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CASE REPORT

Anesthetic management of a white rhinoceros (*Ceratotherium simum*) undergoing an emergency exploratory celiotomy for colic

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Abstract

Observations A 26-year-old male white rhinoceros (*Ceratotherium simum*), weighing approximately 2000 kg was anesthetized for an exploratory celiotomy. Sedation was achieved with intramuscular butorphanol (0.04 mg kg^{-1}) and detomidine (0.025 mg kg^{-1}) and induction of anesthesia with intravenous glyceryl guaiacolate (50 g) and three intravenous boluses of ketamine (200 mg, each); the trachea was then intubated and anesthesia maintained with isoflurane in oxygen using a circle breathing system. Positioning in dorsal recumbency for the surgery and later in sternal recumbency for the recovery represented challenges that added to the prolonged anesthesia time and surgical approach to partially correct an impaction. The rhinoceros recovered uneventfully after 10.4 hours of recumbency.

Conclusions Anesthetic management for an exploratory celiotomy with a midline approach is possible in rhinoceroses, although planning and extensive staff support is necessary to adequately position the patient.

Keywords butorphanol, colic, detomidine, hypercapnia, hypoxemia, isoflurane, rhinoceros.

Introduction

General anesthesia of rhinoceroses is becoming more frequent for a variety of elective or emergency procedures (Cornick-Seahorn et al. 1995; Stegmann et al. 2001; Atkinson et al. 2002; Bush et al. 2004; Adams et al. 2005; Esson et al. 2006; Portas et al. 2006; Goodman et al. 2007). The white rhinoceros is listed as 'Near threatened' in the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN 2008). Worldwide there is a collection of 730 white rhinoceroses in captivity of which 196 are in North America at 56 institutions (Foose & Wiese 2006; WAZA 2008); therefore important efforts are directed at preserving all specimens in captivity and in the wild.

Due to their size and behavior, anesthetic management of rhinoceroses is challenging and adequate planning is necessary to minimize risk. Injectable anesthetic techniques are more frequently used than inhalant anesthesia since most procedures are short and performed under field conditions (Simons & Jenke 1977; Hattingh et al. 1994; Radcliffe et al. 2000; Stegmann et al. 2001; Atkinson et al. 2002; Bertelsen et al. 2004; Adams et al. 2005; Esson et al. 2006; Goodman et al. 2007; Radcliffe & Morkel 2007). However for longer recumbency times or more invasive surgical

procedures the use of inhalant anesthesia is preferred (Simons & Jenke 1977; Stegmann et al. 2001; Portas et al. 2006).

We describe the use of inhalant anesthesia in a white rhinoceros undergoing an exploratory celiotomy for colic signs and his subsequent anesthetic recovery.

Case description

A 26-year-old male white rhinoceros weighing approximately 2000 kg (4400 lb) in an urban zoo exhibited signs of colic for 5 days, characterized by inappetence and abdominal pain. Rectal palpation revealed an empty rectum and an impacted loop of the large colon, which was suspected to be the pelvic flexure. Transabdominal ultrasonography showed distended loops of hypomotile small intestine of 7–8 cm diameter. A large colon impaction and small intestinal ileus, likely secondary to the impaction was suspected.

The patient was treated medically from day 1 through 4, consisting of IM sedation with butorphanol 0.01 mg kg^{-1} (Torbugesic; Wyeth Canada, QC, Canada) and detomidine 0.0125 mg kg^{-1} (Dormosedan; Pfizer Canada, QC, Canada) administered by hand syringe in the hind legs while in a restraint chute, to allow intermittent IV fluid therapy with lactated Ringer's solution (200 L over 4 days) (Baxter Corporation, ON, Canada) and analgesia with flunixin meglumine (0.5 mg kg^{-1} each day) (Banamine; Schering-Plough, QC, Canada) administered through a 16-gauge, 8.3 cm (3.25 inches) catheter (Angiocath; Becton Dickson, UT, USA) placed in each ear vein. Muliple enemas were attempted in an effort to stimulate motility. Multiple unsuccessful attempts to nasogastric intubation were made. Results of complete blood cell count and biochemical profile during these 4 days were consistent with dehydration (PCV, 47–57%; TP, 10.2–11.2 g dL^{-1}; creatinine, 194–800 μmol L^{-1}) and an inflammatory-stress response (white blood cell count, 8.4–11.9 × 10^9 L^{-1}; 74–86% segmented neutrophils, 3–14% bands). Over the course of this period the patient remained stable although displaying signs of colic, inappetence and inability to pass any fecal material. On day 5 an exploratory celiotomy was performed.

On the day of surgery, three teams were involved, consisting of the anesthesia, the surgery and the handling team. The latter was in charge of moving the patient to the restraining chute for administration of anesthesia and subsequently mobilizing the animal to the enclosure (stall) where surgery was performed. The local Fire Department provided and utilized winches, hydraulics, consisting of struts and extensions for shoring and stabilization, and inflatable mats (Holmatro Rescue Equipment B.V., The Netherlands) to move the patient from sternal to dorsal recumbency for surgery and then from dorsal to sternal recumbency for the recovery.

The animal was sedated with IM administration into the right hind leg of butorphanol 0.04 mg kg^{-1} and detomidine 0.025 mg kg^{-1}. The patient was allowed to move to the surgery room where he showed signs of marked sedation and leaned against one of the walls within 30 minutes. Only one of the ear catheters was patent on this day; glyceryl guaiacolate (GG) 10% (Univar Canada Ltd., ON, Canada) was administered IV to effect (50 g) and intermittent IV boluses of ketamine (200 mg; three boluses) (Vetalar; Bioniche Animal Health Canada Inc., ON, Canada) were administered until the patient assumed sternal recumbency. The patient rested his head on the water trough in the stall, which facilitated the process of intubating the trachea. The eyes were covered with a towel around the head and the intubation consisted of passing an introducer [stomach tube (1.2 cm (0.5 inches) external diameter)] into the oral cavity and then into the trachea to advance the endotracheal tube around it. The narrow and long oral cavity made this process difficult; therefore an endoscope was advanced through the mouth to better visualize the oral cavity, which could not be opened more than 8 cm (3.1 inches) in height and was only 14 cm (5.5 inches) in width. The base of the tongue had to be pressed down to advance the introducer tube into the pharyngeal area. Due to the restricted access, the endoscope was removed; the anesthetist introduced his arm at full length but was unable to reach the epiglottis. However, it was possible to press down on the base of the tongue and advance the introducer tube into the pharyngeal area and then between the arytenoids into the trachea while detecting exhalation through the tube for confirmation of correct placement. Immediately a 30 mm low-pressure, high-volume cuffed-endotracheal tube (ET30, Surgivet, Smith Medical Pm Inc., WI, USA) was advanced around the introducer tube into the trachea and the introducer tube removed. Approximately 240 mL of air was used to inflate the cuff to seal the space between the tube and trachea. Oxygen was insufflated at 10 L $minute^{-1}$ and the

patient kept in sternal recumbency for the next 75 minutes until the handling team had prepared the equipment necessary to position the patient dorsally. During this time additional doses of GG and ketamine were administered to maintain the anesthetic plane (total of 25 g of GG and 600 mg of ketamine), which was characterized by adequate muscle relaxation, a strong palpebral reflex, regular pattern of breathing (12–16 breaths minute^{-1}) and a stable pulse rate (50–60 beats minute^{-1}). Before moving the patient to dorsal recumbency 5 mg of detomidine and 200 mg of ketamine were administered IV. The actual process of moving the patient from sternal to dorsal recumbency required 15 minutes; once in dorsal, the patient was connected to two large animal anesthetic machines using a parallel arrangement and fresh gas flows of 10 L minute^{-1} were set in each machine. Mechanical ventilation (IPPV) was attempted by synchronizing both ventilators to each deliver a tidal volume of 10 L, a frequency of 7 breaths minute^{-1} and an I:E ratio of 1:3. However, because the machines were from different manufacturers it was not possible to synchronize them. Therefore one of the machines was disconnected and isoflurane was delivered from a single anesthetic machine using the same settings, except for increasing the tidal volume to 15 L. Throughout anesthesia the patient maintained a basal spontaneous rate of approximately 6 breaths minute^{-1} that was mostly synchronized with the mechanical breaths.

Time under isoflurane (Aerrane; Baxter Corporation) anesthesia was 6 hours, excluding the 90 minutes using injectable anesthesia while the rhinoceros was positioned in dorsal recumbency. Vaporizer settings of 1% isoflurane for the first 30 minutes and of 1.5–2% for the remainder were used. Anesthetic signs during this time consisted of no palpebral reflex, spontaneous breathing efforts and relaxation. The patient moved four times during surgery and was administered a bolus of 200 mg of ketamine and 5 mg detomidine and infused 100–150 mL of GG 5% each time. The movement was slow and consisted of extending the forelimbs with no palpebral reflexes associated with it. The soda lime absorber was replaced once at 3 hours of inhalant anesthesia. Pulse oximetry was measured on the tongue using a finger probe (Datascope Passport D; Datascope Corp, NJ, USA) and values between 88% and 100% saturation were obtained throughout anesthesia. An ECG was placed using lead II and heart rate had decreased to 46 beats minute^{-1} for the remainder of the anesthesia with isoflurane. A 22-gauge 2.54 cm (1-inch) catheter was placed in an artery on the inner surface of the ear 3 hours after the start of inhalant anesthesia, connected to a pressure transducer and monitor (Tektronix; Medilogic Ltd., ON, Canada) to measure systolic, diastolic and mean blood pressure. Average values of 90/48, 62 mmHg were obtained initially and administration of dobutamine (Novopharm Ltd., ON, Canada) at 1 μg kg^{-1} minute^{-1} was effective in increasing pressures to 100/62, 70 mmHg, although it was only given intermittently. Heart rate during isoflurane anesthesia decreased to 40–44 beats minute^{-1}. A total of 65 liters of lactated Ringer's solution was administered during isoflurane anesthesia. Two arterial blood samples were collected into plastic dedicated syringes (Gaslyte; Vital Signs Ltd., CO, USA) during anesthesia at 4 and 6 hours and kept in iced water while at the zoo. During transport for analysis (ABL 700; Radiometer Medical, Denmark) to our clinic (1.5 hours) they were kept at room temperature and were analyzed at 37 °C. The first (pH, 7.230; $PaCO_2$, 63 mmHg (8.4 kPa); PaO_2, 63 mmHg (8.4 kPa); HCO^-_3, 25.2 mmol L^{-1}; ABE, −4.0 mmol L^{-1}; lactate, 7.3 mmol L^{-1}; Hb, 17.9 g dL^{-1}; Na^+, 137.7 mmol L^{-1}; K^+, 3.9 mmol L^{-1}; Cl^-, 99 mmol L^{-1}) and second blood sample [pH, 7.155; $PaCO_2$, 71 mmHg (9.5 kPa); PaO_2, 49 mmHg (6.5 kPa); HCO^-_3, 24.0 mmol L^{-1}; ABE, −6.0 mmol L^{-1}; lactate, 8.1 mmol L^{-1}; Hb, 13.2 g dL^{-1}; Na^+, 137.1 mmol L^{-1}; K^+, 3.5 mmol L^{-1}; Cl^-, 100 mmol L^{-1}] were consistent with a progressive respiratory (hypercapnia) and metabolic (hyperlactatemia) acidosis and hypoxemia.

Access to the abdomen was achieved through a ventral midline incision. During surgery an impaction of the large colon was relieved through a pelvic flexure enterotomy and a high enema was performed to relive a small colon impaction. During this time the patient received 1 g of flunixin meglumine IV, 100 mg IV of metoclopramide (Sandoz Canada Inc., QC, Canada), and 4 g IM of ceftiofur (Excenel; Pfizer Canada Inc., QC, Canada) in the neck muscles. Surgery time was 5.5 hours. For recovery, the patient was positioned in sternal recumbency and kept in this position with the use of inflatable mats until the degree of awareness was adequate for the patient to remain sternal on his own. The patient was extubated at 40 minutes after discontinuing the isoflurane and while in sternal and 10 minutes later was administered IV 5 mg of

2-methoxy-idozoxan (XX) in an attempt to reverse any remaining sedative effects of detomidine. The first attempt to standing occurred 20 minutes later but the patient lost his balance after standing and again assumed sternal recumbency for another 105 minutes before standing successfully.

Post-operative care continued for the next two days and consisted of fluid therapy and analgesic drugs as done pre-operatively; however, the patient eviscerated through the incision on the second day and was euthanized.

Discussion

The anatomical similarities between the rhinoceros' and equine digestive system are remarkable and can lead to the colic signs encountered in this case. This also stimulated our group to perform this type of surgical intervention. This case was anesthetized under 'field conditions' in the stalls used by the rhinoceroses' collection in this zoo since our referral clinic was not adequate for handling this patient during surgery and the post-operative care. Pre-operative planning was minimal in consideration of the emergency characteristics of the surgery. However all possible precautions were taken, including pre-operative disinfection of the stall, transport of equipment from our facility to the zoo and coordination with the staff at the zoo and the Fire Department. Positioning of the patient would not have been possible without the expert guidance of the zoo staff and the Fire Department and their specialized rescue equipment. A patient of this size required efficient *in situ* coordination by all personnel involved. There is one previous case report of an impacted Indian rhinoceros (*Rhinoceros unicornis*) undergoing this type of surgery through a flank approach and under halothane anesthesia (Simons & Jenke 1977).

We used a neuroleptanalgesic combination for initial restraint of the rhinoceros at a dose two- and fourfold of detomidine and butorphanol, respectively, of that used on previous days for medical treatment of the colic. These doses are similar to those reported by other authors (Portas 2004). The profound sedation that resulted allowed for a relatively low dose of GG and ketamine, which was deemed ideal for maintaining cardiovascular stability. In a previous anesthesia of a rhinoceros using a combination of GG, ketamine and detomidine we also noted low requirements for these drugs (Esson et al. 2006; Radcliffe & Morkel 2007).

The use of isoflurane or halothane has been reported for general anesthesia in rhinoceroses kept in lateral recumbency (Simons & Jenke 1977; Cornick-Seahorn et al. 1995; Stegmann et al. 2001). In one rhinoceros IPPV was used delivering a tidal volume of 15 mL kg^{-1} and a peak inspiratory pressure of 25 cm H_2O (Cornick-Seahorn et al. 1995), whereas the others breathed spontaneously (Simons & Jenke 1977; Stegmann et al. 2001). Our case was maintained in dorsal recumbency and we could only deliver a maximum tidal volume of 7.5 mL kg^{-1} that resulted in a PIP of 40 cm H_2O. Regardless of IPPV and positioning, all of these rhinoceroses were hypercapnic and hypoxemic, although the degree of hypoxemia was more profound in our rhinoceros in dorsal recumbency [PaO_2 of 49–63 mmHg (6.5–8.4 kPa) *versus* 91–131 mmHg (12.1–17.5 kPa)] (Cornick-Seahorn et al. 1995) and 118–201 mmHg (15.7–26.8 kPa) (Stegmann et al. 2001) in lateral recumbency. Other authors have also reported marked hypoxemia and hypercapnia in rhinoceroses anesthetized with etorphine and azaperone, where tracheal insufflation with oxygen relieved the hypoxemia but not the hypercapnia (Bush et al. 2004). Similar to other large animal species, positioning exerts a negative effect on gas exchange [ventilation/perfusion ($\dot{V}/\dot{Q}$) mismatch] and blood gases and it is worst in dorsal recumbency (Nyman & Hedenstierna 1989; Brosnan et al. 2002). The higher PIP reported for this case reflects the effects of abdominal distension and weight on the diaphragm that restricts adequate lung expansion and exacerbates the $\dot{V}/\dot{Q}$ mismatch.

Values for blood gases were probably not accurate for PaO_2, based on studies done with horse blood maintained in plastic dedicated syringes at room temperature or in iced water. PaO_2 was shown to increase over time within 5 minutes of collection in iced water samples (Deane et al. 2004; Picandet et al. 2007) and to increase (Picandet et al. 2007) or decrease in samples kept at room temperature (Deane et al. 2004). Regardless of the pattern followed in our patient, the hypoxemia was likely present throughout anesthesia. Interestingly, SpO_2 readings of 88–100% were obtained on several occasions, although readings of less than 94% predominated. The oxygen affinity (P_{50}) of rhinoceroses' hemoglobin is higher than in horses [20 mmHg (2.7 kPa) *versus* 25–26 mmHg (3.3–3.4 kPa)] (Bunn & Kitchen 1973; Baumann et al. 1984). We are unaware of corresponding hemoglo-

bin saturation values for specific PaO_2 tensions; however, using an equine algorithm, a PaO_2 of 63 mmHg (8.4 kPa) and 49 mmHg (6.5 kPa) correspond to an SaO_2 of 94% and 81%, respectively, without correcting for pH or temperature (Smale et al. 1994). In horses, SpO_2 values tend to underestimate SaO_2 (Matthews et al. 1994; Koenig et al. 2003); however it appears that our patient's SpO_2 values overestimated SaO_2 on the assumption that the horse algorithm is applicable to the rhinoceros. Values for $PaCO_2$ in horse blood have been shown to remain accurate for 120 minutes after collection at room or iced water temperature (Deane et al. 2004; Picandet et al. 2007) and the observed increase in $PaCO_2$ between samples 1 and 2 (from 63 to 71 mmHg) may reflect an increase in the degree of $\dot{V}/\dot{Q}$ mismatch and inefficient mechanical ventilation.

We did not correct the blood gases for body temperature since we had no accurate way of measuring core body temperature during anesthesia. Changes in blood gases are minimal unless moderate hypothermia is present (32–33 °C) (Shapiro 1995; Hansen et al. 1999; Bisson & Younker 2006).

Blood pressures were low in our patient compared to values reported under the effects of opioids such as etorphine (LeBlanc et al. 1987; Hattingh et al. 1994; Cornick-Seahorn et al. 1995). This opioid is known to increase blood pressure (Portas 2004) probably through changes in systemic vascular resistance. The use of inhalant anesthesia is associated with lower blood pressures in the rhinoceros as is true for other species (Cornick-Seahorn et al. 1995). The rhinoceros recovered uneventfully despite the prolonged anesthesia time and no signs of myopathy associated with impaired muscle perfusion from hypotension were observed in the immediate post-operative period. Total time from induction to standing was 10.4 hours. One other case was reported to recover successfully after 4.8 hours of halothane anesthesia (Simons & Jenke 1977), whereas two other reported cases undergoing a reproductive and a rectal prolapse examination with use of inhalants were not recovered due to bad prognosis (Cornick-Seahorn et al. 1995) or cardiac arrest (Stegmann et al. 2001).

It was unfortunate that the rhinoceros eviscerated between the second and third day post-surgery. Contributing factors included the impossibility to close the midline with wire instead of umbilical tape due to time constraints and the excessive weight of the abdominal contents, including impacted material that was not anatomically accessible to the surgeons. The fact that this rhinoceros was successfully anesthetized for a prolonged time and the smooth recovery is encouraging for the handling of future cases.

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