Electrostimulation-guided RUMM nerve block in an alpaca (*Vicugna pacos*) for metacarpal bone fracture repair

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Abstract

A female alpaca (*Vicugna pacos*), 1.5 months old, weighing 19 kg, was presented for investigation of acute lameness. After imaging diagnostics, a Salter Harris type 3 fracture of the third left metacarpal bone was identified. The anaesthetic protocol included pre-emptive and multimodal analgesia with systemic drugs such as morphine, ketamine and meloxicam and was complemented by an electrostimulation-guided RUMM (Radial, Ulnar, Median and Musculocutaneous) nerve block as loco-regional anaesthesia technique. As a popular and effective peripheral nerve block described in other species, this technique also contributed to partial analgesia to this patient.

Keywords: Alpaca, loco-regional anaesthesia, RUMM nerve block, levobupivacaine

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Introduction

Anaesthetic protocols have been described for a variety of medical procedures, including surgery, diagnostic imaging and dental procedures in alpacas. General anaesthesia is necessary to ensure the animal remains immobile and pain-free during these procedures (Larenza et al., 2008; Abrahamsen, 2009). Loco-regional anaesthesia is a technique that provides additional pain relief to a specific area of the body by injecting a local anaesthetic drug around the nerves that supply the area (Grubb and Lobprise, 2020). In the last few years, this technique has also been described in alpacas for various procedures, such as surgical interventions or pain management (Grubb, 2014). There are several techniques to approach peripheral nerve blocks using electrostimulation or ultrasound-guided techniques described in the literature that can be used in alpacas (Foster, et al., 2020; Van Wijnsberghe, et al., 2021). The specific type of nerve block used depends on the location of the procedure and the nerves involved (Portela, 2018). Common types of nerve blocks used in alpacas include brachial plexus (Santoro et al., 2022), femoral and sciatic (Foster, et al., 2020; Van Wijnsberghe, et al., 2021), paravertebral and interdigital nerve blocks (Grubb, 2014). Each type of nerve block has its own technique for locating the nerve and injecting the anaesthetic drugs (Portela, 2018). The use of electro-stimulation can improve the accuracy of the nerve block and help to minimize the risk of complications (Grubb and Lobprise, 2020). The most commonly used local anaesthetic drugs in loco-regional anaesthesia in alpacas include

lidocaine, levobupivacaine, mepivacaine and ropivacaine, normally at a dose range of 0.5-2 mg/kg total dose (Grubb, 2014). The following case description intends to demonstrate a successful execution of a RUMM block guided by electrical nerve stimulation in an alpaca undergoing metacarpal osteosynthesis.

Case description

A female alpaca (*Vicugna pacos)*, 1.5 months old, weighing 19 kg was referred to the Large Animal Clinic of the Liège University for lameness. The paediatric patient was accompanied by its mother and displayed normal behavioural patterns for its age and species. For the past 2 weeks, a swelling in the left thoracic fetlock had been noticed in the medial side of the limb. The general physical examination was unremarkable for its age and the orthopaedic examination showed a 4/5 lameness degree from the left thoracic limb and painful on palpation. Radiographs showed a fracture of the dorso-medial part of the condyle of the metacarpal bone III involving the metaphysis and epiphysis, reaching the articular surface. A Salter Harris type 3 distal fracture of the third left metacarpal bone was diagnosed.

An osteosynthesis of the metacarpus was proposed to the owners who signed a written consent authorizing the general anaesthesia and surgery. The alpaca was scheduled for surgery without indication of fasting due to its young age. It was first sedated intramuscularly (IM) with 0.1 mg/kg morphine (morphine, Sterop, Belgium), 0.2 mg/kg of midazolam (Midazolam 5 mg/mL, Mylan, Belgium) and 3 mg/kg of ketamine (Ketamidor® 100mg/mL, Richter Pharma, Germany) in the neck region. A moderate sedation was performed 10 minutes post-administration and, with the animal in sternal recumbency, a 18G jugular cannula (Intraflon2, Vygon, Belgium) was placed in the right jugular vein. Thirty minutes after the premedication, anaesthesia was induced intravenously (IV) with 0.5 mg/kg of ketamine and 1 mg/kg of propofol (Propovet, Zoetis, Belgium) via jugular cannula. The animal was positioned in sternal recumbency, and the neck was extended to facilitate visualisation of the larynx for endotracheal intubation. After topical application on the laryngeal cartilages of lidocaine 10% (Xylocaine spray® 10%, Aspen, France), endotracheal intubation was achieved by using a 20 cm long Miller blade laryngoscope and a 7 mm inner diameter cuffed endotracheal tube (ETT). Once the ETT was in place and the cuff was inflated, the alpaca was positioned in right lateral recumbency and the ETT connected to a circle rebreathing system (Penlon Prima 320 Anaesthesia station, InterMed, United Kingdom). The head and the neck were slightly elevated to avoid regurgitation. Anaesthesia was maintained with isoflurane (IsoFlo 100%, Zoetis, Belgium) delivered in 100% oxygen. The animal was allowed to ventilate spontaneously before surgical instrumentation and loco-regional anaesthesia was performed. Once surgery started, mechanical ventilation was implemented using a volume-controlled ventilation mode with a tidal volume of 10 mL/kg and an inspiration to expiration ratio (I:E) of 1:2. Respiratory rate (RR) was adjusted to maintain normocapnia (35 - 45 mmHg end-tidal carbon dioxide pressure) and a peak inspiratory pressure of up to 10 cmH2O. The end-tidal isoflurane concentration (EtIso) varied between 0.7% and 1.2% throughout the procedure. The multiparametric device (VT-9000, Veterinary techniques Int., The Netherlands) was used to monitor RR, heart rate (HR), electrocardiogram (ECG), pulse oximetry (SpO2), EtIso, end-tidal carbon dioxide pressure (EtCO2), inspired fraction of oxygen (FiO2), peak inspiratory pressure (PIP), non-invasive blood pressure (NIBP; pressure-cuff placed on the right forelimb) and oesophageal temperature continuously.

During the procedure and recovery period Lactated Ringer solution (LRs) (Vetivex solution, Dechra, Netherlands) supplemented with 2.5% glucose (glucose 30% Kela, Kela, Belgium) was administered at a rate of 5 mL/kg/h through the IV cannula. An active forced air warming device (Bair Hugger 775 model, 3M Health care, Germany) was used to avoid hypothermia.

After the correct positioning of the animal and following clipping of the hair on the medial and lateral aspect of the left thoracic limb, standard surgical preparation of the skin for nerve block was performed. A radial, ulnar, median and musculocutaneous (RUMM) nerve block was performed as previously described in dogs by Trumpatori et al. (2010) and Bortolami et al. (2012) and aided by a peripheral nerve locator (TOF-Watch S, Organon Ltd, Ireland). A volume of 1.9 mL levobupivacaine 0.5% (Levobupivacaine 0.5%, Fresenius Kabi, Belgium) was used to desensitize the radial nerve and 1.9 mL for the ulnar, median and musculocutaneous nerves, corresponding to a total dose of 1 mg/kg (total volume = 3.8 mL). This dose was define by extrapolation from studies in other species with levobupivacaine (Bortolami et al. 2012). In this instance, the radial nerve was approached on the lateral aspect of the mid-humeral region, between the lateral head of the triceps and the brachialis muscles, while the ulnar, median and musculocutaneous nerves were approached through a single injection on the medial aspect of the mid-humeral region, where the humeral shaft can be palpated caudal to the biceps muscle. A 20-gauge insulated needle of 100 mm length (SonoPlex STIM, Pajunk, Germany) was inserted perpendicularly into the skin and gently advanced delivering an initial electrical current of 2 mA with a frequency of 1 Hz for each approach. The muscle contraction and extension of the elbow and fetlock joints (twitches) were used to confirm that the tip of the needle was close to the nerve. At this moment, the current was decreased in a stepwise response manner (0.1 mA) to ensure that the needle was not penetrating the nerve fibres. No muscular contraction was observed in response to 0.4 mA current. After confirming the absence of blood aspiration, levobupivacaine was administered perineural with no significant resistance.

General anaesthesia lasted for 2 h and 30 minutes and the surgical procedure lasted 1h and 50 minutes. Hypotension (arterial blood pressure under (MAP) under 60 mmHg) was noticed during anaesthesia and treated with a 10 ml/kg bolus of LRs administered over 15 minutes, followed by a continuous infusion rate of 5 ml/kg/h supplemented with 2.5% glucose during the entire procedure. Before the beginning of surgery, the alpaca received 4.4 mg/kg of ceftiofur (Cefokel 50 mg/mL, Kela, Belgium) IM and 0.5 mg/kg meloxicam (Meloxidyl 5 mg/ml, CEVA, Belgium) subcutaneously (SC). Surgery started 55 minutes after the beginning of inhalation anaesthesia and 25 minutes after the RUMM block. During the procedure, two boluses of 0.5 mg/kg ketamine IV were administered: the first was given right after the skin incision (due to a sudden 25% increase in MAP compared to the baseline value) and the second was administered when the screw was being applied (with an increase of 15% in HR and 20% in MAP when compared to the baseline values). Glycaemia was monitored every 45 min and remained within normal ranges during the entire procedure. No active or passive regurgitation were observed during general anaesthesia. A compressive bandage (Robert Jones dressing) was performed from the scapula up to the hoof in the end of the surgery for postoperative support and stabilisation in the first 3-4 weeks.

Recovery from anaesthesia was smooth and uneventful. Endotracheal extubation was performed 15 minutes after the end of inhalation anaesthesia. Clinical signs were within normal range and the alpaca shortly returned to standing position. When returned

to its mother, the animal showed immediately suckling behaviour.

The alpaca remained hospitalised with his mother for clinical monitoring (mentation, suckling behaviour, faeces, urine production and associated pain behaviours like bruxism). Pain assessment was performed using a Visual Analogue Scale (VAS). The day after surgery, the animal was ambulatory but dragging the tip of the hoof on the floor and was not completely supporting the limb, despite a normal physical examination and feeding behaviour. This side-effect disappeared 24h after the nerve block was carried out and the alpaca regained normal gait. Meloxicam 0.5 mg/kg SC was administered every 2 days and morphine 0.1 mg/kg IM in 4h intervals was defined as analgesic rescue if signs of pain or discomfort were seen. On the third postoperative day, the alpaca and its mother returned home. One months later, it was re-admitted for follow-up examination. Radiographs showed a normal ossification process and there was an improvement in the locomotion pattern. A new Robert Jones bandage was performed and removed 4 weeks later, when complete healing was observed.

Discussion

General anaesthesia in alpacas is a complex and potentially risky procedure that requires careful consideration and planning to ensure the safety and well-being of the animal. Several factors that should be taken into account when planning anaesthesia for alpacas. These include the age, weight, and overall health status of the animal, as well as the type and duration of the procedure (Larenza et al., 2008; Abrahamsen, 2009). In our case, a young alpaca of 1.5 months with a bone fracture needed general anaesthesia and one of the main concerns was a short fasting and the monitoring of glycaemia. As LRs was supplemented with glucose, the glycaemia remained normal during the anaesthesia period.

Commonly used anaesthetic agents in alpacas include injectable anaesthetics (such as ketamine and xylazine) and opioids (butorphanol and morphine) for pre-emptive analgesia and pain management (Taylor et al., 2017). Induction of anaesthesia can be achieved with a combination of ketamine with benzodiazepines, propofol or alfaxalone (del Alamo 2015). Maintenance is normally achieved with inhalational agents such as isoflurane or sevoflurane. The anaesthetic protocol chosen in our case is in agreement with the techniques described in the literature (Abrahamsen, 2009; Abrahamsen, 2014).

The use of loco-regional anaesthesia can be advantageous as it reduces the risk of pain sensitisation and the odds of respiratory and cardiovascular complications associated with systemic anaesthesia due to its sparing effect. Additionally, it can provide excellent pain relief for the specific area of the procedure, allowing for better postoperative recovery (Adams, 2017). Electric nerve stimulation and ultrasound-guided nerve block (alone or in combination) are the standard techniques to perform loco-regional anaesthesia in veterinary medicine (Portela, 2018). Electric nerve stimulation involves the use of a specialized device that generates an electrical current of low-intensity (up to 5 mA) and short-duration (1-2 Hz repetition rate) to locate and stimulate the peripheral nerve or nerve plexus (muscle twitch as response) using an insulated needle. In our case, we successfully applied the peripheral nerve stimulation and block technique (Van Wijnsberghe, et al 2021). On the other hand, ultrasound guided nerve block allows the direct visualization of the nerve as well as the surrounding tissues by means of the ultrasound probe and machine. Although it required specialized training and experience, this technique ensures real-time visualization and delivery of the anaesthetic solution

delivered to the desired site (Portela, 2018). The major limitation of our case was the impossibility to combine the electric nerve stimulation and the ultrasound guided nerve block techniques for anaesthesia optimization and higher safety standards for the patient. This was due to the lack of available equipment (ultrasound machine).

Most commonly local anaesthetic drugs described for loco-regional anaesthesia in alpacas include lidocaine, bupivacaine, mepivacaine and ropivacaine (Grubb, 2014). In our case, the chosen drug was levobupivacaine at a total dose of 1 mg/kg that revealed to be satisfactory, as part of a multimodal analgesic approach, when practiced by an electric nerve stimulation, and without major side effects for the patient. This molecule and dose were considered efficient and safe for this paediatric patient due to its minimal cardiovascular side effects. Although loco-regional anaesthesia can provide effective pain relief, there are some concerns that should be taken into account when using it (Grubb and Lobprise, 2020). These concerns include local tissue irritation or damage, incomplete pain relief, nerve damage, systemic toxicity and technical difficulty (Portela, 2018). The only side effect or complication observed in our case was a delayed normal gait that it is believed to be the result of the compressive bandage performed. This bandage may have decreased the blood flow across the limb and, consequently, promoted a prolonged perineural retention of the local anaesthetic and nerve desensitization.

During anaesthesia, alpacas should be closely monitored to ensure adequate oxygenation, ventilation, and cardiovascular function. Vital signs such as heart rate, respiratory rate, blood pressure, and oxygen saturation should be regularly checked, and any abnormalities should be addressed promptly (Abrahamsen, 2014). The alpaca from this case showed great hemodynamic stability and the changes in heart rate and mean blood pressure seen during maintenance of anaesthesia are most likely related to momentaneous painful stimulation that were treated with ketamine analgesic rescues. Moreover, no active or passive regurgitation occurred during the procedure time, which is more often in older individual. Recovery from anaesthesia is also a crucial moment and should also be closely monitored to ensure that the animal is fully awake and able to stand and move around without difficulty (Larenza et al., 2008), which was our case scenario. The alpaca from this case report returned to standing position and normal behaviour shortly after the isoflurane ceased to be deliver. Post-operative care is also important for alpacas undergoing general anaesthesia (Abrahamsen, 2009; Adams, 2017). This includes the administration of pain management medications such as meloxicam in our case. Although there isn't a validated pain scales for alpacas, pain evaluation should be based in agreement with tools to support identification of pain in mammals and pain signs should be addressed promptly (Adams, 2017; Cohen and Beths, 2020). In our case, no signs of postoperative pain or discomfort were observed in the alpaca.

In conclusion, the RUMM nerve block with levobupivacaine, by means of an electrostimulation-guided technique, provided an effective control of nociception and was a satisfactory multimodal approach in this alpaca undergoing metatarsal fracture repair.

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