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Anesthetic Management of Camelids (4 September 2000)

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Introduction
Similar to other species, general anesthesia in Camelids (e.g., llamas, alpacas, camels) may be induced and maintained with injectable agents, inhaled agents or a combination of these agents. Previous reports describe the use of many drugs (e.g., xylazine, guaifenesin, ketamine, thiopental, halothane and isoflurane) for sedation and general anesthesia [1-5]. Techniques used to support and monitor these animals in the peri-anesthetic period have also been described in depth elsewhere [1-5]. Hence, the focus of this manuscript will be to add to this base of information by reviewing new material pertinent to the anesthetic management of primarily llamas and alpacas. Brief descriptions of anesthetic techniques for the camel are also included; readers are referred to a recent review article for further detail [3].

Sedation, Tranquilization, Chemical Restraint
Intramuscular (IM) and intravenous (IV) administration of xylazine or xylazine and ketamine has been extensively described for use in llamas, alpacas and camels [2,4,6,7] While these drugs alone and in combination do provide effects ranging from sedation to short-term anesthesia, the degree (level of sedation or anesthesia) and duration (may range from 10 to 60 minutes) of response in individual animals is variable. While the variability in the response may be influenced in part by unpredictable drug absorption from the IM administration site, the IM route is still preferred by many veterinarians due to the difficulties encountered when locating and establishing venous access in Camelids.

Barrington et al., describe the use of butorphanol (0.1 mg/kg, IM) in combination with intra-testicular lidocaine (2 %, 2 - 5 ml / testicle) for chemical restraint to facilitate standing castration in over 100 llamas [8]. Their impression was that the animals receiving butorphanol appeared less stressed than those receiving only intra-testicular lidocaine.

Using the dose of butorphanol described by Barrington et al., as a starting point and after preliminary dose-response studies, Mama et al., evaluated the cardiopulmonary and behavioral effects of xylazine (0.03 or 0.04 mg/kg, IM), butorphanol (0.3 and 0.4 mg/kg, IM) and ketamine (3 or 4 mg/kg, IM) in 7 male llamas and 7 male alpacas [19]. Due to prior investigator experience with this drug regime (indicating the need for higher drug doses in alpacas), alpacas received the higher dose of each drug. Five out of 7 animals in each group became recumbent in an average of 4.3 (llamas) and 6.7 (alpacas) minutes. Induction quality was good with animals generally showing some degree of ataxia before assuming a sternal or lateral position. Despite receiving lower drug doses, llamas appeared more deeply anesthetized and remained recumbent for a longer duration (mean time to standing 63 min) than did alpacas (mean time to standing 22 min). All animals recovered without apparent complications.

During drug-induced recumbency minor manipulations including ocular centesis and catheter placement were easily performed. Direct mean auricular arterial blood pressure was well maintained averaging 131 mm Hg in llamas and 144 mm Hg in alpacas; heart rate ranged from 29 - 37 beats/min in llamas and 37 - 49 beats/min in alpacas. While ventilation was only slightly compromised (average PaCO2 was 46 - 49 mm Hg), the PaO2 (average 45 - 55 mm Hg, average barometric pressure 640 mm Hg) decreased to clinically unacceptable levels
in some animals implying the need for inspired oxygen supplementation during recumbency induced with xylazine, butorphanol and ketamine.

**Regional Anesthetic Techniques**

As demonstrated in the report by Barrington et al., the regional administration of a local anesthetic can facilitate surgical intervention and minimize the need for administration of drugs with systemic effects [8]. This can greatly change the peri-anesthetic management of the animal and minimize the potential for complications (e.g., regurgitation, myopathy) associated with drug-induced recumbency. The use of local anesthetics to facilitate laceration repair and surgical intervention (e.g., inverted L block for paralumbar approach) have been described in llamas and camels and are largely extrapolated from experiences in other species (predominantly cattle) [4,9,10].

In camels, 12 - 15 ml of 2 % lidocaine may be administered in the caudal epidural space with the animal in sternal recumbency. This dose is reported to produce analgesia of the perineum, udder or scrotum for 1 - 2 hours without influencing motor control [10].

Grubb et al., evaluated the use of lidocaine and xylazine for epidural analgesia/anesthesia in llamas [11]. Diagnostic and surgical procedures involving the rectum, vagina and perineum may be performed in standing animals using this technique. Further, this technique may be used to provide regional analgesia. Onset and duration of analgesia was evaluated in 6 mature llamas following sacrococygeal administration of lidocaine (0.22 mg/kg), xylazine (0.17 mg/kg) and a combination lidocaine and xylazine. Behavioral (e.g., sedation) and physiologic (e.g., heart rate, respiratory rate) were also evaluated at predetermined intervals following drug administration.

Time to onset of analgesia was similar in the lidocaine (average of 3.2 minutes) and xylazine/lidocaine (average of 3.5 minutes) groups. Onset time in the group receiving xylazine alone was longer averaging 20.7 minutes; duration of analgesia in this group was intermediate (187 minutes) between the lidocaine only group (average of 71 minutes) and the xylazine/lidocaine group (average of 326 minutes). Evidence of mild sedation was seen in only some of the animals receiving xylazine. Ataxia was not observed when the animals were standing or encouraged to stand from the seated position.

**Anesthetic Induction and Maintenance Techniques**

While the aforementioned regional techniques are suitable for numerous situations, general anesthesia is warranted in animals scheduled for highly invasive surgical procedures (e.g., celiotomy). The inhalation anesthetics (e.g., halothane, isoflurane) have been used to maintain anesthesia in camels, llamas and alpacas. Recently results of two studies highlight the anesthetic dose requirement, behavioral and cardiopulmonary effects of isoflurane in llamas [12,13]. The minimum alveolar concentration (MAC) of isoflurane in eight otherwise unmedicated mature llamas was 1.05 +/- 0.17 % (barometric pressure 760 mm Hg) [12]. Anesthetic induction took an average of 19 minutes from time of first isoflurane breath to orotracheal intubation. Animals were anesthetized for approximately six hours during the study but regained a sternal posture with the ability to support their heads an average of 23 minutes after the anesthetic was discontinued.

Six of the aforementioned eight animals in whom MAC had been previously determined were anesthetized with isoflurane in oxygen at a later date and then administered one of three doses (1.0, 1.5 and 2.0 MAC) of isoflurane in random order [13]. Cardiopulmonary responses were assessed at each dose and during both spontaneous and controlled ventilation. As anesthetic dose was increased, a decrease in mean arterial blood pressure and an increase in heart rate were observed in animals during both spontaneous and controlled ventilation. Cardiac output and PaCO₂ recorded during spontaneous ventilation were higher than those recorded when ventilation was controlled. The PaCO₂ was also influenced by anesthetic dose in spontaneously ventilating animals (increasing in value as anesthetic dose increased).

The average time from induction to endotracheal intubation was 17 minutes. Recovery to sternal recumbency and standing averaged 15 and 36 minutes, respectively. During anesthetic induced recumbency, spontaneous behaviors (e.g., swallowing, limb movement) decreased with increasing anesthetic depth. Jaw tone and palpebral reflex activity appeared to be most consistently influenced by anesthetic dose; positive responses decreased as dose increased. Eyelid aperture also tended to increase in a dose-dependent manner and in five of six llamas the globe was centrally positioned at 2 MAC (deep plane of anesthesia).

Following anesthetic induction with injectable agents, anesthesia has been successfully maintained in camels using halothane [14,15]. White et al., report mean saphenous arterial blood pressure ranging from 76-115 mm
Hg during anesthesia maintained with halothane [15]. Mean carotid arterial pressure reported in another study was lower in halothane-anesthetized camels when compared to those receiving only thiopental [14].

Respiration during halothane anesthesia was characterized by a shallow rapid pattern, but PaCO² increased progressively up to a high value of 57 mm Hg [15]. Both studies describe recovery from anesthesia as uneventful. Ecternal recumbency was achieved in an average of 25 to 39 minutes for animals in each of two studies; time to standing was more variable [14,15].

While inhalation anesthetics continue to be used to maintain anesthesia, the need for specialized delivery equipment generally limits the use of this technique to the hospital environment. The advent of short acting, rapidly cleared IV drugs provides veterinarians with the option of maintaining general anesthesia using continuous infusions (or repeated injections) of injectable agents. Duke et al., evaluated propofol, a drug with these potentially beneficial characteristics, for anesthetic maintenance in 5 llamas [16]. The cardiopulmonary effects of two infusions of propofol (0.2 mg/kg/min and 0.4 mg/kg/min) were assessed following administration of 2 mg/kg IV for anesthetic induction. The infusions were maintained for 60 minutes during which time llamas receiving the higher dose appeared adequately anesthetized and generally unresponsive to external stimuli. Conversely, llamas receiving the lower dose were noise sensitive and made some weak attempts to raise their head. Animals stood an average of 13 to 22 minutes following termination of the low and high dose infusion, respectively and showed little to no ataxia.

During anesthetic maintenance with both infusions of propofol the heart rate was increased (to approximately 90 beats/min) over pre-drug values (of approximately 55 beats/min). Mean carotid arterial pressure was similar to pre-drug values and ranged from an average of 103 mm Hg to 147 mm Hg during drug-induced recumbency. Although the PaCO² increased and PaO² decreased in recumbent animals, the values remained within a clinically acceptable range (mean PaCO² no greater than 45 mm Hg and mean PaO² no less than 83 mm Hg). Three llamas did however become dyspneic and required placement of a nasopharyngeal tube to ensure a patent airway.

Propofol (2 mg/kg IV) has also been used in premedicated (with xylazine and diazepam) camels to induce and maintain short-term anesthesia [17]. Duration of recumbency was longer in animals receiving high doses of xylazine and diazepam and ranged from an average of 26 minutes to an average of 60 minutes. Heart rate increased from post sedation values averaging 45 beats per minute to a high value of 88 beats per minute 10 minutes after propofol administration. Respiratory rate ranged from 12-18 breaths per minute during drug-induced recumbency.

Muscle Relaxation During General Anesthesia
When muscle relaxation provided by the anesthetic agents alone is not adequate (e.g., intraocular surgery, reduction/repair of a displaced long bone fracture), drugs that block the neuromuscular junction are used as adjuncts during general anesthesia. Hildebrand et al., evaluated the efficacy of atracurium, administered via intermittent IV bolus (0.15 mg/kg initial dose, followed by 0.08 mg/kg) or IV infusion (0.15 mg/kg initial dose, followed by 0.4mg/kg/hr) in halothane anesthetized, mechanically ventilated llamas [18]. Both methods were found to provide adequate relaxation in these animals as monitored by reduction of the evoked hind limb digital extensor tension (twitch), but authors noted that twitch strength recovery time was variable between animals. Residual neuromuscular blockade was antagonized with edrophonium (0.5 mg/kg IV). Atropine (0.01 mg/kg IV) was given with this reversal agent to avoid its muscarinic side effects.

Summary
While none of the recent developments in anesthetic management of Camelids provide flawless technique, they offer additional options and opportunities to provide improved care to llamas, alpacas and camels needing sedation or general anesthesia.

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