Challenging anaesthetic management of captive reindeer (*Rangifer tarandus*): Report of 4 cases

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Summary

Four captive reindeer underwent anaesthesia to allow dehorning or drainage of lymph nodes abscessation. Premedication was based on xylazine (dose range: 0.075-0.5 mg/kg, IM or IV), with or without ketamine (dose range: 1-2 mg/kg, IM or IV), all of which failed to produce effective sedation without side effects. During anaesthesia, 2 reindeer experienced severe hypoxaemia and hypoventilation. Recovery was smooth in 3 out 4 animals, but delayed in one reindeer sedated with 0.5 mg/kg of xylazine IV; this patient required repeated atipamezole administrations (0.01 mg/kg IM given 3 times) to regain normal locomotion. Anaesthesia of reindeer is challenging and useful dose ranges for safe and effective anaesthesia are mostly unknown.

Keywords: anaesthesia, ketamine, reindeer, sedation, xylazine

Herausforderungen beim Narkosemanagement von Rentieren in Gefangenschaft: Eine Fallserie

Zur Enthornung und zur Drainage abszedierter Lymphknoten wurden 4 in Gefangenschaft gehaltene Rentiere anästhesiert. Die auf Xylazin (Dosierungen von 0.075-0.5 mg/kg, IM oder IV), allein oder in Kombination mit Ketamin (Dosierungen von 1-2 mg/kg, IM oder IV), basierende Prämedikation führte in verschiedenen Dosierungen und Applikationsarten nicht zu einer zufriedenstellenden, nebenwirkungsfreien Sedation. Die intravenöse Narkoseeinleitung mit Ketamin sowie die darauffolgende endotracheale Intubation verliefen problemlos. Während der Narkose zeigten 2 Tiere eine schwere Hypoxämie und Hypoventilation. Drei der 4 Rentiere zeigten eine zufriedenstellende, ruhige Aufwachphase. Bei einem vierten Rentier, welches mit Xylazin (0.5 mg/kg) intravenös sediert wurde, war die Aufwachphase verlängert, und es musste mehrmals mit Atipamezol (dreimalige Verabreichung von 0.01 mg/kg IM) behandelt werden bis es wieder normal laufen konnte. Die Narkose von Rentieren stellt eine besondere Herausforderung dar, da sichere und wirksame Dosierungen der Anästhetika zu wenig bekannt sind.

Schlüsselwörter: Anästhesie, Ketamin, Rentier, Sedation, Xylazin

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Introduction

Wild ungulates often undergo field anaesthesia, which can be accomplished with different techniques including dart guns, net guns and helicopter capture. Common purposes for capture are research, marking programs, mapping, and control and re-establishment of population through translocation of animals in areas designated to conservation of wildlife (Jessup, 2014). Beside wildlife capture, captive non-domestic ungulates may be anaesthetised to undergo clinical procedures. This scenario usually allows a more conservative approach in terms of doses of anaesthetic agents used for immobilization to guarantee animal safety and decrease the risk for the personnel involved.

Very little is published about the anaesthetic management of captive non-domestic ungulates, and only two of these reports focus on reindeer (Schytte Blix et al., 2011; Evans et al., 2013). Some investigators (Sontakke et al., 2007) reported the use of xylazine dosages in Axis deer ranging from 0.5 to 3.5 mg/kg IM, depending whether it was given alone or in association with IM ketamine (1.25-2.5 mg/kg), and found that 1 mg/kg xylazine and 1.5 mg/kg ketamine was the best combination in terms of quality of anaesthesia and lack of adverse effects. Other researchers (Schytte Blix et al., 2011) used 1 mg/kg of IM xylazine to premedicate captive reindeer undergoing experimental procedures. However, these authors did not report any detail with respect to the sedative and cardiovascular effects of the sedative agent, and no information is published about the use of alpha-2 antagonists in this species. Furthermore, inter-individual variability was found with respect to the pharmacodynamics of both xylazine and ketamine in reindeer (Mikstacki et al., 2013), possibly due to genetic variation and genetic polymorphism.

The aim of this case series was to report the challenging anaesthetic management of 4 captive reindeer. The issues encountered during the peri-anaesthetic period, as well as the possible measures to be undertaken in order to improve anaesthetic safety, are discussed.

Case presentation

Case 1

A 3-year-old male neutered reindeer weighing 75 kg was referred to the hospital for surgical treatment of retropharyngeal and parotid lymph nodes abscessation. Physical exam revealed a bilateral, grade I/VI, holosystolic heart murmur. Heart rate (HR) was 67 beats per minute (bpm) and respiratory rate (RR) 12 breaths per minute. Rectal body temperature was 38.5 °C, Body Condition Score (BCS) was 3/5 and both rumen contractions and stool production were deemed normal. Except for a decreased PCV (24%), blood parameters were within normal ranges for the species (Catley et al., 1990; Miller et al., 2013). An ASA category risk of III was assigned. The reindeer was fasted for 18 hours but had access to water until 2 hours prior to anaesthesia.

Intravenous (IV) xylazine (0.5 mg/kg; Rompun, Bayer, UK) resulted in sedation and sternal recumbency. Ten minutes later, general anaesthesia was induced with IV ketamine (2 mg/kg; Anaesthamine, Animalcare, UK) and the trachea intubated under manual guidance with a cuffed 10-mm endotracheal tube (ETT), which was then connected to a circle breathing system. Anaesthesia was maintained with isoflurane (Isoflurane, Abbott, UK) in 75% oxygen and 25% air (fresh gas flow: 2 L/min) and the end tidal concentration (ET) of isoflurane varied between 0.9-1.2% throughout the procedure. A lactate-containing polyionic replacement crystalloid solution (Vetivex, VioVet, UK) was administered at 5 ml/kg/h during anaesthesia.

Arterial blood pressure was measured through a catheter placed in the left femoral artery. Intra-operative monitoring also included electrocardiography (ECG), capnography, pulse oximetry, spirometry and arterial blood gas analysis (VetScan i-STAT 1, Abaxis, CA). The animal was positioned in left lateral recumbency during surgery. Shortly thereafter, primary respiratory acidosis and compensatory metabolic alkalosis were diagnosed on the basis of the following parameters: arterial partial pressure of carbon dioxide ($PaCO_2$) of 74 mmHg with ET CO_2 of 45 mmHg, bicarbonate (HCO_3^-) concentration of 39 mmol/L, base excess (BE) of 13 and pH of 7.33. Intermittent positive pressure ventilation (tidal volume: 10-12 ml/kg; peak inspiratory pressure: 20 cm H_20; RR: 8-12 breaths per minute and positive end expiratory pressure: 3-5 cm H_2O) was initiated. A second arterial sample was analysed 20 minutes later and revealed improvement of the respiratory acidosis ($PaCO_2$ of 46.5 mmHg with ET CO_2 of 35 mmHg), but even more severe metabolic alkalosis (HCO_3^- concentration of 40.6 mmol/L; BE of 18 and pH of 7.55). Cardiovascular variables, as well as arterial oxygen saturation (SaO_2), stayed within normal ranges during the anaesthetic, which lasted 75 minutes. Phenylephrine (1 mg; Phenylephrine Inj., Admipharm, UK) was applied topically to prevent nasal oedema and the animal was transferred to the recovery box and positioned in sternal recumbency. Fifteen minutes after the end of surgery, the reindeer was still unresponsive to stimulation although breathing and heart rhythm and rate were regular. Atipamezole (0.01 mg/kg; Sedastop, Animalcare, UK) was administered IM, and then repeated after 20 minutes at the same dose. Shortly after the second dose, the reindeer attempted to stand and started to chew actively the

endotracheal tube. At that point the trachea was extubated and meloxicam (0.5 mg/kg; Metacam, Biehringer Ingelheim, UK) was administered IV. Although the animal could stand and walk, 2 hours after the end of anaesthesia it was still slightly ataxic and reluctant to eat. A third dose of atipamezole (0.01 mg/kg) was administered IM and resulted in improved mentation and locomotion, as well as increased appetite and responsiveness in surrounding. The animal remained bright and overall in good clinical condition during the following days, and was discharged from the hospital 10 days after admission.

Case 2

A 3-year-old gelding reindeer weighing 80 Kg was referred for surgical removal of overgrown antlers towards the nasal bones, with formation of velvet overgrowth protuberances which were prone to bleeding and developing fly strike infections. Owing to the demeanour, physical restraint of the reindeer was challenging, however clinical examination could still be accomplished without sedation and revealed good general condition, regular heart rhythm with a HR of 100 bpm, and a BCS of 3/5. An ASA category risk of II was assigned. The reindeer was fasted for 18 hours but had access to water until 2 hours before anaesthesia. Broad spectrum antibiotics were administered IM for 3 days prior to anaesthesia.

Sedation was first attempted with IM xylazine (0.075 mg/kg), which failed to provide adequate tranquillization and was therefore repeated after 10 minutes at the same dose and via the same route, this time in combination with IM ketamine (1 mg/kg). Twenty-five minutes later an additional 1 mg/kg ketamine was administered IM as the animal was still standing, bright and responsive to manipulation. This resulted in adequate sedation to allow jugular catheter placement. General anaesthesia was induced with a further 3 mg/kg of IV ketamine. A further dose of IV ketamine (0.5 mg/kg) was required for endotracheal intubation, which was achieved with a 11-mm ETT. The reindeer was positioned in sternal recumbency and the ETT cuffed and connected to the circle breathing system. Anaesthesia was maintained with isoflurane (ET between 0.9-1.5 %) in oxygen (2 L/min). Crystalloids were administered as for case 1. Analgesia consisted of meloxicam (0.5 mg/kg) and butorphanol (0.025 mg/kg; Torphasol, Animalcare, UK), both administered IV before the beginning of surgery. Additionally, a cornual block was achieved by infiltrating both the infra-trochlear and the zygomaticotemporal branches of the trigeminal nerve with 5 ml of 2% procaine (Novocaine, CHEBI, UK) (Adams, 1979). Monitoring included ECG, capnography and pulse oximetry, with the probe positioned on the tongue. During the anaesthetic, physiological variables remained stable (HR: 80-110 bpm; RR: 10-20 breaths per minute) and the animal was allowed to breathe spontaneously. At the end of anaesthesia, which lasted 35 minutes, the reindeer was transferred to the recovery box, where it was extubated in sternal recumbency 15 minutes later. Peri-operative complications were not observed and the reindeer started to show normal appetite and locomotion approximately one hour after extubation. Discharge from the hospital occurred one day after surgery.

Case 3

A 3-year-old gelding reindeer weighing 80 Kg was presented for overgrown antler de-horning. The animal appeared healthy and in good condition and pre-anaesthetic clinical examination revealed a BCS of 3/5, a rectal body temperature of 39.2 °C and a HR of 100 bpm. The uncooperative nature of the animal did not allow further pre-anaesthetic investigation; an ASA category risk of I was assigned. Starvation and pre-operative pharmacological treatment, as well as surgical procedure, intra-operative monitoring, fluid rate and analgesic protocol, were the same as described for case 2.

The reindeer was premedicated IM with xylazine (0.075 mg/kg) and ketamine (1 mg/kg). The degree of sedation achieved was sufficient to allow insertion of a 16 G jugular catheter. General anaesthesia was induced 25 minutes after premedication with 2 mg/kg of IV ketamine. The trachea was intubated with a 10 mm ETT and oxygen administered via ETT at a flow rate of 4 L/min. The animal remained in sternal recumbency during anaesthesia, which was maintained with boluses of IV ketamine (one bolus of 0.5 and 2 boluses of 1 mg/kg), administered every 10-15 minutes on the basis of the evaluation of clinical signs of anaesthetic depth (palpebral and corneal reflexes, jaw and muscular tone, swallowing and occurrence of movements). During the procedure, HR was not stable but ranged from 50 to 100 bpm, with the highest values recorded after ketamine administration. The pulse oximeter readings for arterial oxygen saturation (SpO2) were lower than normal (87-93%) and reached critically low values (81 and 67%) on two occasions toward the end of anaesthesia. After 50 minutes from intubation, the animal was transferred in the recovery box and positioned in sternal recumbency, and extubated shortly thereafter. Approximately one hour and 15 minutes after extubation, the reindeer was fully recovered from anaesthesia and showed normal appetite, faecal production and locomotion. There were no post-operative complications and the animal was discharged from the hospital the day after surgery.

Case 4

A 4-year-old male castrated reindeer weighing 65 Kg was scheduled for surgical de-horning of overgrown antlers.

It was considered healthy based on the clinical examination. Thoracic auscultation was unremarkable, HR was 80 bpm, RR 24 breaths per minute, rectal temperature 37.8 °C and BCS 3/5. The animal was starved for 16 hours and had free access to water until 2 hours before anaesthesia. Sedation was attempted with an IM combination of xylazine (0.3 mg/kg) and ketamine (1 mg/kg). Because 15 minutes later the animal still appeared bright and responsive, one third of the first dose of xylazine, combined with another 1 mg/kg of ketamine, was administered IM. Twelve minutes later the level of sedation was still deemed inadequate, therefore 2 mg/kg of ketamine were given IM. At this point acceptable sedation was achieved and a 16 Gauge catheter was inserted in the left jugular vein. General anaesthesia was induced with IV ketamine (2 mg/kg) and maintained with 2 additional boluses of IV ketamine (0.5 mg/kg each), administered at 10 minute-intervals. Oxygen was supplemented via nasal tube and the reindeer was positioned in sternal recumbency throughout the procedure. Pre-operative pharmacological treatment, surgical procedure, intra-operative monitoring of cardio-respiratory variables, fluid rate and analgesic protocol were the same as described for cases 2 and 3. The procedure lasted 35 minutes and the reindeer recovered 15 minutes after the last ketamine injection. Post-operative complications were not observed and the animal was discharged from the hospital the day after surgery.

Discussion

This case series describes the challenges encountered while anaesthetizing 4 reindeer with xylazine-ketamine combinations at various doses and routes of administration, followed by inhalational anaesthesia in 2 cases. The first issue which arose was the identification of a useful drug combination to achieve safe and adequate sedation.

In order to sedate the reindeer, dosages of xylazine ranging from 0.075 to 0.5 mg/kg, with or without ketamine, were administered, and none of the tested sedation protocols resulted in effective immobilization and tranquillization without causing side effects. The first reindeer received 0.5 mg/kg xylazine IV, half of the lowest published dose for IM use in the species, which produced recumbency within a few minutes and adequate sedation. However, this animal remained ataxic and was reluctant to eat for a couple of hours after recovery, and repeated administrations of atipamezole were deemed necessary to achieve normal mentation and locomotion. For this reason, it was decided to administer doses lower than 0.5 mg/kg to the other animals, and to change the route of administration from IV to IM. Nevertheless, both the intermediate (0.3 mg/kg) and the lowest (0.075 mg/kg) doses of xylazine tested in this report, although combined with IM ketamine, required to be repeatedly administered before they resulted in appreciable sedation.

A retrospective analysis of these 4 cases, together with an attentive review of the published work (Arnemo et al., 1993; Sontakke et al., 2007; Schytte Blix et al., 2011; Evans et al., 2013; Mikstacki et al., 2013), seems to indicate that doses of xylazine lower than 0.5 mg/kg, preferably with the adjunction of 2 mg/kg of ketamine, may be adequate for captive reindeer, provided that the route of administration is IM injection rather than IV. Whether it is better to start with a sub-optimal dose, likely to be re-administered to achieve the desired effect, or instead to directly administer a higher dose, more likely to result in adequate immobilization but also in side effects, remains an open question. Safe field immobilization of wild ruminants implies early return to locomotion and consciousness, in order to enable the animals to escape from predators and accomplish thermoregulation (Read, 2003). From this perspective, too deep sedation is undesirable. On the other hand, repeated IM injections carry the potential for unacceptable stress for the animals, increased risk for the personnel involved and, possibly, capture myopathy, a complication that is associated with high morbidity and mortality in wild ruminants.

We encountered the common problems typically associated with wild ungulate anaesthesia, namely hypoventilation, respiratory acidosis and hypoxaemia (Fernandez-Moran et al., 2000; Janovsky et al., 2000; Murray et al., 2000; Read, 2003). Interestingly, in case 1 severe hypercapnia could only be detected by the arterial blood gas analysis, as capnography showed normal values of expired carbon dioxide. This high arterial-end tidal carbon dioxide gradient was interpreted as indicative of ventilation/perfusion mismatch (West, 2000) and seems to suggest that, although this may be unpractical under field conditions, advanced instrumental monitoring is desirable when wild ruminants are anaesthetized.

In case 3, hypoxaemia was suspected based on low pulse oximetry readings. Interestingly, intra-tracheal oxygen, supplemented at 4 L/min, failed to restore normal SpO_2 values. This is in contrast with what the findings of an earlier report, where nasal oxygen supplementation at a rate of 2 L/min could reverse hypoxaemia in wild Norwegian reindeer anaesthetized with medetomidine and ketamine (Evans et al., 2013). However, the lack of confirmation of the hypoxaemic condition with arterial blood gas analysis does not allow a conclusive statement. The administration of xylazine might have caused an error in pulse oximetry measurements owing to im-

paired peripheral perfusion (Kästner, 2006). Moreover, to the best of the authors' knowledge, no pulse oximetry device has been validated in reindeer, which raises an issue on the validity of SpO_2 readings in this species. Although cases 2 and 4 had a quick recovery and showed early return to normal locomotion and behaviour, the occurrence of hypoventilation with or without hypoxaemia during anaesthesia could not be ruled out in these animals, because monitoring was basic and mostly relied on clinical assessment. Hypoxaemia is a very common sequel of wildlife immobilization, and was observed in fallow deer (Fernandez-Moran et al., 2000), white-tailed deer (Hsu and Shulaw, 1984; Murray et al., 2000) and red deer (Janovsky et al., 2000) anaesthetized with alpha 2 agonist-based combinations. In the reindeer object of this report, xylazine might have altered respiratory mechanics and gas exchange by increasing airway pressure and respiratory resistances, and by decreasing lung compliance (Kästner, 2006).

As a non-selective alpha 2-agonist, the sedative and cardiopulmonary effects of xylazine are preferentially reversed with less selective antagonists, such as yohimbine (Hsu and Shulaw, 1984; Jessup et al., 1985; Renecker et al., 1985; Ndeereh et al., 2001). Because yohimbine is not available in the UK, xylazine was antagonized with atipamezole to facilitate recovery in one reindeer. The decision to antagonize xylazine despite the long time (75 minutes) elapsed from its administration and the end of anaesthesia was based on the consideration that pharmacokinetics and pharmacodynamics of this drug in reindeer are largely unknown. Choosing the dose to be administered posed a challenge. The atipamezole: xylazine ratio has been reported to be 1:10 (Arnemo et al., 1993). However, the existing literature seems to suggest that much lower doses of atipamezole may still be effective for wild ruminants. Gentile and colleagues found that 0.38 ± 0.37 mg/kg of IV atipamezole was effective to quickly reverse xylazine (0.24 ± 0.03 mg/kg IM) immobilization in Apennine chamois (Gentile et al., 2015). The atipamezole dose used in case 1 was considerably lower compared to published recommendations, however this dose was found insufficient to reverse the sedative effects of xylazine and repeated administrations were necessary so that animal could regain normal locomotion and behaviour. In the light of these considerations, it is reasonable to assume that an atipamezole dose higher than 0.01 mg/kg would be needed to antagonize 0.5 mg/kg of IV xylazine in reindeer.

Conclusion

Optimal anaesthetic management of reindeer remains a challenge owing to the paucity of published dose ranges for the species and possibly to inter-individual variability. Common problems reported during wild ungulate anaesthesia, namely hypoxaemia and hypoventilation, are likely to be encountered also in reindeer, and may go undetected if only basic monitoring is used.

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Défis dans la gestion de la narcose des rennes en captivités: une série de cas

Quatre rennes détenus en captivité ont été anesthésiés pour procéder à un écornage et pour le drainage d'un ganglion lymphatique abcédé. Une prémédication à base de xylazine (dosage allant de 0.075 à 0.5 mg/kg, IM ou IV), seule ou en combinaison avec de la kétamine (dosage de 1 à 2 mg/kg, IM ou IV), n'a pas conduit, dans différents dosages et voies d'application, à une sédation satisfaisante et indemne d'effets secondaires. L'induction de la narcose avec de la kétamine par voie intraveineuse suivie d'une intubation endotrachéale s'est faite sans problème. Durant la narcose, deux animaux ont montré une grave hypoxémie et une hypoventilation. Trois des quatre rennes ont présenté une phase de réveil satisfaisante et calme. Chez le quatrième animal, qui avait été prémédiqué avec de la xylazine par voie intra-

Complessa gestione anestesiologica di renne in cattività: 4 casi

Quattro renne tenute in cattività sono state anestetizzate per decornazione o per un drenaggio linfonodale. In premedicazione, l'impiego di xylazina (dose di 0.075-0.5 mg/kg, IM o IV), da sola o in associazione alla ketamina (dose di 1-2 mg/kg, IM o IV), non ha portato a un livello di sedazione adeguato e privo di effetti collaterali. La successiva induzione dell'anestesia generale con ketamina e l'intubazione sono avvenute senza ulteriori complicazioni, quali la grave ipossiemia e l'ipoventilazione. Queste ultime si sono invece riscontrate nel corso del mantenimento dell'anestesia.
Al termine delle procedure, tre renne hanno avuto un soddisfacente risveglio mentre l'ultima, cui la xylazina (0.5 mg/kg) era stata somministrata per via endovenosa, ha avuto un recupero funzionale prolungato. Tre differenti somministrazioni di atipamezolo (0.01 mg/kg IM

veineuse (0.5 mg/kg), la phase de réveil a été prolongé et une application répétée d'atipamezol (trois fois 0.01mg/kg IM) a été nécessaire jusqu'à ce qu'il puisse de nouveau marcher normalement. La narcose des rennes représente un défi particulier car le dosage sûr et efficace des anesthésiques et trop peu connu.

per volta) sono state quindi necessarie prima del completo ricovero. La mancanza di definizione di dosi efficaci e sicure per l'anestesia della renna rende così l'anestesia generale una procedura difficile da eseguire.

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