- Adult cattle carries greater risk of developing myopathies and neuropathies following prolonged recumbency, so good positioning and protective padding must be ensured
- Following recumbency esophageal opening is submerged in ruminal contents, normal eructation can not occur, and gas accumulates. The degree of bloat depends on the amount of fermentation and on the length of time that gas is allowed to accumulate
- Gross distension of the rumen becomes a hazard if anesthesia or recumbency is prolonged and regurgitation can follow from this
- In addition, the weight of the abdominal viscera and their contents prevents the diaphragm from moving freely on inspiration and ventilation becomes shallow, rapid and inefficient for gas exchange within the lungs.
- In unfortunate circumstances, the aspirated regurgitatants obstruct the airway, cause asphyxia, and bring the patient to death within 24 hours of developing the complication.
- The danger of regurgitation can be minimized by:
  - Starvation prior to anesthesia
  - Water deprivation prior to anesthesia
  - In lateral recumbency, elevating the neck to avoid easy regurgitation and positioning the head sloped down to facilitate drainage of saliva (large amount produced) and other intraoral materials.
  - Passing down a stomach tube so as to allow drainage of ruminal materials (and also accumulated gas) during the recumbency
  - Cleansing solid materials in the mouth at the end of anesthesia, and leaving the ET tube with the cuff inflated until the animal is in sternal recumbency, is swallowing and is able to withdraw its tongue into the mouth
- Important consideration is the use of anesthetics to those animals for human consumption. Most anesthetic drugs are not approved for use in food animal species and these drugs are administered on extra-label use basis. If animals were to be shipped to market, and a residue

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- In camelids, two sites are recommended; 3-4 cm dorsal to angle of ventral border of mandible, and cranial to the ventral process of 5th cervical vertebra, for easier access to the jugular vein
- Other veins for venous catheter placement include the auricular vein and the coccygeal vein
- For jugular catherization 12-14 G for large ruminants, and 16 – 18 G for camelids and small ruminants are suitable

Preanesthetic agents

- A good preanesthetic sedation facilitates smooth induction and has anesthetic sparing effect during maintenance
- There are a few choices available
- Sedative/opioid combination (neuroleptanalgesia) is most popular (e.g. xylazine and butorphanol; acepbleur s6.2blnol; acept

Xylazine

- A potent hypnotic which provides deep sedation and popular as premedicant
- Onset of action following IV injection at 2 min, reaching peak effect in 5 minutes.
- Dose dependent severe cardiovascular effect: bradyacardia, AV dissociation, myocardial depression (decreased cardiac output)
- May cause hypoxemia and hypercapnia and pulmonary edema (this is most notable/predicatble in small ruminants, particularly in the sheep)

- When used in combination with a thiobarbiturate or ketamine, induction quality is improved and a lower volume of these anesthetic agents is required.
- Triple-Drip (Guaifenesin / Ketamine / Xylazine or GKX)
  - To mix triple-drip solution combine one liter 5% guaifensin (50 mg/ml, final concentration) with 100 mg of xylazine (0.1 mg/ml, final concentration) and 1 gram of ketamine (1 mg/ml, final concentration)
  - Loading dose 0.5 -2 ml/kg is given as an IV drip "to effect" for intubation and then continue on a slow drip until the isoflurane has fully taken effect (usually 5-10 minutes).
  - Alternatively, following xylazine-ketamine induction, guaifenesin-ketamine combination (there is no need to add xylazine as half life of xylazine is longer than ketamine in cattle) can be administered intermittently or CRI at the rate of 0.5 - 2 ml/kg/hr

Thiopental

- The ultra-short acting thiobarbiturate, thiopental, provides approximately 10-15 minutes of anesthesia when used alone.
- Recovery is through redistribution of the agent from the brain into the other tissues
- Maintenance of anesthesia through continuing use of thiopental is not recommended due to accumulative effect and resultant prolonged recovery
- Maintenance of anesthesia for longer periods of time can be accomplished through the use of inhalation anesthesia.
- 6-10 mg/kg in unpremedicated animals provides 10-15 minute of recumbency
- Thiopental (2 g) can be combined with guaifenesin (50 g) and can be administered at 100 mg/kg guaifenesin-4 mg/kg thiopental titrated to effect
- Pentobarbital, a short acting barbiturate was a commonly used injectable anesthetic agent in ruminants but is largely replaced by contemporary induction agents.

Propofol

- Propofol can be used in small ruminants or in calves for the induction and maintenance of general anesthesia. It provides rapid induction and is very rapidly eliminated from the plasma. 5-6 mg/kg IV produces 4-9 minutes of anesthesia
- Maintenance of anesthesia can be achieved using a constant rate of infusion.
- Expense is the primary limiting factor (along with impractically large volume for rapid administration) for use of this agent in large ruminants

Inhalation Agents (Isoflurane, Halothane, Sevoflurane, or desflurane)

- In small ruminants and calves general anesthesia can be induced by administering isoflurane, halothane, sevoflurane, or desflurane with a facemask
- For faster induction and less exposure to anesthetic gases, these agents can also be administered through nasotracheal intubation
- It is preferable to use non-rebreathing circuits for quicker induction and then switched to the circle rebreathing systems

Table1 Sample doses for injectable anesthetics in the cattle

Comb. #	Premedication	Dose mg/kg	Induction agents	Dose mg/kg
1	Xylazine	0.1	Ketamine	2
2	Xylazine	0.05	Diazepam Ketamine	0.05 2
3	Xylazine Butorphanol	0.05 0.02	Ketamine	2
4	Xylazine Butorphanol	0.03 0.02	Diazepam Ketamine	0.05 2
5	Xylazine ± Butorphanol	0.05-0.1 0.02	Guaifenesin followed by ketamine bolus	To effect

-3 1 BT /TT0 1 7 315.24 523.56 107.519461/TT0 6

- The laryngeal spasm is not uncommon in small ruminants and llamas to tactile stimulation. Topical desensitization of the larynx with use of lidocaine can be helpful to limit this.
- Nasotracheal intubation can be an alternative in difficulty of orotracheal intubation
- Following intubation, correct placem 7eB-7(r)3(e)ubation, corron

Maintenance

Inhalation anesthesia is the method of choice for maintaining anesthesia for prolonged procedure. Intravenous techniques can be used for a short anesthetic procedure.

Inhalational anesthesia

- Halothane, isoflurane, sevoflurane, and desflurane are available,
- Because of economic implications, halothane used to be the most widely used inhalant but it is no longer marketed, and isoflurane has become the most commonly used inhalant.
- Problems associated with inhalation anesthesia occur more frequently and in greater magnitude than in small animals, with more pronounced hypotension, hypoventilation, and reduction of cardiac output
- More dramatic consequence to the operation is likely if anesthetic plane is not well controlled

Nitrous oxide

- Analgesia from N_2

- 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 (the magnitude of this abnormality increases with body size and duration of recumbency).

- Vapor setting is at 5% (3-4 % in small ruminants) at induction with oxygen flow at 20 ml/kg/min and is reduced between 1.5-3 % during the maintenance with oxygen flow at 10 ml/kg/min
- Isoflurane, similar to halothane, induces a dose-dependent cardiovascular depression.
- 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.
- Isoflurane is less prone to cause arrhythmia compared to halothane

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 it is getting cheaper.
- Sevoflurane (1 MAC = 2.3 %) is less potent than halothane or isoflurane, but more potent than desflurane
- Sevofluraneis it

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Monitoring

- Anesthetic monitoring is important to maintain a proper plane of anesthesia and to prevent excessive insult to the cardiovascular, respiratory, and central nervous systems.
- Anesthetic depth can be measured by observation of the following signs: physical movement or jaw chewing in response to stimulation, eye position and degree of muscle tone, and presence or absence of palpebral reflexes etc. There are some differences in the eye position in the ruminants. The eyes rotates ventrally as anesthesia deepens rather than rotating rostroventrally and only the sclera is seen; it then rotates centrally during deep anesthesia

Figure 4 Testing palpebral reflex to assess anesthetic depth

- Body temperature is also an important parameter to monitor during anesthesia. Because of the tendency for anesthetized animals (more so in small ruminants) to lose body heat, supplemental heat sources are often required to maintain adequate body temperature (100-103

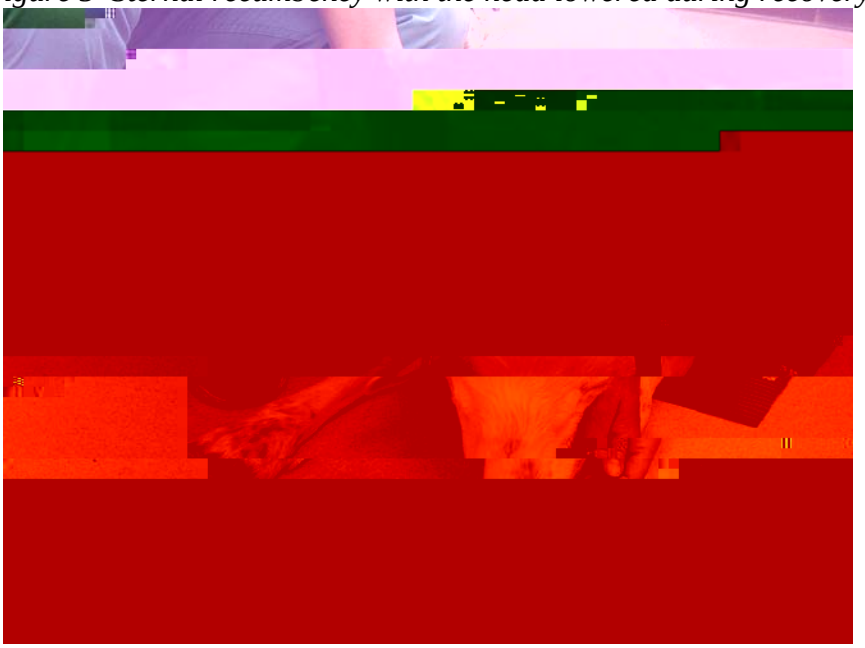
Perioperative pain management

- Assessment of pain in ruminants can be difficult because of their stoic nature.
- Behavioral changes associated with pain include decreased appetite, sluggishness, indifference to the surrounding, and avoiding human contacts.
- Changes of body temperature, respiratory rate, heart rate, and blood pressure can also be used to assess pain. These signs, however, are not always reliable indicators of pain.
- Due to the difficulty of accurately determining pain levels in ruminants, the routine use of analgesic therapy prior to and following painful or surgical procedures is recommended.
- Several types of drugs have been used to provide analgesia in ruminants including opioids, α2-adrenergic agonists, local anesthetics, and nonsteroidal anti-inflammatory drugs (NSAID's).
- Significant variations exist in regards to duration of action and quality of analgesia provided by these agents.

Recovery

- Ruminants seldom attempt to stand up and remain in sternal recumbency until able to stand
- Position in sternal recumbency with a pad placed under the mandible with the mouth end below the level of the larynx to drain saliva/regurgitants and prevent aspiration

Figure 5 Sternal recumbency with the head lowered during recovery



- Regurgitation in ruminants is always a possibility and therefore the ET tube cuff must remain in place as inflated

Figure 6 A llama in sternal recumbency

Figure 7 Pigs may resent human handling and it may present difficulty in effective premedicating

Drug administration

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Endotracheal intubation

- Intubation is not easy in the pig.
- The shape and size of the head and mouth make the use of a laryngoscope difficult
- Laryngeal spasm is easily provoked so that intubation must be carried out under deep general anesthesia or with the aid of muscle relaxant or local anesthetic spray
- The size of ET tube when compared to those used in dogs of similar weight is unexpectedly smaller (e.g. 6 mm ID for a 25 kg pig)
- Introduction of the tube may be made easier by using stylet. Malleable metal stylet or plastic urinary catheter can be used
- Laryngoscopes made for man can be suitable for small pigs, but Rowson laryngoscope may be needed for large pigs to expose the larynx to view
- The rima glottis is extremely small and the larynx is set at an angle to the trachea, causing difficulty in passing the ET tube beyond the cricioid ring.
- The induced pig is usually placed in dorsal recumbency with the head and neck extended. The shape of larynx is unique in the pig so that flexing the neck will facilitate when the tube's progress arrested with re-angled tube end.
- When resistance to the advancement of the ET tube is met, the tube is rotated to 180 degree which should effectively introduce the tube beyond the ventral floor of the larynx and allow successful completion of the intubation

Anesthetic maintenance

- Just as in the other domestic species maintenance of anesthesia for prolonged duration is best done with inhalation anesthesia
- Isoflurane, halothane, sevoflurane and desflurane all can be used, although halothane is the least desirable due to malignant hyperthermia.
- In farms, procedures such as C-section can probably be best performed under epidural or regional anesthesia.

Porcine malignant hyperthermia

- Some strains and breeds suffer from a biochemical myopathy which manifests itself during general anesthesia
- Termed 'porcine malignant hyperthermia', this is characterized by development of muscle rigidity, tachypnea, tachycardia, a severe sustained rise of body temperature, hyperkalemia, respiratory acidosis and metabolic acidosis.
- Common breeds affected by this syndrome include heavy muscled show pigs such as Poland-China, Pietrain, Landrace, Large White, Hampshire. Some breeds are less susceptible and include Duroc breed.
- Dantrolene sodium, a skeletal muscle relaxant, givenorally in doses of 2 to 5 mg/kg 6 to 8 hours before the induction of anesthesia, may prevent the onset of the syndrome in susceptible pigs and IV in doses of 2 to 10 mg/kg, has proved of some use in treating the established condition

Recovery

- During recovery it is important to keep the pig in warm environment as due to their lack of body hair they are prone to develop hypothermia if left in cold surrounding
- Adequate post-operative pain relief should be provided by opioi