ANESTHESIA IN THE CRITICAL EQUINE PATIENT
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With any equine anesthesia comes risk of death. Statistics gathered in a worldwide study and reported within the last year state that the death rate for healthy horses undergoing anesthesia is about 0.9% (1:100 horses). When you add in sick and emergent patients the rate of death increases to 1.9% (1:50 horses). The risk of death in surgical colic patients is 10 times greater than that in a healthy horse undergoing an elective procedure. Compare this to 1:2,065 and 1:1,483, the numbers in cats and dogs respectively. These numbers are startling and emphasize the importance of gathering as much data as possible during the pre-anesthetic work-up of the emergent patient. The anesthetist needs every advantage during the anesthetic period, and work-up data can lead to good patient stabilization prior to induction. Because equine anesthesia is NEVER without risk, the anesthetist becomes in charge of risk management. The risks to the patients range from skin wounds through myopathies and neuropathies to death. The risks to anesthesia and surgical staff must also be considered. Determining the risks and selecting the best anesthetic protocol to control these risks and their adverse side effects is the primary responsibility of the anesthetist, with the help and support of the surgical staff.

The vast majority of critical patients fall in ASA categories 3-5/E; horses with severe systemic disease (severe anemia, strangles) to a moribund horse not expected to live for more than 24 hours (foal with a uroperitoneum with severe metabolic damage). Getting a history on the patient is the first step and is not always as easy as it sounds. Next should be the physical examination. The cardiovascular and respiratory systems should be scrutinized, as this is where the complications during the anesthetic period are most likely to arise. The musculoskeletal system should be considered as well, because if the patient is ataxic or has lameness while awake, induction and more importantly, recovery can be adversely affected. If there is a musculoskeletal abnormality, a recovery plan to possibly include assistance should be discussed and formulated prior to induction of anesthesia.

A TPR should be completed during the physical exam as well. An abnormal temperature whether it be hypo- or hyperthermic should be noted and the cause determined. An elevated HR or RR should be investigated thoroughly as well. Any irregular heart beats or arrythmias ausculted must be addressed, as should abnormal lung sounds detected. Irregularities with the heart should be further worked up with an EKG (to determine the type of arrhythmia) and an x-ray (if an enlarged heart is suspected).

An x-ray of the chest might be warranted if, on auscultation of the chest, loud breath sounds, congestion or muffled sounds are heard, particularly if there is a history of trauma.

Abnormalities are almost certain to be discovered during the physical examination of the emergent patient, especially a horse in the throngs of colic or a foal with a septic joint or uroabdomen. The most serious of these would be cardiovascular shock, which needs to be treated vigorously and immediately.

An invaluable diagnostic tool at our disposal is bloodwork, which commonly includes electrolyte evaluation, complete blood count (CBC) fibrinogen, and serum chemistry that evaluates muscle, kidney, liver and plasma proteins. Not coincidentally, anesthetic drugs and the anesthetic event most often affect the same systems adversely.

All critical and emergent patients should have a jugular catheter placed upon admission. This provides ready access to the vein for fluid or medication administration or emergency
drugs. Fluid therapy is the most common stabilization method used in the equine patient, whether it is to combat shock, hypovolemia, cardiovascular compromise or hemorrhage. The types of fluids may differ depending on the type of stabilization necessary. In most instances, the bigger the gauge of catheter placed the better, 10 or 12 gauge particularly in the colic patient or patient where blood loss is expected. If the 10 or 12 gauge catheters worry you, two 14 gauge catheters, one in each jugular is the next best thing.

Often times, the emergent patient is in need of IMMEDIATE surgical intervention and a work-up is minimal at best. Blood work may still be started but stabilization must occur post induction on the surgery table.

The anesthetist needs to be prepared at all times for an emergency case to present itself. Therefore it is always a good idea to have the anesthetic machine cleaned and set up ready to go. I also like to have emergency drugs drawn up prior to induction, especially if I am concerned about cardiovascular compromise occurring at the time of induction. A simple emergency kit with a few doses of each of the most commonly used drugs such as epinephrine, ephedrine, atropine or glycopyrrolate dosed for a 500kg horse is easy to prepare and invaluable in a CPR emergency.

Some of the most common emergency anesthetic events in equine patients are dystocia, colic, septic foal, septic joints, fractures, patent uracus, head trauma and myelogram, and uroabdomen. The most common surgical emergency in adult horses is exploratory laparotomy for the resolution of intestinal colic and I will concentrate on this protocol. Contributing to the risk factors of this surgery are conditions such as endotoxemia and compromised mesentery and/or intestine resulting in cardiovascular collapse. Of course there are other factors in other surgeries that cause similar risks. Dehydration can cause reduced cardiac output. Increased heart rate, weak pulses, prolonged capillary refill time and cyanotic membranes are signs of poor cardiac function. Abdominal distention can increase respiratory effort and decrease effectiveness. Pain, as a side effect of the colic or other condition, can become uncontrollable even in the face of multiple doses of analgesic drugs. This then becomes a deciding factor for proceeding with anesthesia. A stomach tube may need to be managed during anesthesia if it was passed to relieve abdominal distention and prevent aspiration or gastric rupture.

Hypovolemia and electrolyte imbalance are present in all but a very few surgical colic patients. Many times both conditions are severe in nature and require vigorous fluid therapy. Your choice of therapies may include one or more of the following; crystalloids or isotonic fluids, colloids or hypertonic fluid. Although isotonic fluids such as Lactated Ringer’s, Acetated Ringer’s (which I prefer) or Normasol are readily available, the large volumes that need to be administered to a dehydrated 1000 lb. adult horse can cause interstitial or pulmonary edema and take a long time to deliver. A dose of 50ml/kg/hr is necessary and in the unstable shocky patient, this type of fluid is rapidly lost from circulation. In these critical patients prone to shock, hypertonic fluid should be added to the treatment protocol. Not only does a smaller volume need to be infused to provide a profound effect that can last for an hour or more, but it can be infused over a shorter period of time (5-15 minutes). Most commonly, 7% NaCl or hypertonic saline at a dose of 2-5 ml/kg is used as it is inexpensive, commercially prepared and has anti-inflammatory and positive inotropic properties. I suggest administering 1 liter of 7% NaCl to the adult horse prior to induction and a second liter can be given during surgery if the patient’s condition has not stabilized.

Colloids such as Hetastarch or dextrans are fluids containing very large molecules that remain in the vascular space for a longer period of time and help to expand the intravascular
volume. Although in comparison with crystalloids the dose of colloid is small (5-10mls/kg), using it alone is impractical as it is commercially prepared in 500ml bags that are relatively expensive. An economic and effective alternative is to administer 1 liter of hypertonic saline and 2mls/kg of Hetastarch.

During the time of stabilization treatment and prior to induction, a very painful horse may need to be managed with sedation and analgesia. There are several classes of drugs to be considered. Alpha2 agonists are usually the drugs of choice as they contain both sedative and analgesic properties. Within this class of drugs, there are two commonly used products. Xylazine at the low dose of 0.2-0.4 mg/kg can be given as needed. Detomidine can also be used but can have a longer duration of action and more profound adverse effect on gut motility. If the decision for surgery is being delayed until the patient exhibits another painful episode, the wait may be prolonged with detomidine use.

NSAIDs such as flunixin (banamine), phenylbutazone and ketoprofen provide anti-inflammatory and analgesic properties particularly in patients with colic that could be resolved medically. Many times multiple doses of these drugs have been given by the patient’s owner, trainer or referring veterinarian in an attempt to medically treat the colic condition and avoid surgery. If this class of drugs has not been administered, it is a good choice for the anesthetist.

Opioids are clearly analgesic in nature but have side effects that need to be considered prior to their use. Morphine is a good analgesic (0.1-0.25 mg/kg; low dose IV higher dose IM) but can cause severe ileus, has a long onset time and can cause excitement when used alone. Butorphanol, which would be my drug of choice, is less potent than morphine but appears to have little or no effect on motility, has a short onset time, has good analgesic properties and, given with a small dose of xylazine, causes little or no excitement. Respiratory depression with butorphanol is minimal also. Butorphanol at a dose of 0.02 – 0.05 mg/kg IV can greatly reduce the dose of xylazine needed at time of premedication for induction.

Endotoxemia is a somewhat controversial subject as far as treatment is concerned. Some surgeons like to preventatively administer either Polymixin B or anti-endotoxin serum due to the belief that the majority of colicking patients are already or will become endotoxemic. Other surgeons apply the wait and see approach. Neither form of treatment is without adverse side effects. Anti endotoxin serum can cause a reaction and does not seem to be as effective as the Polymixin B. There are reports of nephrotoxicity with the use of this product but usually not at recommended doses (1000-6000 IU/kg, IV).

Premedication with antimicrobials such as K penicillin or gentamycin should occur at least 15 minutes prior to induction as a profound drop in blood pressure can accompany the administration of some of the drugs in this class.

The drugs included in the induction phase are generally based on personal experience and availability. Some drug combinations that can be considered are:

1. Butorphanol + Xylazine + Diazepam/Midazolam + Ketamine
   Opioid and benzodiazepine allow for lower dose of alpha2 agonist and better relaxation
2. Guaiaphesin (50mg/kg) + Thiopental (3mg/kg) or guaiaphenesin (50mg/kg) + ketamine
   (2mg/kg) following premedication with sedative and analgesic
After the patient is induced, I recommend that it be left in sternal recumbency for intubation. The chance for reflux and aspiration of gastric contents is high especially in the cases where abdominal distention is severe. Intubation prior to placing the horse in lateral recumbency secures an airway and decreases the chance for aspiration. If the patient is severely distended, it may be necessary to provide oxygen supplementation prior to attaching it to the anesthesia machine. This can be facilitated by the use of a demand valve. Intermittent positive pressure ventilation will probably be necessary for the entire anesthetic episode to insure adequate ventilation and O₂ delivery. High airway pressures may be needed to accomplish good ventilation until the abdomen is opened and the pressure relieved. End-tidal CO₂ may remain in the high range until adequate ventilation can be provided.

Once the patient is placed on the table and inhalant anesthesia is being delivered, the anesthetist may observe that a lower level of inhalant or lower MAC value may be necessary to achieve a surgical plane of anesthesia than would normally be expected in the same patient when healthy. For example, a young, healthy horse being anesthetized for an elective arthroscopy may require an end tidal of isoflurane of 1.6 while he may only need an end tidal of 1.1 if being anesthetized for a large colon impaction. This may be due to effects of endotoxemia. Total or partial intravenous anesthesia should be considered if the patient’s vital parameters such as blood pressure and heart rate are adversely affected even at a reduced MAC value. Adding intermittent or constant rate infusion doses of ketamine throughout the surgery can reduce MAC, add analgesia and increase blood pressure.

After starting inhalant anesthesia, cardiovascular support should be addressed. Preload or end-systolic pressure can be improved by fluid therapy. The most commonly used fluids are Lactated Ringer’s, Acetated Ringer’s (not commonly found commercially) or Normasol R. These isotonic mixtures are used interchangeably and are a good choice. To provide significant assistance to the cardiovascular system, volumes of 10-20 ml/kg/hr may need to be infused, thus the importance of a large gauge or multiple catheters. Colloids are only indicated if hemorrhage or hypoproteinemia develop.

In the event that fluid therapy is inadequate (and in the endotoxemic horse it most commonly is), positive inotropic therapy may be necessary. Horses with severe colic conditions appear to require larger doses of positive inotropes to normalize blood pressures. The most commonly used drug of this class is dobutamine, which is a cardioselective β₁ adrenergic agonist. The dose of dobutamine is 0.5-5 mg/kg/min and I recommend starting at 2 mg/kg/min and adjusting as needed. Dopamine at the same dose can be effective also but is not cardioselective. Ephedrine (0.05-0.1 mg/kg in single slow injection) is sometimes effective if dobutamine is not but has some adverse effects. It can make the patient light causing a need for increased MAC of your inhalant and can cause a predisposition to arrhythmias probably because it crosses the blood-brain barrier. Note: Some colic patients will not respond to the inotropes favorably. I recommend that you check a blood gas sample for iCa as it may be low despite normal calcium results on the chemistry. Infusing calcium slowly at a dose not to exceed 20mg/kg cannot only cause your positive inotrope to work more efficiently but also has inotropic properties itself.

When considering anesthetizing a very young foal (<60 days), especially one that is premature or compromised due to some form of sepsis, the delicacy of both the circulatory and pulmonary systems needs to be taken into account. Closure of vascular shunts takes 2-4 weeks in the full term foal and longer in the premature one. The shunts are likely to remain or re-open in the septic premature foal. When using arterial blood gas analysis to assess your patient, the
anesthetist needs to remember that PaO$_2$ and PaCO$_2$ levels differ from an adult horse in the foal that is < 7 days old. PaO$_2$ is lower and PaCO$_2$ is higher in the very young foal. In the laterally recumbent foal PaO$_2$ values are even 10-15 mmHg less than in the standing foal. In these foals cardiac output is directly dependent on heart rate, making it as or more important than blood pressure.

Because young foals tend to lapse into recumbency with sedation, some procedures like radiographs that are non-invasive or painless can be performed without general anesthesia. O$_2$ should be supplemented when possible during sedation. Benzodiazepines, diazepam /midazolam, (0.05-0.1 mg/kg IV) and the opioid butorphanol (0.02-0.03 mg/kg) can be used alone or in combination to produce effective sedation in sick or neonatal foals. Alpha$_2$ agonists such as xylazine and detomidine should be avoided in sick or very young foals. (I tend to avoid alpha$_2$ class drugs in any foals under 45 days or sick foals less than 60 days of age). Older and healthy foals can be sedated with alpha$_2$ agonists; xylazine (0.3-1.0 mg/kg IV), detomidine (0.005-0.01 mg/kg IV), medetomidine (0.0035-0.005 mg/kg IV) or romifidine (0.03-0.1 mg/kg IV).

In general, sick or neonatal foals tend to have reduced dose requirements for both injectable and inhalant drugs. The MAC for both isoflurane and sevoflurane are reduced dramatically in sick or very young foals, possibly due to partially developed CNS or diminished pain sensitivity. Conversely, older healthy foals that have excitable temperaments can require higher than expected doses and MAC levels. In the very young, premature or sick foal, mask inhalant induction is both possible and sometimes preferable. “Masking” can be achieved with a circle system through either a facemask held over the foals nose or a nasotracheally intubated tube. A nasotracheal tube may cause the foal more distress if placement is attempted without previous sedation. In very sick foals, this may not occur. If no sedation is your preference, I recommend the facemask as it can be successfully accomplished. Increased mortality, however, has been linked to mask inductions perhaps due to rapid uptake of inhalants in neonatal foals.

Injectable induction of anesthesia is most commonly achieved with varying doses of diazepam / midazolam and ketamine in the sick or very young foal. For a light plane of anesthesia to facilitate non-invasive or short procedures such as joint lavage or radiographs, ketamine(1-2 mg/kg IV) can be used with diazepam (0.05 mg/kg IV). This mixture can be given to effect throughout the procedure. For a deeper plane of anesthesia, the young or sick foal can be premedicated with pentazocine(0.3-0.5 mg/kg IV) or butorphanol (0.02-0.03 mg/kg IV) and then induced with ketamine (2-3 mg/kg IV) and diazepam/midazolam (0.05mg/kg IV)

Again, xylazine should be avoided in the sick or very young foal. Propofol (2mg/kg) could be a good substitute for the ketamine/diazepam but must be given slowly to minimize apnea. Propofol can be used with or without sedation although without previous sedation a higher dose may be necessary, apnea might be more likely and propofol provides little or no analgesia. Due to the cost of propofol, premedication and a lower dose might be preferable and the benefits to the patient should be weighed against said cost.

Maintaining anesthesia can be achieved with inhalants, partial intravenous anesthesia (PIVA), or total intravenous anesthesia (TIVA). There are advantages and disadvantages to each protocol. Selection of an anesthetic plan should be determined on a case-by-case basis and personal experience and comfort should be considered. I prefer PIVA including pentazocine, ketamine, midazolam, lidocaine and isoflurane. This multi-modal approach appears to eliminate prolonged recovery. Monitoring the patient and attempting to maintain minimum parameters in key physiological areas makes the anesthetic period safer and provides for a more consistent positive outcome. In the very young foal, mean arterial blood pressure can be lower than the
adult horse (40 - 60 mmHg) as cardiac output is dependent on heart rate. Therefore the heart rate in the neonate should be >50 BPM and bradycardia should be treated aggressively with positive inotropes. Intermittent positive pressure ventilation, whether manual or mechanical, should be provided, as hypoventilation and resulting hypoxia are common. PaCO₂ measured with a capnograph or arterial blood samples should be <50 mmHg. Whenever possible, warm air or water should be used to provide external heat for the foal. Circulating warm water blankets placed next to instead of under a foal or forced air blowers used with patient blankets placed next to or over the foal work well. Towels or thin blankets can be wrapped around the legs and placed over the neck and head of a foal in dorsal recumbency or used to cover the entire body of a foal in lateral recumbency. These efforts sometimes seem inadequate, especially when large volumes of room temperature liquids are being used to lavage the surgical sites, however they do reduce the predisposition for hypothermia and are beneficial to your patient. A very important and sometimes overlooked parameter in foals is blood glucose. This is especially true in the sick, non-suckling foals. Periodic monitoring of the glucose can be followed by administration of glucose, or fluids can be administered throughout the anesthetic period as a preventative to hypoglycemia. Lactated ringers or normasol R can be given (3-5ml/kg/hr) concurrently with 5% dextrose in either 0.45% NaCl or H₂O (2-5ml/kg/hr).

Thermal regulation is of utmost importance in all foals but none so critically as the septic foal. The very nature of the sick foal predisposes it to inadequate heat production or conservation. Muscle activity, both voluntary and involuntary, are decreased or inhibited. The average foal also has low body fat and high metabolic rate. This causes increased O₂ consumption, hypoxia and hypoglycemia during attempted heat conservation. Side effects of hypothermia or numerous and can include decreases in inhalant MAC, decreased rate of metabolism and drug elimination and prolonged recovery. This is especially true of the foal with a septic joint where profuse joint lavage with room temperature fluids adds to hypothermia. It is recommended that warmed fluids be utilized whenever not contraindicated.

Recovery in emergency patients can be difficult and should be considered carefully before the end of the surgery. Assisting the patient with ropes is a safe way to help ensure a good outcome.