elevating the patient's head and ad-

Table 4
Drugs Used to Control Pain

Drug	Dosage (mg/kg)	Route	Duration (hr)	Comments
Nonsteroidal Antiinflammatory Drugs				
Aspirin	Dog: 10	PO	12–14	Platelet dysfunction
	Cat: 10	PO	48	Gastrointestinal hemorrhage
Carprofen	Dog: 1–2	PO	8–12	
Ketoprofen	Dog: 1–2	IV	6–8	
Etodolac	Dog: 10–15	PO	24	
Sedatives (Alpha-2 Agonists)				
Xylazine	Dog: 0.1–0.3	IM	1–5	Cardiovascular and respiratory depression
	Cat: 0.05–0.2	IM	1–5	
Medetomidine	Dog: 0.01–0.02	IM, IV	1–5	Cardiovascular and respiratory depression
Opioid Agonists				
Morphine	0.2–0.5	IM	2–6	Bradycardia, respiratory depression; use low dose in cats
Oxymorphone	0.02–0.1	IM, IV	2–6	Bradycardia, respiratory depression; use low dose in cats
Fentanyl patch	25, 50, 75, 100 µg/hr		48–120	
Opioid Agonist-Antagonists				
Pentazocine	1.0–4.0	IM, IV	0.5–1	
Butorphanol	0.2–0.4	IM, IV	1–4	Use lower dose in cats
Nalbuphine	0.6–1.5	IM, IV	1–5	Inconsistent activity
Buprenorphine	0.005–0.01	IM, IV	4–12	Occasional excitement
Opioid Reversal Agents				
Naloxone	2–20 µg/kg	IV, IM	0.5–1	Excitement
Alpha-2 Agonist-Antagonist				
Atipamezol	0.01–0.02	IM, IV		Increases activity, excitement
Local Anesthetics				
Lidocaine (2%)	0.5–1.0			
	50 µg/kg/min			
Bupivacaine (0.25%)	1–3	Selective nerve blocks	4–6	Addition of 1:100,000 epinephrine prolongs duration; 10–15 min latency for analgesic effect
	0.5	Epidural		
Ropivacaine	1–3	Selective nerve blocks	4–12	Addition of 1:100,000 epinephrine prolongs duration; minimal motor blockade
	0.5	Epidural		

ministering mannitol also aid in controlling intracranial pressure.

PAIN CONTROL

Recognition of Pain

Pain in animals is defined as an aversive sensory and emotional experience (a perception) that elicits protective motor actions, results in learned avoidance, and may modify species-specific traits of behavior, including social behavior. We tend to interpret animal pain anthropomorphically: If a noxious stimulus would cause us pain, we assume that it would also cause pain in an animal. The presence of pain and its quantitation are obviously more difficult to assess in animals than in humans because of the inability of the animal to verbally express suffering. Thus we probably underdiagnose the presence of pain and, when it is diagnosed, underestimate its severity.

It is helpful to try to objectively assess the degree of discomfort. This is important because many of the tra-

ditional therapies for pain relief can have adverse physiologic effects, such as respiratory and cardiovascular depression. Pain relief should not be instituted without first evaluating the degree of any physiologic derangement and the effects pharmacologic intervention will have on such derangements. Attempts have been made to assess pain by objective interpretation of pain-induced changes in normal physiologic behavior. Vocalization is commonly used to assess whether an animal is in pain; however, the degree of vocalization in response to pain is inconsistent among animals as stoicism varies both among and within breeds. Furthermore, animals may undergo an “emergence delirium” (i.e., a period of vocalization and spontaneous limb movement that may be confused with postoperative pain) in the immediate postoperative period. This seems especially true in dogs recovering rapidly from anesthesia compared to those experiencing more prolonged recoveries.

Sinus tachycardia and tachypnea are two physiolog-

ic changes that occur in response to pain. Unfortunately, a multitude of other factors commonly present in the postoperative or convalescent period (e.g., hypovolemia or the stress or fear of being placed in new and strange surroundings) can also cause tachycardia and tachypnea. Other changes in behavior or normal physiologic parameters that can occur in response to pain include aggressive behavior when a painful limb or extremity is touched, dilated pupils, loss of appetite, and inability to sleep. The clinician must base assessment of pain on all of these factors as well as on knowledge that certain conditions such as orthopedic surgery, thoracotomy (especially via a sternotomy approach), ear ablation, and other major invasions of

body cavities are generally associated with a significant degree of pain. Pain should be assessed with the understanding that behavior is often abnormal in animals that are confined to the critical care unit regardless of the degree of pain they experience. Finally, traumatized animals should be treated for pain independent of their physical and physiologic signs (Table 4). Remember: When treating traumatized patients, play it SAFE (Stabilize, Analgesia, Fluids and semi-continuous Evaluation).

REFERENCE

1. Muir W, Hubbell J, Bednarski R, et al (eds): *Handbook of Veterinary Anesthesia*. St Louis, Mosby, 1995.

