EQUINE ANESTHESIA

L y L e DVM PhD DACVA

Introduction

- Higher morbidity and mortality associated with general anesthesia (1:100) in comparison to small animals (1:1000) or human (1: 200,000)
- No change of the risk ratio for the last 30 years, but the duration of surgery extended.
- Unique anatomic and physiologic characteristics presents additional challenge
- More pronounced cardiovascular depression (hypotension and reduced cardiac output) at equipotent MAC than other species such as dogs and cats
- The size, weight temperament and tendency to panic of the adult horse introduce the risk of injury to the patient and to the personnel.
- Prolonged recumbency is unnatural in the horse
- When a horse is placed in dorsal recumbency, the weight of the abdominal contents presses on the diaphragm and limits lung expansion, leading to hypoventilation. If the drugs used to produce anesthesia depress cardiovascular function, these changes will be exaggerated due to a ventilation-perfusion mismatch.

Standing chemical restraint and preanesthetic agents

- Due to higher risk associated with general anesthesia in this species, standing chemical restraint can offer safer alternative for many procedures
- Neuroleptanalgesia (neuroleptics + opioids) or sedative/opioid combination are most popular
- Produced by the concurrent administration of a sedative/tranquilizer and a narcotic analgesic (e.g. detomidine and butorphanol; acepromazine and morphine)
- Better restraint and analgesia (the combination is synergistic, not merely additive)
- Many procedures can be performed which would not be possible with the tranquilizer or sedative alone
- Dose sparing effect on both drugs
- Better cardiovascular preservation
- Can provide satisfactory working condition for minor surgery when combined with local anesthesia
- Less expense, less risk, less logistics
- This combination can also be effective as preanesthetic medication to produce reliable sedation (e.g. xylazine and butorphanol combination)
- A good preanesthetic sedation facilitate smooth induction and has anesthetic sparing effect during maintenance

Ac e

- Major tranquillizer

- Hypotensive
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- Depressed intestinal motility will last longer than the sedative effects of the drugs. Do not feed the horse until intestinal motility returns, otherwise the horse may become colicky
- Platelet aggregation
- Uterine contractions in cows. The incidence of abortion in pregnant mares has not been established. Detomidine in this regard has been regarded better alternative both in cows and mares.

Detomidine

- More popular in Europe (cheaper than xylazine)
- Duration of sedation longer acting than xylazine (twice), lasting at least 45 min
- 5 - 20 mcg/kg IV
- Similar side effects in all other aspects with xylazine
- Precautions are similar to those given for xylazine. Sedation may be inadequate if horse was excited before administration of detomidine.

Romifidine

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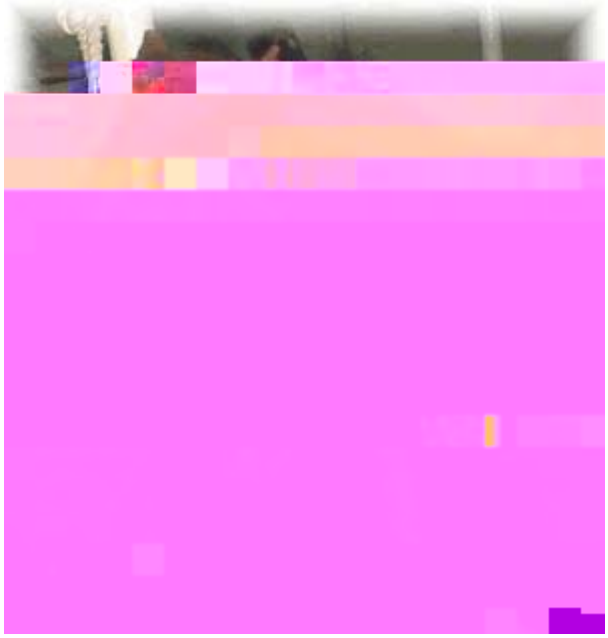
Preanesthetic Preparation

- No grain is to be fed 24 hours before anesthesia. No hay is to be fed 12 hours before anesthesia.
- Water is OK
- Foals scheduled for general anesthesia are usually allowed to nurse up to 1 hour before scheduled induction time
- Laboratory evaluation (minimum are PCV, TP, BUN, glucose)
- Additional tests may be warranted if sick and carries higher risks
- Review patient's medical history; check for deworming dates. Wait at least one week, preferably two, following organophosphate treatment.
- Do a physical examination to determine any abnormalities. Auscultate for cardiac dysrhythmias and murmurs, or abnormal lung sounds.
- Stabilize animal's physiology in debilitated animals (e.g. colic, ruptured bladder)
- IV catheterization in place
- A 12-14 gauge 3 – 5 inch long catheter is used for most horses.
- Pick the feet and clean the debris and dirt or cover the shoes
- Rinse the mouth with warm water prior to induction
- The mouth is washed out thoroughly using a dose syringe and water. This is done to prevent the endotracheal tube carrying food material into the trachea and lungs.

Mouth rinsing

IV catheterization



ANESTHETIC INDUCTION

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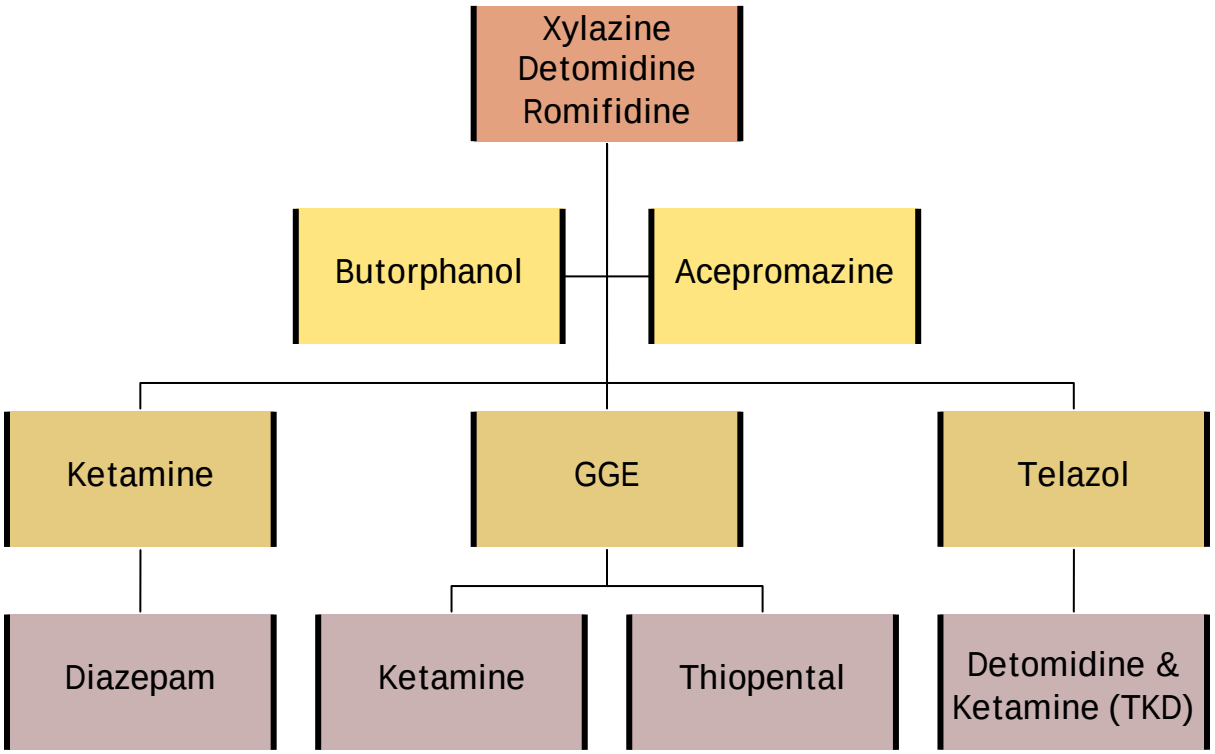
- Techniques to induce:
  - Swing door
  - Free fall
  - Hydraulic table

[illegible]

- Xylazine premedication and ketamine (±diazepam) Induction
- Ketamine administered alone without sedative premedication to the horse causes excitement
- Ketamine is injected 3-5 min after [illegible]

- When animal knuckles following adequate dose (usually 50 mg/kg), a rapid bolus dose of 0.5 mg/kg ketamine IV or 2 mg/kg thiopental sodium is administered to provide smooth anesthetic induction
- Anesthesia can then be maintained either on inhalational agent or intravenous anesthetics.
- Available in 5, 10, 15 % in commercial preparation, but concentration higher than 15 % is not recommended for use due to hemolysis.
- Can be mixed with thiopental sodium, ketamine or xylazine in the diluent
- Home-made GGE may form precipitates if left unused for prolonged period, but rewarming the diluent will resolve this, and the efficacy of the agent is not altered. This problem is not seen with commercial preparations.
- Variations (see the chart below)
  - Substitute xylazine with detomidine or romifidine
  - Add butorphanol to premed
  - Add acepromazine to premed
  - Add diazepam to induction
  - Add/substitute guaifenesin ± thiopental to induction
  - Add/substitute Telazol, detomidine to induction (TKD mixture)



Maintenance of Anesthesia

Many anesthetic agents can be used for maintenance of anesthesia

Inhalational anesthetics

- Problems occur more frequently and in greater magnitude than during canine anesthesia
- More pronounced hypotension, hypoventilation, reduction of cardiac output
- More dramatic consequence to the operator and the patient if anesthetic plane is not well controlled
- Halothane, isoflurane, sevoflurane, desflurane recovery differ. The fasted recovery may not be the best quality

Nitrous oxide

- Analgesia from N_2O reduces inhalational anesthetic requirement therefore less cardiovascular depression.
- However, even with 50 % oxygen and 50 % nitrous oxide mixture hypoxemia is common probably due to the nitrous oxide dissolving into gaseous space such as GIT and leading to the V/Q mismatches.
- Use of this agent is not recommended in this species (exception is foals and small-sized equids)

Halothane (Fluothane)

- Halothane has the highest metabolism, so avoid in hepatic insufficiency
- Currently it is not marked in the US, but some equine practices still carry it in their inventroy
- This agent is being largely displaced by newer agent such as sevoflurane and isoflurane as the cost of the newer agents becomes more affordable, however some equine practitioners use it other than cost reason, mainly for superior recovery quality (particularly important for orthopedic cases)
- 1 MAC halothane in horses is 0.9%, and 0.7 % in foals
- Always administered via endotracheal tube after induction of anesthesia with injectable

Isoflurane (Aerrane®, Isoflo®)

- Used to be much more expensive than halothane, but the price has come down substantially for the past few years, so more frequently used
- Quicker anesthetic stabilization and more rapid recovery
- However, in some recovery from anesthesia to consciousness is too quick leading to poorer quality. Sedation with a minute dose (0.2 mg/kg) of xylazine has been recommended to provide better recovery in some orthopedic procedures.
- 1 MAC in horses is 1.3%, and 0.9%. in foals
- The degree of respiratory depression is greater with isoflurane than halothane.
- As anesthesia deepens, the respiratory rate tends to increase with halothane and decrease with isoflurane.
- Controlled ventilation (IPPV) is recommended for isoflurane anesthesia
- Isoflurane, similar to halothane, induces a dose-dependent cardiovascular depression.
- Little difference in cardiovascular function has been noted between halothane and isoflurane when horses are breathing spontaneously.
- Under controlled ventilation, the cardiac output has been demonstrated to be significantly higher during isoflurane anesthesia.
- Isoflurane causes more peripheral vasodilation than halothane, which is responsible for a low arterial blood pressure, but tissue looks more bright and pinky indicating better perfusion.

Sevoflurane (Ultane®)

- Anesthetic induction, recovery, and intraoperative modulation of anesthetic depths to be notably faster than halothane and isoflurane.
- More expensive than halothane and isoflurane, but the price is getting lower.
- Sevoflurane (1 MAC = 2.3 %) is less potent than halothane or isoflurane, but more potent than desflurane

The following table lists some sample doses for injectable anesthetics in the horses

Comb. #	Premedication	Dose mg/kg	Induction agents	Dose mg/kg
1	Xylazine	1	Ketamine	2
2	Xylazine	0.7	Diazepam Ketamine	0.05 2
3	Xylazine Butorphanol	1 0.02	Ketamine	2
4	Xylazine Butorphanol	0.5 0.02	Diazepam Ketamine	0.05 2
5	Acepromazine Xylazine	0.04 0.6 to 1.1	Ketamine	2
6	Xylazine	0.6 to 1.1	Guaifenesin followed by ketamine bolus	100 (G) or "to effect" 1 (K)
7	Acepromazine or Xylazine	0.04 0.6	Guaifenesin 50 g mixed with 2 g thiopental followed by thiopental bolus	100 (G) – 4 (T) or "to effect" 2 (T)
8	Acepromazine or Xylazine ± Butorphanol	0.04 0.6 0.02	Guaifenesin 50 g mixed with 2 g thiopental followed by thiopental bolus	100 (G) – 4 (T) or "to effect" 2 (T)
9	Detomidine ± Butorphanol	0.01 0.02	EMC /P <</MCI	

Monitoring

- Potentially life-threatening values
  - HR < 24 beats/min
  - MAP < 60 mm Hg
  - RR < 4 breaths/min
- Evaluation of CNS
  - Eyeball position (central), pupil size, palpebral reflex (sluggish), corneal reflex (strong)
  - Nystagmus can be present, but usually indicates light plane (exception: dissociative drugs)
  - Lack of movement in response to surgery, muscle relaxation
- Evaluation of CVS
  - Palpation of peripheral arterial pulse quality, rhythm
  - CRT
  - Evaluation of blood loss
- Evaluation of Respiratory system
  - Color of mucous membrane
  - Characteristics of breathing pattern
- ECG
- Blood pressure
  - Direct measurement always if possible
  - Maintain MAP above 60 mmHg, or 70 mmHg in heavy muscled breeds
  - Dobutamine at the rate 1 –

Recovery

- The incidence of recovery associated complication is higher than other domestic species
- Airway obstruction is a concern: nasal edema can easily develop in dorsal recumbency and then cannot breathe after extubation
- Nasal spray of vasocontrictors (e.g. phenylephrine) are commonly applied, or alternatively nasal intubation is performed to secure patent airway (NB. make sure it is well secured to the animal's head/collar using tapes as loose tube may fall into the trachea during the recovery and may cause fatal airway obstruction)
- Supply with high flow oxygen during recovery (> 15 L/min)
- Demand valve can be used to give high flow oxygen and adequate tidal volume so as to assist ventilation to prevent hypoxemia
- Animals with preexisting neurologic signs (ataxia), rhabdomyolysis (tying-up), and lineage of

Post-anesthetic complications

- One of the major risks associated with equine general anesthesia is “post anesthetic myopathy”
- Myopathy or nerve damage in the limbs sometimes develops following general anesthesia as a result of ischemia or pressure damage.
- Most common form is ischemia of shoulder muscles or hindquarters resulting in lameness or inability to stand
- The horse cannot stand or will have difficulty in standing. Horses that were in lateral recumbency are most frequently lame in the dependent forelimb and/or hind limb
- Lameness is not always present immediately after the horse stands, but may develop 1-2 hours later.
- Post anesthetic myopathy prevention
- Positioning of limbs: lower forelimb forward, upper limbs elevated and supported, lower hind limb backward
- Foam pads, air mattress, water bed
- Maintain mean arterial pressure above 60-70 mm Hg
- Treatment of post-anesthetic myopathy
  - Pain management and anti-inflammatory agents (NSAID, Corticosteroids)
  - Fluid therapy
  - Diuresis
  - Calcium
  - Sling and ropes to support the torso
  - Physical therapy (gentle massage)
  - Positive inotropes to maintain CO and BP
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Case Example

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Problem	Significance on Potential Complication	Plan
CNS depression	Decreased dosage, hypoventilation	Reduce the calculated dose rates, controlled ventilation
Hypovolemia	Hypotension	Fluids before anesthesia
Abdominal distension	Hypotension, hypoventilation	Decompress before anesthesia, controlled ventilation
Metabolic acidosis	Hypotension, decreased dosage, prolonged recovery	Give sodium bicarbonate before anesthesia if pH < 7.2 and deficit > 10
Azotemia	Decreased dosage, prolonged recovery, post-operative renal failure	Use less than the usual calculated dose rates, dopamine infusion during anesthesia
Hypocalcemia	Hypotension	Give calcium
Dysrhythmias	Hypotension, cardiac arrest	Treat dysrhythmias, support CV function
Pain	Increased sympathetic activity	Provide analgesics eg, xylazine, butorphanol, flunixin meglumine etc.

Signalment	"Karma" 5 y.o. Female Quarter horse weighing 450 Kg
History	colicky for 24 hrs
Physical examination	HR 80, RR 40, Temp: 103, weak pulse on palpation, distended abdomen, decreased GIT motility, depressed
Laboratory evaluation	PCV 60, TP 10, BUN 25-35, glucose 130, PaO_2 60, $PaCO_2$ 25, pH 7.25, HCO_3^- 16, Na^+ 140, K^+ 5, Ca^+ 1.02, Cl^- 95
Patient preparation	Fluids: Normosol 40 ml/kg IV reassess PCV TP and electrolytes, and physical exam
Induction	Lower dose Xylazine 0.8 mg/kg + butorphanol 0.02 mg/kg Ketamine 2mg/kg + diazepam 0.02 mg/kg
Maintenance	Sevoflurane in oxygen
Monitoring	ECG, Capnography, Direct arterial blood pressure, Temperature, Arterial blood gas and electrolytes, blood loss, CRT, ocular reflexes etc.
Recovery	Quiet, dark and warm environment Oxygen supplementation and ventilatory support using demand valve Sedation with 0.2 mg/kg xylazine Small nasal tube to secure patent airway after extubation uneventful