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Monitoring of inhalant anesthesia in the horse should emphasize the cardiovascular system, the respiratory system, and the eye. As inhalant anesthesia deepens to surgical planes, the eye rotates medially; the eyelids cease voluntary closure, and tear production decreases. Lateral nystagmus may continue until surgical planes are reached. The palpebral reflex (eyelid closure following brushing of the lids) should decrease as anesthesia deepens and is generally weak but present at surgical planes. Corneal reflexes (closure of the eyelids following pressure on the cornea) should be present at all times during anesthesia. When the corneal reflex is absent, the horse is too deeply anesthetized and the anesthetic plane should be lightened. The anal reflex may be used to evaluate the depth of anesthesia if the head is covered. Absence of an anal reflex indicates the animal is too deeply anesthetized.

Physical monitoring of the cardiovascular system includes evaluation of pulse rate and strength, perfusion time at the gums, and auscultation of the heart. Heart rate does not change consistently as anesthesia deepens with halothane and normally ranges between 25 and 50 beats per minute during anesthesia. Rates less than 25 require the use of anticholinergics to increase the rate. Heart rates in excess of 50 may indicate light planes of anesthesia, hypotension, hypercarbia of hypoxemia. Pulse strength will decrease as the depth of anesthesia increases. The pulse pressure is a reflection of the difference between systolic and diastolic blood pressure and not a true indicator of perfusion pressure. A subjective indication of perfusion pressure can be attained by gauging the digital pressure required to occlude the pulse in a peripheral artery. Capillary refill time may be measured by blanching out the gums and counting the seconds until the color returns. Color of the mucous membranes is combined with capillary refill and used as an indicator of perfusion. Prolonged capillary refill time indicates decreases in perfusion, usually evidence for decreases in cardiac output. Alterations from the normal pink color of the gums may indicate poor perfusion, toxemia, cyanosis, or hypercarbia.

More definitive monitoring of the cardiovascular system is accomplished by directly or indirectly measuring arterial blood pressure and monitoring the electrocardiogram. Arterial blood pressure may be indirectly monitored using Doppler, oscillometric or plethysmographic techniques. Indirect blood pressure monitoring techniques are used as indicators of arterial blood pressure rather than absolute determinations. The accuracy of doppler techniques is dependent upon the selection of an appropriately sized occlusive bladder. Oscilometric and plethysmographic techniques may be inaccurate at low heart rates and during pronounced sinus arrhythmia or 2nd degree atrioventricular heart block. Both techniques are reasonably accurate in normotensive horses but their accuracy in hypotensive horses is questionable.

Direct monitoring of arterial blood pressure is accomplished by catheterizing a peripheral artery. With practice the facial artery, transverse facial artery and great metatarsal artery are all easily palpated and catheterized. Catheters for use in arterial pressure measurement range from 17 to 21 gauge in diameter. The pressure...
in the artery can be measured using a simple manometer. More elaborate commercial units for the measurement of arterial blood pressure generally combine pressure measurement with a tracing of the electrocardiogram. Commercial units utilize pressure transducers and display the pressure wave form on a screen or compute the pressure and display it digitally. Alterations in blood pressure are a reasonable good index of the depth of anesthesia. Blood pressure falls as anesthesia deepens and increases as anesthesia lightens. Mean arterial blood pressure should range between 60 and 90 mm of Hg during anesthesia. A mean arterial blood pressure less than 60 mm of Hg is associated with the loss of autoregulation of blood flow to vascular beds and should be avoided. Mean arterial pressures greater than 90 mm of Hg are a sign of light anesthetic planes and movement may be anticipated.

Hypotension should be treated often evaluating the depth of anesthesia, administering fluids to correct hypovolemia, or administering vasoactive drugs. Hypotension may simply be a sign of too deep of an anesthetic plane. If the anesthetic plane is appropriate, the rate of fluid administration should be increased. The maintenance rate of fluid administration under anesthesia ranged between 5 and 10 ml per kilogram of body weight per hour. Fluid administration at this rate maintains a patent catheter; replaces water losses ad promotes urine output. Choice of fluid is dependent upon the horse’s physical condition, acid-base and electrolyte status. In normal horses a balanced electrolyte solution with a bicarbonate source included is a good choice.

The rate of fluid administration can be increased with a pump if hypotension occurs. Packed cell volume (PCV) and serum total protein (TP) should be monitored to assess the horse’s fluid status. Fluid rates should be decreased if the PCV falls below 25% or the TP falls below 5.5g/dl. Hypovolemia in the presence of low PCV and TP must be corrected using blood or blood products which have oncotic value. Hypotensive states, which do not respond to fluids, may require the use of vasoactive agents such as dopamine or dobutamine. Dopamine (1-5 ug/kg/min) and dobutamine (1-5 ug/kg/min) increase cardiac output and arterial blood pressure. The dose rates listed are guidelines. Both drugs are given slowly and to effect then titrated to maintain blood pressure within acceptable limits. Signs of overdose with both agents include tachycardia, hypertension, and supraventricular and ventricular premature depolarizations. Should overdose occur the infusion should be discontinued. Both drugs have very short serum half-lived so their effects decrease rapidly when discontinued. Phenylephrine, ephedrine, and calcium are other agents, which have been used to increase arterial blood pressure. Phenylephrine increases peripheral resistance thus raising arterial blood pressure but cardiac output may be decreased. Ephedrine and calcium raise cardiac output and arterial blood pressure but the response to their administration may be delayed and unpredictable. Dopamine or dobutamine are preferred because of their ease of administration, predictability of effect, and their ability to increase cardiac output as well as arterial blood pressure thus promoting peripheral perfusion. Response to a cardiopulmonary emergency is facilitated by prior assembly of an emergency pack.

Monitoring of ventilation in the equine includes measurement of ventilatory rate, assessment of tidal volume, and measurement of arterial blood gases or indicators of arterial blood gases (pulse oximetry, end-tidal CO2 [ETCO2]). Ventilatory rate is easily measured and should range between 5 and 20 breaths per minute in the anesthetized horse. Assessment of the adequacy of the volume of respiration is difficult and one is often misled. The only true measurement of ventilatory adequacy is the measurement of arterial blood gases from a sample of arterial blood anaerobically collected. Measurement of the end tidal concentration of carbon dioxide in the airway gas can be used as an assessment of arterial carbon dioxide tension thus used to determine ventilatory adequacy. Horses which are placed on their back or anesthetized for greater than 90 minutes can be expected to hypoventilate. Decreases in ventila-
tion promote hypercarbia, hypoxemia, and acidosis, which may predispose to myositis and nerve paralysis. Ventilation may be assisted by manually squeezing the rebreathing bag and inflating the chest, but ventilators, which mechanically inflate lungs, are more efficient in maintaining respiration. Ventilators function by delivering a preset tidal volume or a preset peak inspiratory pressure. Tidal volume should be set at 10-14 ml/kg of body weight if a volume cycled ventilation is used. Peak inspiratory pressure should be set at 20-25 cm of water initially if a pressure cycled ventilation is used. Respiratory rates should range between 5-10 breaths per minute. The expiratory time of the ventilatory cycle should be equal to or preferably exceed the inspiratory time. The positive pressure within the chest that occurs during the inspiratory phase impedes venous return to the heart. Venous return to the heart increases during the expiratory phase to compensate for this decrease. These guidelines are only rough indicators for artificial ventilation of the horse. The only true measure of ventilatory adequacy is the sampling and measurement of arterial blood gases. Horses which are being ventilated correctly (PaCO\(_2\) of 40 mm of Hg) occasionally become hypoxemic (PaO\(_2\) less than 80 mm of Hg). The cause of the hypoxemia is not completely understood but probably results from mismatches of ventilation and perfusion which occur in horses placed in lateral or dorsal recumbency. Increases in cardiac output accomplished by the administration of fluids and drugs promoting cardiac contractility may help reduce the oxygen deficits.

Recovery is the most crucial phase of equine anesthesia, and one of the most difficult to control. As the horse awakens from anesthesia, he may try to stand before he has recovered the coordination to do so. If the horse tries to regain his feet and fails, he may become excited, try again and fall again, thrashing and flailing about. With continued thrashing the horse can easily injure himself or his handlers. Horses which try to regain their feet too rapidly may be sedated with small doses of IV xylazine (100 mg) in the recovery stall. Small dosages of IV xylazine supply sedation for 10 to 15 minutes, allowing the horse a longer time to exhale more halothane and regain more coordination before he attempts to stand.

It is rarely necessary to rush an animal to his feet following general anesthesia. Optimally the horse will lie quietly for 20-35 minutes, roll to his sternum and sit there for 10-15 minutes, then rise to his feet. Some horses require longer periods for recovery. If the horse has not attempted to rise one hour after the end of anesthesia, a handler should enter the recovery stall and stimulate him. Often these horses are merely resting and will roll to their sternum then come to their feet following light stimulation. Recovery should only be rushed if the horse has cardiopulmonary dysfunction in the recovery stall. Horses breathe better in sternal recumbency than in lateral or dorsal recumbency, thus horses that have labored respiration, poor color, or hypoxia should be rolled to their sternum and be supported in that position. It is not necessary to rush the animal to its feet from sternal recumbency.

Care should be taken to recover the horse in an area, which is free from extraneous stimuli. The area should be quiet and have lights that can dimmed. Two handlers should remain in the immediate area until the horse has regained his feet. Ideally recovered stalls should have padded walls and floors with good footing. All sharp objects should be removed from the area. Alternatively, the animal may be recovered outdoors on a lawn. Turf provides excellent footing for recovery and some padding should the horse fall. Recovery stalls should have a hook above for a hoist and have secure rings mounted on the wall. The horse may be helped to its feet by placing a head and tail rope on him and running the ropes through rings on opposite sides of the box. The head and tail rope are tightened as the horse rises to his feet to support the horse, helping him catch his balance. More experienced handlers may prefer to remain in the box with the horse and simply grasp his tail and halter to steady him as he rises.

Many horses become hypoxemic when removed from the anesthetic machine due to their positioning and the sudden decrease in
inspired oxygen concentration. Oxygen may be supplemented in the recovery period by using a nasal oxygen catheter. Flows of oxygen should be set at a minimum of 15 liters per minute to effect a demonstrable change in arterial oxygen tension. More efficient use of oxygen can be made using a demand valve, which supplies oxygen at high flows during the inspiratory phase of respiration. Significant increases in arterial oxygen tension can be made using the demand valve.

Extubation should be done when the horse begins to swallow and attempts to chew. The cuff should be deflated, then the tube removed. Following removal of the tube, the mouth gag should also be removed. The tube can be left in place until the horse is standing but this technique is not recommended for routine use.

Horses which have respiratory stridor during recovery may require a nasotracheal intubation. Prolonged anesthesia in dorsal recumbency may lead to edema of the nasal folds and mucosa. Rarely laryngospasm or laryngeal paralysis may occur requiring a tracheostomy.