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CASE REPORT

Wildlife

Anaesthetic management in adult reindeer (*Rangifer tarandus tarandus*) undergoing exploratory laparotomy for jejuno-jejunal intussusception surgery resection

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Abstract

A 2-year-old, male reindeer (*Rangifer tarandus tarandus*) presented for further investigations and treatment of acute colic signs. On clinical investigations, an ultrasonographic abdominal exam revealed multiple hypomotile, dilated and fluid-filled small intestinal loops. Based on clinical findings and increased signs of abdominal pain, small intestine obstruction was suspected, and an exploratory laparotomy was performed. The animal was premedicated with medetomidine (0.003 mg/kg) and butorphanol (0.05 mg/kg) intravenously. General anaesthesia was induced with ketamine (2 mg/kg intravenously) and propofol (3 mg/kg intravenously), and maintained with isoflurane in oxygen. Additional analgesia was provided with methadone (0.1 mg/kg intravenously) and ketamine (0.5 mg/kg intravenously). A jejuno-jejunal intussusception requiring resection of approximately 6 inches (15 cm) was identified and jejuno-jejuno anastomosis was performed. Fluid resuscitation was administered for treatment of hypotension during general anaesthesia. Recovery from anaesthesia was uneventful. Nevertheless, the deer was euthanased 5 days later due to clinical deterioration.

KEYWORDS

anaesthesia, deer, intussusception, reindeer

BACKGROUND

Most procedures on wild ungulates are usually performed in the field, and different techniques to accomplish field anaesthesia have been described including the use of darts and net guns. The capture and chemical restraint of wild animals are often conducted for purposes such as research, marking and mapping programmes and population control.[1] However, captive non-domestic ungulates like cervids may require general anaesthesia to undergo more invasive clinical procedures. This clinical scenario entails a different anaesthetic approach to guarantee animal and personnel safety.

At the time of writing this report, limited literature regarding the anaesthetic management of captive non-domestic cervids is available, and only few of these publications focus on reindeer.[2–6] The selection of the best anaesthetic protocol in these species represents a challenge for the anaesthetist due to the limited published data regarding the pharmacology and adverse effects of anaesthetic drugs in these animals, and the often-unknown age, history, temperament and health conditions. Furthermore, environmental conditions of capture and handling, ambient temperature and stress conditions also represent an additional challenge for immobilisation of wild species. Previous publications showed that high environmental temperature and stress were associated with higher dose requirements to achieve adequate and reliable immobilisation.[7,8] Therefore, the goals of anaesthesia in cervids include the use of effective and reliable anaesthetics, predictable, reversible, with a rapid onset of action and minimal adverse effects. To achieve these goals, different drug choices have been described, including the use of different α_2-receptor agonists (medetomidine, dexmedetomidine, xylazine) and combinations of α_2-receptor agonists with opioids (butorphanol), and/or dissociative anaesthetics such as ketamine, and tiletamine/zolazepam combinations in both captive and wild deer.[6,9–14] The addition of hyaluronidase to different anaesthetic protocols has also been described in wildlife species to facilitate capture.[15–18] Nevertheless, while these drug combinations have been reported more often during field anaesthesia, procedures that require longer anaesthesia duration demand a constant control of anaesthetic

plane, which can be accomplished with inhalant anaesthetic agents.[19–22]

To the authors' knowledge, the selection of the anaesthetic protocol of wild ungulates undergoing invasive procedures, such as an abdominal surgery, is poorly described in the literature. For this reason, here we report the anaesthetic management in a reindeer with jejuno-jejunal intussusception undergoing exploratory laparotomy and jejuno-jejuno anastomosis.

CASE PRESENTATION

A 2-year-old gelding captive reindeer, used for entertainment events and accustomed to human interaction, was referred to the Equine Referral Hospital of the Royal Veterinary College (University of London) for further investigations and treatment of acute abdominal discomfort and inappetence. Upon presentation, the reindeer was quiet with marked abdominal discomfort, weighing 65 kg, with a body condition score of 4/9. Physical examination could be accomplished without sedation and identified regular heart rhythm with a heart rate (HR) of 100 beats per minute, respiratory rate (f_R) 56 breaths per minute, a rectal temperature of 39.0°C, and pink, tacky mucous membranes with a capillary refill time (CRT) of 2 seconds. Thoracic auscultation revealed harsh pulmonary signs bilaterally, associated with increased respiratory effort. Rumen contractions were present.

INVESTIGATIONS

Blood analysis (venous blood gas and biochemistry) revealed a packed cell volume of 52%, a total protein concentration (TP) of 82 g/L (reference interval [RI]: 52–71) and a lactate concentration of 2.2 mmol/L (RI: 0.6–2.5). Biochemistry was unremarkable based on previously published values.[23]

Further investigations could not be performed without sedation, and butorphanol (Dolorex 10 mg/mL, MSD Animal Health; 0.01 mg/kg) was administered intramuscularly with good effect, and a 14 G (130 mm) over the wire catheter (Milacath-Extended Use, Mila International) was placed in the right jugular vein. Abdominal ultrasonographic examination identified multiple hypomotile dilated and fluid-filled small intestinal loops on the right side of the abdomen. The ultrasound of the left side of the abdomen showed amotile, ingesta-filled intestinal loops, presumed to be spiral colon.

Abdominocentesis was performed, and peritoneal fluid yielded a nucleated cell count of 1.2×10^9/L, a TP of 38 g/L and a lactate concentration of 1.7 mmol/L.

Faecal sample was taken, and a faecal egg count showed 1680 Strongyle eggs per gram of faeces and five coccidia per gram of faeces.

Based on clinical findings, potential small intestine obstruction was suspected, but not confirmed. Medical management was initiated with administration of intravenous (IV) fluid therapy (Hartmann's solution, Vetivex 11, Dechra) at 5 mL/kg/h and pain relief in the form of meloxicam (Metacam 5 mg/mL, Boehringer Ingelheim; 0.5 mg/kg IV).

LEARNING POINTS/TAKE-HOME MESSAGES

- Selecting an adequate anaesthetic protocol for captive wild ungulates is important to ensure unconsciousness, immobilisation, analgesia, safety of the animal and veterinary team, and haemodynamic stability.
- Premedication of wild ungulates with a combination of butorphanol–medetomidine has been shown as an effective combination to achieve a safe sedation level and restrain.
- The combination of ketamine–propofol for induction of general anaesthesia resulted in less rigidity effect, adequate plane of anaesthesia and smooth quality of induction.
- A multimodal analgesic approach, including ketamine, methadone, locoregional analgesia and meloxicam, guarantees good levels of peri-operative analgesia.
- Common problems associated with wild ungulate anaesthesia include hypoventilation, respiratory acidosis and hypoxaemia. An adequate anaesthetic management, including oxygen supplementation and use of mechanical ventilation (when available), can minimise the occurrence of these complications.

TREATMENT

Approximately 3 hours after admission, the animal showed increased signs of abdominal pain, and exploratory laparotomy was recommended. On clinical examination, the reindeer was quiet, alert and responsive, laying down, with an HR of 75 beats per minute and f_R of 40 breaths per minute, pink and moist mucous membranes, CRT 2 seconds and a persistent rectal temperature of 39.0°C. An American Association of Anesthesiologist category of 4E was assigned.

Sedation was first attempted with IV medetomidine (Medetor 1 mg/mL, Virbac; 0.003 mg/kg) and butorphanol (0.1 mg/kg). The reindeer was clipped and prepared for surgery under sedation, and same dose of medetomidine was repeated 40 minutes later to allow adequate preparation of the surgical area (Figure 1). This resulted in adequate sedation and sternal recumbency was achieved. During the preparation time, the ambient temperature was approximately 2°C–5°C. The animal was pre-oxygenated during this period with 100% oxygen (at 6 L/min) administered through a nasal canulae, and fluid therapy was administered in the form of Hartmann's solution (Vetivex 11, Dechra) and was infused initially at 5 mL/kg/h. Sixty minutes after repeated sedation, general anaesthesia was induced IV with an initial dose of ketamine (Ketamidor 100 mg/mL, Chanelle Pharma; 2 mg/kg), followed by propofol (PropoFlo Plus 10 mg/mL, Zoetis; 3 mg/kg). Orotracheal intubation was achieved with a 11-mm cuffed silicone endotracheal tube. A stomach tube was passed through the mouth to try to divert any reflux material away from the pharynx. The patient was transferred to the surgical table, placed in left lateral recumbency, and connected to a circle breathing system and a large animal anaesthetic machine and ventilator

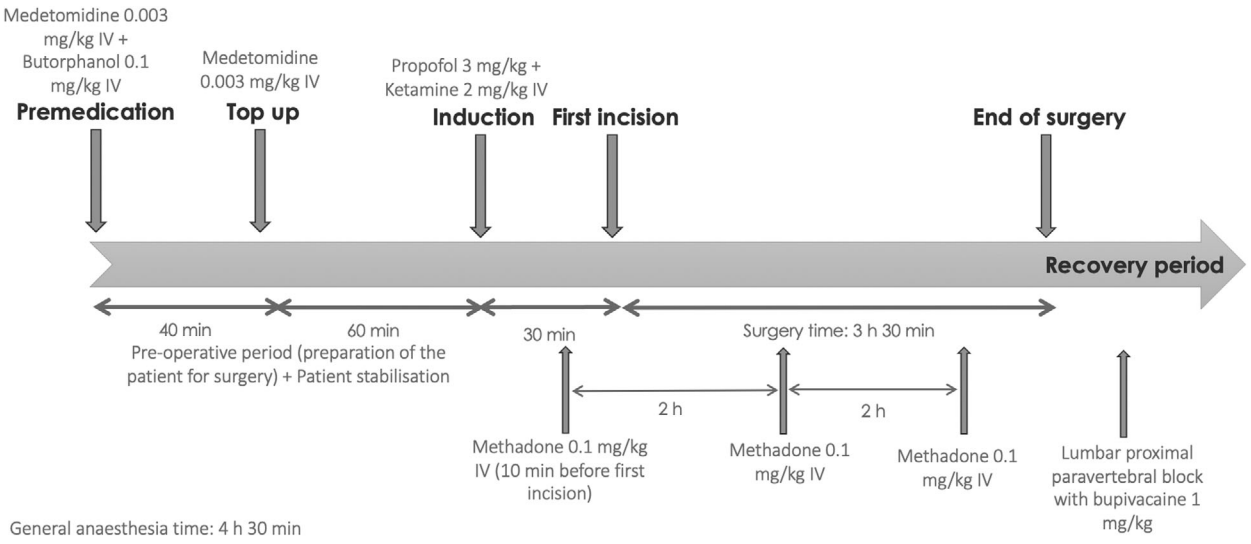

FIGURE 1 Time of events during the anaesthetic management. IV: intravenous.

(Tafonius Junior, Hallowell EMC, Vetronic Services). Anaesthesia was maintained with isoflurane (Isoflurane 100% w/w Inhalation Vapour, Henry Schein, Piramal Critical Care) in 60%–70% oxygen in combination with medical air, aiming for initial end tidal isoflurane (FE'Iso) of 1.3%.

A multiparameter monitor (Carescape Monitor B450, GE Healthcare) was used for continuous monitoring of electrocardiogram, HR, invasive blood pressure (IBP) and non-invasive blood pressure measurements, f_R, capnography, pulse oximetry (SpO_2), end tidal CO_2, inspiratory and expiratory fractions of oxygen (FiO_2 and ETO_2) and FE'Iso during the procedure. Mean FE'Iso during general anaesthesia was 1.1% and FiO_2 varied from 58% to 73%. Mechanical ventilation utilising volume control was initiated before surgery. Initial settings were tidal volume of 1 L with an *I*:*E* ratio 1:2 and f_R of 18 breaths per minute. A 22-gauge catheter (22GA 1.00 IN BD Angiocath, BD UK) was placed in the right auricular artery for monitoring of IBP. Hartmann's solution was infused initially at 10 mL/kg/h.

The right abdominal flank was aseptically prepared, and animal was transferred to the surgical theatre, where ambient temperature ranged from 17°C to 19°C. Vital parameters at this point were: HR 80 beats per minute, f_R 18 breaths per minute, SpO_2 100%, $ETCO_2$ 37 mmHg, systolic arterial blood pressure 75 mmHg, mean arterial blood pressure (MAP) 55 mmHg, diastolic arterial blood pressure 40 mmHg and temperature 38.2°C. Hypotension was defined as MAP less than 70 mmHg, and two boluses of 5 mL/kg Hartmann's solution over 5 minutes were administered to treat hypotension during general anaesthesia. Once normotension was achieved (defined as MAP > 70 mmHg on IBP), fluid therapy was decreased to 5 mL/kg/h. During surgical intervention, three different arterial blood gas samples were analysed in three different time points, and no significant abnormalities were observed (Table 1). There were no episodes of hypoxaemia under general anaesthesia, with P_aO_2 maintained above 400 mmHg, and S_aO_2 at 100%.

Ten minutes before first incision (2 hours 10 minutes after the dose of butorphanol and 20 minutes after induction of general anaesthesia), methadone (Synthadon 10 mg/mL, Animalcare; 0.1 mg/kg IV) was administered as part of the analgesia protocol. A 10–15 cm skin incision was made in the mid paralumbar fossa and muscle layers (external abdominal oblique, internal abdominal oblique and transversus abdominis) were incised. Upon entering the abdomen, the caecum and ascending colon were identified, and a portion of jejunum was exteriorised, which showed marked distension and discoloration. A jejuno-jejunal intussusception requiring resection of approximately 15 cm was identified and jejuno-jejuno anastomosis was performed using an interrupted Lembert pattern. A penrose drain was placed oral and aboral to the resection site. The laparotomy was closed routinely.

During surgical procedure, three boluses of ketamine (0.5 mg/kg IV) were administered when nociceptive reaction (defined as increased in 20% baseline HR and MAP, as described by Mansour et al.) was identified.[24] Methadone (0.1 mg/kg IV) was repeated approximately 2 hours after first dose and before the end of the surgical procedure to provide additional analgesia (approximately every 2 hours). Total surgical time was 3 hours 30 minutes, and total anaesthesia time was 4 hours 30 minutes. At the end of surgery, a lumbar proximal paravertebral block was performed with bupivacaine hydrochloride (Marcain Polyamp Steripack 0.5%, AstraZeneca; 1 mg/kg) using a previously published approach in ruminants to block T13 to L2 spinal nerves.[25–28] After local block was performed, volatile agent was stopped, and mechanical ventilation was discontinued once the animal regained spontaneous ventilation. The reindeer was transferred to recovery box, positioned in sternal recumbency with the head elevated and nose pointing toward the ground, and extubated 5 minutes later once signs of gag reflex and swallowing were present. Temperature was 38.8°C during the recovery period. The recovery was uneventful, and the reindeer stood up 35 minutes after extubation.

OUTCOME AND FOLLOW-UP

Immediate post-operative care included the administration of buprenorphine (Buprecare 0.3 mg/mL Inj., Animalcare; 0.01 mg/kg IV every 6 hours for 48 hours), benzylpenicillin sodium (Geepenil Vet 300 mg/mL, Nimrod Veterinary Products; 12 mg/kg IV twice a day), marbofloxacin (Marbocyl

TABLE 1 Arterial blood gas results obtained during general anaesthesia.

Time (minutes)	pH	PCO_2 (mmHg)	PO_2 (mmHg)	BE (mmol/L)	HCO_3 (mEq/L)	TCO_2 (mmol/L)	SO_2 (%)	Na^+ (mmol/L)	K^+ (mmol/L)	iCa^{+2} (mmol/L)	Glu (mg/dL)	Hct (%)	Hb (g/L)
60	7.357	47.7	420	0	26.5	28	100	130	4.3	1.19	138	42	14.3
120	7.438	39.6	342	3	26.8	28	100	130	5.3	1.09	102	44	15.0
180	7.346	49.3	406	2	27.4	29	100	130	4.6	1.15	97	43	14.5

Abbreviations: BE, base excess; Glu, glucose; Hb, haemoglobin; HCO_3, bicarbonate; Hct, haematocrit; PCO_2, partial pressure of carbon dioxide; PO_2, partial pressure of oxygen; SO_2, oxygen saturation; TCO_2, total carbon dioxide.

10%, Vetoquinol UK; 2 mg/kg/day IV), Hartmann's solution (at 5 mL/kg/h) supplemented with glucose administration (Glucose 50% Inj., Steriflex; 4 mL/h), and vitamin B12 supplementation (Catosal 10%, Vitamine B12 Inj., Bayer; 10 mg/kg IV twice a day). Flunixin (Pyroflam 50 mg/mL Inj., Norbrook; 2.2 mg/kg IV once a day) was added as part of the post-operative analgesia protocol 2 days after initial administration of meloxicam (as mentioned in the Investigations section).[29] The reindeer remained inappetent and did not pass faeces. Total parenteral nutrition following a standard formula at 30 mL/h was initiated on Day 3 after surgery and oral rumen stimulant (Pro-Rumen oral powder, Vetoquinol) was added to medical treatment.

Repeated ultrasonographic examination showed distended and only partially motile small intestine in the right abdomen. Main differential diagnosis at this point included ileus, dehiscence of the anastomosis site or early adhesion formation. Peritoneal fluid could not be obtained through abdominocentesis.

Based on clinical deterioration of the animal and poor prognosis, the reindeer was euthanased 5 days after the surgical procedure.

A postmortem examination was performed, which confirmed transmural fibrino-suppurative jejunitis and steatitis in the area of jejunal anastomosis. Given the absence of additional microscopic findings, the cause of deterioration in this animal was presumed dehiscence of the jejunal anastomosis, leading to septic peritonitis. The most likely cause for the jejunal intussusception was the presence of an initially high nematode burden (likely decreased in number as a result of anthelmintic treatment).

DISCUSSION

Anaesthesia of non-domestic ungulates such as the deer represents unique challenges for the anaesthetist, as some characteristics including relevant history, temperament and health status of the animal are often unknown. Different anaesthetic protocols have been described to ensure adequate restraint and safety of these wild species and veterinary healthcare personnel involved.[5,6,11,21,22,30] In addition to different anaesthetic agents, the use of hyaluronidase, a hydrolysing enzyme that depolymerises the hyaluronic acid and increases tissue permeability, in combination with analgesic and sedative agents have been described. The use of hyaluronidase in free and wild ruminants has shown to reduce immobilisation time, time to recumbency and to facilitate patient management.[15–18] In the present case, however, the animal presented was a captive reindeer with severe acute abdominal discomfort, it was very tolerant to manual restraint and venous catheterisation was possible with minimal sedation. Furthermore, the veterinary literature lacks information regarding the anaesthetic management in deer undergoing abdominal surgery.

The main goals of general anaesthesia in the present case, based on the previously mentioned characteristics, included unconsciousness, immobility, analgesia, safety of the animal and veterinary team, and guarantee of haemodynamic stability despite the progressive clinical deterioration and the blunting of the stress response. The balanced anaesthetic protocol described here ensured these goals were met in this reindeer requiring jejuno-jejuno anastomosis.

The drugs of choice for premedication included medetomidine and butorphanol. The combination of α2-adrenoreceptor agonists and butorphanol has been demonstrated in different studies to be effective in order to provide good sedative and analgesic effect, because of their synergistic effect.[10,12,15] Doses chosen in the present case were lower than those described in previously published literature (0.05–0.2 mg/kg medetomidine alone or 0.03–0.125 mg/kg combined with ketamine)[9,13,16] due to the clinical deterioration of the deer during hospitalisation and ease to handle him. In addition, ambient temperature at the moment of general anaesthesia and surgical intervention was characteristic of winter conditions, which has been associated with lower dose requirements compared to higher ambient temperature conditions.[7,8] Moreover, butorphanol was chosen among other opioid drugs due to its short duration of action and mild sedative and analgesic effects,[13,14,19–29,31–33] which allowed the animal to become recumbent and to prepare the surgical area without deep sedation nor cardiovascular depression. Several publications have shown that deer can be prone to hypoxaemia, especially when sedated with α2-adrenoreceptor agonists[5,22,34,35]; for that reason, pre-oxygenation was maintained during the duration of the pre-operative period.

For induction of general anaesthesia, propofol, a non-barbiturate hypnotic, was chosen in combination with ketamine, a dissociative agent, as a co-induction agent. The use of ketamine in wild non-domestic ungulates has been extensively described to provide adequate chemical immobilisation when in combination with other agents, such as α2-adrenoreceptor agonists, and to provide adequate analgesia.[22] In this case, we believe that the use of propofol in combination with ketamine resulted in less muscle rigidity, adequate plane of anaesthesia to allow endotracheal intubation and smooth quality of induction.

To control surgical pain, different opioid drugs have been described for the immobilisation of some deer species, such as etorphine, carfentanil, thiafentanil and fentanyl.[22,33] In order to provide higher level of analgesia, methadone was included in the anaesthetic protocol and administered before first

incision was performed. A previously published study in sheep by Bellini and De Benedictis showed that methadone was able to minimise the percentage increases in HR and MAP during surgical stimulation, suggesting adequate control of the cardiovascular response following nociceptive stimulus. However, a decrease in HR was also observed after methadone administration, reason why the authors decided to avoid a full mu opioid as a premedication agent while the patient was still being stabilised. In addition, with the administration of ketamine during the surgical procedure, methadone provided adequate level of intraoperative analgesia. This was evident by the return to pre-incisional vital values after analgesics were administered IV. Further analgesia was added to the analgesic protocol at the end of the procedure with a lumbar proximal paravertebral block in order to reduce the use of opioids in the post-operatory period, which could be associated with reduced intestinal motility. The decision to avoid locoregional techniques before surgery was related to the clinical deterioration of the animal before general anaesthesia and to avoid a delay in the time to first incision.

Previous publications have reported common problems associated with wild ungulate anaesthesia, which included hypoventilation, respiratory acidosis and hypoxaemia. These complications are typically encountered in wildlife immobilisation, associated with recumbency, development of ruminal tympany, lack of oxygen supplementation and administration of drugs, such as α2-adrenoreceptor agonists, due to respiratory depression.[5,13,22,36,37] In the present case, hypoxaemia was not observed in arterial blood gas during the duration of general anaesthesia. This could be the result of the preoxygenation during the pre-operative period, and the oxygen supplementation and use of mechanical ventilation during the duration of general anaesthesia. It is noteworthy to mention that a period of 24-hour fasting is recommended in ungulates to prevent the development of ruminal tympany and respiratory compromise. Signs of possible development of ruminal tympany were monitored during the duration of anaesthesia with no interventions needed, probably related to the previous history of inappetence of the presented animal.

The authors believe that the balanced anaesthetic protocol, multimodal analgesic approach and haemodynamic support described in the present case allowed us to meet the aforementioned goals: immobilisation, unconsciousness, adequate level of analgesia, haemodynamic stability and personnel safety. However, more experience in the anaesthetic management of these species and clinical presentation is required in other to determine the best anaesthetic approach to achieve an acceptable outcome.

AUTHOR CONTRIBUTIONS

All authors were involved in the anaesthetic case management. Cristina Parra Martínez and Cristina Bianchi anaesthetised the patient and were involved in the immediate post-operative care. Natalie Young and Andrew Fiske-Jackson performed the exploratory laparotomy for jejuno-jejunal intussusception surgery resection and were involved in the post-operative care. Cristina Parra Martínez collected data and wrote the case report. Cristina Bianchi, Natalie Young and Andrew Fiske-Jackson reviewed the case report.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

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ETHICS STATEMENT

Ethics approval was not required for this case.

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