Bovine Field Anesthesia

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Introduction:

The general intent of this session is to review the sedative drug options (on their own and/or prior to general anesthesia) and the anesthetic options for field surgeries in cattle which are practical in Canada. The objectives are to review the major anatomic and pharmacologic bovine differences that greatly impact the success of the practitioner and specifically address what can be done safely in the field.

Pre-anesthetic Preparation

The major anatomic and physiologic features that increase the general anesthetic risk in cattle include: i) a tendency to regurgitate and therefore potentially aspirate if the airway is not protected, ii) the potential to develop ruminal distention (bloat), iii) the potential to develop neuropathies and myopathies with recumbency, and iv) the potential development of hypoxemia on room air with recumbency and/or general anesthesia. These same risks may become evident with recumbency on its own in cattle.

Calves under 2 months of age can be considered monogastric animals because they lack a fully functional rumen; however very young calves, neonatal (<2-4 weeks), or even pediatric (4 weeks to 2 months) may have immature liver and kidney function. Most pharmacology textbooks refer to calves of 4 months of age having normal liver and renal function. The younger calves may demonstrate immature organ function with a prolonged duration of action of injectable agents and inhalational anesthesia is recommended for the true neonatal animal. As the calf ages rumination develops and the risk of regurgitation and aspiration increases despite the positive development of mature organ function.

In general, pre-anesthetic preparation in cattle includes a physical examination, fasting, estimation of body weight, and appropriate laboratory evaluation if indicated. Pre-anesthetic fasting recommendations typically reported are that 2-4 month old calves be deprived of food and water for 2-8 hours, and that 4-6 month old calves be fasted for 12-18 hours and deprived of water for 8-12 hours. Adult cattle should be fasted 24-36 hours and deprived of water for 12-18 hours. Very large bulls will typically be fasted for 36-48 hours and water withheld for 12-18 hours. Fasting true neonates is not recommended and should not be withheld for more than 2 hours because of the development of hypoglycemia as glycogen storage in the liver is minimal.

For the field situation with general anesthesia with injectable agents in calves, having the animal off feed may not always be possible and the increased risk of regurgitation and aspiration as the calf ages needs to be realized by the practitioner. Fasting and water deprivation will decrease the incidence of tympany and regurgitation by reducing the overall volume of fermentable ingesta, hence re-scheduling a surgery in an older calf will minimize your risk.
Physiologic Changes Associated with General Anesthesia in Cattle

- **Respiratory System**

  Hypoventilation (therefore hypercapnia) is generally profound at surgical planes of anesthesia in calves and cattle. The respiratory pattern of anesthetized cattle is characterized by a high respiratory rate and small tidal volume (20-30 breaths/minute in cattle and 20-40 breaths/minute in calves). The true neonatal calf will also exhaust more easily and hypoventilation will become significant during spontaneous ventilation due solely to their age as in other species. With prolonged surgeries, most anesthetized cattle require ventilatory support. Hypoxia can occur particularly if the animal is in dorsal recumbency, or has not been held off-feed adequately, or develops ruminal distension. For short-term injectable anesthesia and surgery most calves will likely have a reduced PaO\(_2\), or become hypoxemic (PaO\(_2\)<60 mmHg) while breathing room air. In the field the short duration of injectable anesthesia will minimize a high morbidity and mortality from this.

  It is also important to note that recumbent adult cattle with or without sedation on room air will also have significant reductions in PaO\(_2\). Ruminal tympany and advanced pregnancy will also severely decrease ventilation during recumbency. Experimentally, inflation of the rumen in awake healthy cattle to pressures similar to what is generated with bloat and recumbency decreases lung volume, increases PaCO\(_2\), and decreases PaO\(_2\). In general, as surgical time continues beyond 20-30 minutes, the risk increases and should not be continued beyond one hour. Be prepared to supplement inspired oxygen (which can be done), and/or support ventilation when longer surgical times are required. Xylazine administration can also cause hypoxemia through mediator release by alveolar macrophages in the lung, although this is more commonly reported in small ruminants (sheep).

- **Cardiovascular System**

  Hypotension can occur particularly if the animal is dehydrated or septic. Bradycardia can follow the administration of xylazine. Cardiac output in the neonatal or pediatric calf is primarily dependent on heart rate. Stroke volume is therefore fixed and increases or decreases in preload and afterload are poorly tolerated. Parasympathetic tone dominates in the immature heart therefore the bradycardic influence of certain drugs such as alpha2-agonists may induce severe hypotension. Hence blood loss becomes significant quickly in the pediatric animal. (approx 5 ml/kg). Heart rates for normal anesthetized cattle are typically 40-60 beats/minute (with alpha2-agonist) and 70-90 beats/minute (without alpha2-agonist). Normal heart rates for calves are more varied in the range of 90-120 beats/minute and will decrease as they age.

- **Gastrointestinal**

  Salivation-can lead to airway obstruction if the airway is not protected. Anticholinergics generally are not administered due to poor efficacy (anticholinesterases) and risk of increasing viscosity of secretions. Regurgitation -positioning of the head down with the mouth lower than the larynx so that material can drain is important to prevent aspiration even when the animal is intubated (do not consider endotracheal tubes 100 % protective for aspiration). The incidence of regurgitation will typically be less with the animal in sternal, then lateral (less with left lateral recumbency versus right lateral), with dorsal having the highest potential. Other factors that may contribute to increased intra-ruminal distension are the fall after induction, tight belly bands used to secure the animal on a table, rolling the animal from side to side or onto its back, or coughing stimulated from tracheal intubation with the animal too light. Retrograde esophageal contractions are easily observed in a lightly anesthetized animal and may indicate impending regurgitation. The animal should not be moved aggressively after heavy sedation or induction unless an endotracheal tube has been inserted.
**Sedation / Pre-medication**

In adult cattle most field surgeries are performed with sedation and local or regional anesthesia. The reason general anesthesia with injectable or inhalational anesthesia is not typically performed in adult cattle is primarily related to the risks of general anesthesia and recumbency with any ruminant, cost of equipment required for intubation and maintenance, withdrawal times, as well as economic factors. Luckily, cattle are willing, compared to horses, to accept mechanical restraint with or without sedation and with local anesthesia while not inflicting severe injury to itself or those around it.

Sedation can be used on its own in cattle or it can be used in combination with injectable anesthetics as discussed below to provide general anesthesia. When discussing sedation of patients, the term “level of sedation” is frequently used to describe the degree of CNS depression of the patient. The level of sedation is generally referred to as mild, moderate or heavy and generally correlates with how easy it is to arouse the patient. Moderate or heavy sedation in cattle will cause recumbency and also increases the risk of bloat and aspiration even when used on its own without general anesthesia. Therefore, the practitioner must always keep in mind the potential for life threatening consequences induced by recumbency and heavy sedation in cattle, especially if they are not off feed.

Several factors should be taken into consideration when selecting the appropriate sedative agent in cattle including; withdrawal times, pregnancy status of the animal, desired duration of sedation, need for analgesia in addition to sedation, and the cardiopulmonary status of patient. There is also variation within breeds of cattle to their sensitivity to alpha2-agonists. In general hereford cattle are more sensitive than Holstein cattle and other anecdotal evidence suggests Brahmans to be the most sensitive.

The alpha2-agonists are the most commonly used drugs for sedation in cattle. Other drugs such as acepromazine, chloral hydrate and pentobarbital have long histories of use in cattle, however they are not likely as commonly used and more importantly they are not analgesics hence do not offer major advantages in routine situations.

Xylazine, detomidine, medetomidine and romifidine are the alpha2-agonists available in Canada. The alpha2-agonists offer the advantages of providing predictable sedation ranging from mild to profound, good analgesic properties, and can be administered IV or IM. The main disadvantages in cattle are bradycardia, hypotension, respiratory depression, hypoxemia, tympany, diuresis, increased uterine tone, and unexpected recumbency. They are contraindicated in debilitated, hypoxemic, hypovolemic animals or in cattle with urinary obstruction or 3rd trimester of pregnancy (xylazine). Of these, xylazine is likely most often used in Canada to provide sedation in cattle. It is commonly cited that xylazine has oxytocin like effects, which may result in abortion in pregnant cattle. Fetal death is likely due to hypoxia from prolonged constriction of blood vessels in the myometrium and placenta from the alpha2 induced intrauterine hypertensive effects. Detomidine has not been reported to have the same uterine effects in cattle and can also be used as a sedative although more expensive and on average 10X the cost of xylazine/mL. Multiple reports have surfaced in the literature using medetomidine in calves. As this drug is more specific, the analgesic and sedative properties of this drug are more profound, however, this drug is also more expensive. With the need for improved analgesic agents in ruminants medetomidine may have a place in food animals if drug approval moves forward. Established withdrawal times for medetomidine in cattle are not available as compared to xylazine and detomidine.

**Suggested doses include:**

**Xylazine**

- 0.01-0.05 mg/kg IV (usually I start with 0.02 mg/kg and top-up)
- 0.1-mg/kg IV and 0.2 mg/kg IM will result in recumbency and sedation for approximately one hour.

**Withdrawal times:** IV or IM: 48 hrs milk; 3 days meat
Detomidine
2.5-10 mcg/kg IV will provide standing sedation for approximately 30-60 minutes
40 mcg/kg IV will produce profound sedation and recumbency
100 mcg/kg by dart have been used to immobilize free-ranging cattle

Withdrawal times: 72 hrs Milk; 3 days meat – off label

Medetomidine:
5 mcg/kg IV standing sedation
10 mcg/kg IV recumbency in cattle
30 mcg/kg IM induces recumbency and sedation for 30 minutes in calves

Withdrawal times: ??

Combinations of xylazine and butorphanol have been have been used by this author in cattle to provide neuroleptoanalgesia at doses are 0.01-0.02 mg/kg IV of each. It is important to note that butorphanol is not approved for food producing animals, but is likely the most commonly used opioid in cattle in North America, but it is off label. At a dose of 0.05 mg/kg SC every 4-6 hours withdrawal suggestions are 4 days meat and 72 hours milk.

Benzodiazepines can be used as sedatives in calves and will produce good muscle relaxation with mild to moderate sedation. They typically should not be given to adult cattle unless the practitioner is prepared to support ataxia and recumbency. Diazepam does have a suggested withdrawal time of 30 days for meat and it should not be administered to lactating dairy cows. Diazepam can be administered at 0.1 mg/kg IV in calves. Due to the nature of the drug vehicle of diazepam absorption will not be complete with IM administration and minimal effects will be observed and is not recommended by this route in a food-producing animal due to meat quality issues. In calves, diazepam can be used on its own for sedation at this dose and will induce recumbency. In a sick or truly neonatal animal this author prefers diazepam as a sedative as it is safe with minimal cardiovascular effects. However, it is not an analgesic as is xylazine. Diazepam may cause prolonged recovery times in the neonatal calf (<2 weeks of age), and reversal with flumazenil may be indicated. When general anesthesia and intubation is to be performed in a calf, then diazepam may be required at higher doses, 0.25 mg/kg IV.

Induction
There are situations where general anesthesia is required for certain surgeries in the field. Injectable agents are most appropriate for true field situations as these drugs do not require major equipment, such as an inhalational machine, allowing the drugs to easily be transported to the patient. Major surgical interventions in cattle or calves requiring prolonged recumbency times should be referred to a hospital equipped with inhalational anesthesia, respiratory support equipment, and other equipment essential to allowing successful general anesthesia and recovery. While economics may be a limiting factor in many instances preventing referral, the likelihood of regurgitation and aspiration in adult cattle with general anesthesia is so high, approximately 30%, and reported up to 60-80% in unfasted ruminants, that unless the practitioner has the equipment and ability to perform tracheal intubation or ventilatory support the end results will inevitably lead to an unacceptably high morbidity and mortality and cannot be recommended. Regurgitation in non-anesthetized cattle is fairly low and intubation is not practical.

Most likely, field anesthesia situations relate to surgeries in calves, namely umbilical herniorrhapsy, cast or splint application, or major wound repair. Inhalational anesthesia with a small animal anesthetic machine with single soda-lime canister (calves under 40 kg) or double soda lime canister (up to 150 kg) is appropriate if available in the mixed animal clinic and the calf is easily transported. In both situations, local or regional anesthesia, NSAID’s, +/- butorphanol are necessary to provide analgesia and minimize the need for additional injectable or inhalational
anesthetics. In general sedation may not always be necessary in cattle due to their nature and acceptance of restraint, however, in most situations pre-anesthetic sedation is of benefit.

General anesthesia can be induced by either injectable drugs or in young calves (2-4 weeks) by inhalational anesthesia (halothane, isoflurane, sevoflurane). Injectable drugs available include thiopental, ketamine, guaifenesin, and propofol. Intravenous access is highly recommended but mandatory if using GG or thiopental. Options include jugular and auricular veins. For the typical field event, the most likely injectable technique would consist of ketamine with or without diazepam after a pre-medication with an alpha2-agonist. Inhalational anesthesia as mentioned above is an option if the calf can be transported to the clinic.

Thiopental administered at 6-10 mg/kg in the unsedated animal and 4-6 mg/kg with sedation will give approximately 10-15 minutes of surgical anesthesia time with acceptable muscle relaxation. It is typically given following GG or high dose xylazine. Recovery from induction doses of thiopental is based upon redistribution of the drug from the brain to other tissues. Metabolism of this agent continues for some time following recovery until final elimination occurs. Maintenance of anesthesia with thiopental is not recommended because saturation of tissues will cause recovery to be unacceptably prolonged. Thiopental is very irritating if given peri-vascular.

Ketamine is commonly used in veterinary anesthesia. It provides mild cardiovascular stimulation, which is of benefit in sick animals. Ketamine will induce immobilization on its own, but will have incomplete analgesia, and poor muscle relaxation so is typically administered with xylazine +/- diazepam to improve the quality of anesthesia. Ketamine is typically administered at 3-5 mg/kg IV after pre-medication with xylazine (0.03-0.05 mg/kg IV), with additional injections of ketamine of 1-2 mg/kg IV as required for maintenance. In general additional doses of ketamine will need to be given every 5 minutes to prolong surgical anesthesia time to up to 30 minutes. The total induction dose volume of ketamine as additional boluses should not be exceeded again. The benefit of a local anesthetic block with even an injectable anesthetic regime will not only provide better pre-emptive analgesia for the animal preventing wind-up of pain transmission, but will also minimize the need for excessive injectable administration. Intramuscular administration of these agents (xylazine 0.1-0.2 mg/kg IM followed by 10-15 mg/kg IM; with injections of 3-5 mg/kg IM as needed) are reported for calves, however, this author recommends intravenous administration when possible to better control the depth of anesthesia and prevent excessive depth and hang-over at recovery.

Guaifenesin (GG) is a centrally acting skeletal muscle relaxant that can be used to induce recumbency in cattle, or given with ketamine or thiopental for induction and intubation. GG is an adjunct to anesthesia only-not a general anesthetic. Only 5% solution should be used in cattle as hemolysis occurs at higher solution concentrations. These solutions can be given rapidly to effect, but IV access is required as it is very irritating perivascularly. Typical doses include (50 mg/kg; or 2mL/kg). For calves, syringes should be used to ensure overdose does not occur as volumes required are in the range of 50-100 mls and most companies supply GG in a 1L format. GG does require warming and will precipitate at room temperature, which is a definite disadvantage in any practice, but especially for the field situation in Canadian temperatures.

For older calves, ketamine and xylazine may be added to the GG to be given for surgical maintenance but the rate will be based on depth of the animal and sometimes will be faster than the rate recommended and other times will be reduced or even off to ensure your animal is not too deep.

Combine: GG – 1L of 5%, Xylazine – 100 mg, Ketamine – 1000 mg
Dose: 2 ml/kg/hr

GG may have an advantage for sedation, casting, or surgical maintenance in calves for shorter procedures, but in adult cattle in the field without the ability to intubate it is unlikely to be a viable option.
The withdrawal times suggested for single or repeated doses of injectable agents at the doses above are as follows:

<table>
<thead>
<tr>
<th>Agent</th>
<th>Meat (days)</th>
<th>Milk (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketamine</td>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>Diazepam</td>
<td>30</td>
<td>do not administer to lactating</td>
</tr>
<tr>
<td>Guaifenesin</td>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>Thiobarbiturates</td>
<td>1</td>
<td>24</td>
</tr>
</tbody>
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**Anesthetic Protocols – Calves**

**Protocol 1: Sick, younger calf**
- Premedication: Diazepam 0.1-0.2 mg/kg IV
- Induction: Ketamine 2 mg/kg IV
- Maintenance: Injectable Ketamine 1-2 mg/kg IV; (Halothane or Isoflurane)

**Protocol 2: Healthy calf**
- Premedication: Xylazine 0.01-0.05 mg/kg IV or IM
- Induction: Ketamine 2 mg/kg IV
- Maintenance: Injectable Ketamine 1-2 mg/kg IV; (Halothane or Isoflurane)

**Airway Management**
Despite being relatively difficult, it is always recommended to secure an airway in ruminants under general anesthesia due to the high probability of regurgitation and the potential for subsequent airway obstruction. Cattle and ruminants in general are difficult to intubate because of their anatomical differences; the tongue is thick and fleshy, jaw mobility is low and the larynx is sloping and positioned very caudal in the field of view. Also, watch the length of the endotracheal tubes in ruminants as if it is too long it can obstruct the right main stem bronchus.

**Techniques for intubation**
- Blind intubation
- Direct Visualization (+ guide stylet); calves
- Palpation (+ guide stylet)

**III. Monitoring**
Anesthetic depth can be monitored with ocular rotation and other eye signs, and cardiorespiratory parameters. Ketamine administration will offset the bradycardia induced with xylazine sedation. Animals typically demonstrate a cluster style or Cheyne-Stokes respiration with ketamine administration in which the animal will have an increase in rate and depth, which is followed by progressively slower rate and a brief period of apnea. In general hypoventilation is noted.

The progression of ocular rotation is consistent in cattle and relates to depth with injectable or inhalant drugs. Ketamine has been cited to cause a more central eye due to ocular muscle tone, but this is typically when used on its own at high IM doses. When given IV with other sedative and analgesic agents ocular rotation occurs.
Bovine Eye Signs

1. Awake
2-5. During the transition from light to deep anesthesia, the eye moves ventrally. Occasionally, the eye can be noted to move caudodorsally as in 3, then will transition to central if it rotated caudally and then will rotate ventrally. There will be a very brisk palpebral with 2-4 and this will decrease to a weaker palpebral with the position in 5. The eye will remain moist.

6. As the eye moves centrally again as in 6, at a deeper plane of anesthesia, the palpebral will be absent and the eye will appear dry. This depth is not necessary.

References: