Journal of Zoo and Wildlife Medicine 41(1): 115–120, 2010

IMMOBILIZATION AND INTRAVENOUS ANESTHESIA IN A SUMATRAN RHINOCEROS (*DICERORHINUS SUMATRENSIS*)

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Abstract: This paper reports in detail, for the first time, on two anesthetic procedures performed on a 15-yr-old, 530 kg, adult male Sumatran rhinoceros (*Dicerorhinus sumatrensis*). The anesthetic procedures were carried out in order to perform semen collection via electro-ejaculation, using well-established methods, and in order to examine and sample bilateral corneal opacities. Anesthesia for the first procedure was induced with a combination of 5 mg (0.0094 mg/kg) butorphanol tartrate and 5 mg (0.0094 mg/kg) detomidine hydrochloride administered intramuscularly. Subsequently, 0.74 mg (0.0014 mg/kg) etorphine and 3 mg (0.0057 mg/kg) acepromazine, with an additional 1.5 mg butorphanol (0.0028 mg/kg) and 1.5 mg (0.0028 mg/kg) detomidine, were administered intramuscularly. The second procedure was carried out using an intramuscular combination of butorphanol (0.019 mg/kg) and detomidine (0.019 mg/kg), followed by etorphine (0.0023 mg/kg) and acepromazine (0.009 mg/kg). During the second procedure, the depth of anesthesia was managed with very small, supplemental intravenous doses of 50 mg ketamine (0.094 mg/kg). Sequential arterial blood gas analysis demonstrated respiratory acidosis with hypoxemia. Heart rate and respiratory rate ranged between 60–74 beats per minute (bpm), and 10–20 breaths per minute, respectively. Reversal after 100 min, with the intravenous administration of 150 mg (0.28 mg/kg) naltrexone and intravenous 20 mg (0.038 mg/kg) atipamezole, was uneventful and rapid, with the animal standing after 2 min. This combination provides satisfactory general anesthesia in this critically endangered species and will facilitate veterinary management of this species in captivity.

Key words: Anesthesia, blood gases, *Dicerorhinus sumatrensis*, management, Sumatran rhinoceros.

INTRODUCTION

There are five species of rhinoceros; the white rhinoceros (*Ceratotherium simum*) and the black rhinoceros (*Diceros bicornis*) in Africa and the Indian rhinoceros (*Rhinoceros unicornis*), Sumatran rhinoceros (*Dicerorhinus sumatrensis*), and Javan rhinoceros (*Rhinoceros sondaicus*) in Asia. With the exception of the Javan rhinoceros, the other four species are maintained in captivity. Only 275 Sumatran rhinoceroses are thought to survive in the wild, and only a handful of individuals are maintained in captivity.[8] The Sumatran rhinoceros is also called the ''hairy rhino'' due to its hairy body and tufted ears. Because of its rapid rate of decline in the wild, it is considered the most endangered of all rhinoceros species. Poaching has decreased the numbers by 50% in the past 15 yr, and the remnant populations in Indonesia and Malaysia are very small and highly fragmented. The species only survives in areas where it is physically protected by anti-poaching units.[8]

Though training and conditioning to restraint chutes has proven useful in several captive rhinoceros individuals, most procedures still require chemical restraint.[16] The literature provides numerous reports on the sedation and anesthesia of the two African species and of the Indian rhinoceros.[10] Reports and experience concerning chemical restraint in the Sumatran rhinoceros are extremely rare. To the authors' knowledge, the only description of general anesthesia in this species emanates from the Port Lympne Zoo (United Kingdom). In this case report, the critically ill female, ''Subur,'' was anesthetized with the opioid etorphine hydrochloride and was subsequently euthanized.[4] The North American rhinoceros husbandry resource manual anecdotally reports of a general anesthesia with 300 μg/kg butorphanol and 60 μg/kg detomidine hydrochloride.[1] Standing sedation with 25 mg butorphanol in a female at Sungai Dusun, Malaysia, has been previously reported.[11] Zoo Malacca in Malaysia has reportedly sedated two adult individuals for minor procedures with 0.98–1.23 mg etorphine in combination with 4–5 mg acepromazine.[10] A combination of 80 mg butorphanol and 80 mg azaperone has been suggested for handling snared Sumatran rhinos.[13]

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As an alternative, 1 mg ethorphine in combination with 60 mg azaperone is also suggested.[12]

To the authors' knowledge, this is the first detailed description of two general anesthesia procedures in a Sumatran rhino.

MATERIALS AND METHODS

The two procedures were performed on a 15-yr-old male held at the Sepilok Rehabilitation Centre, which is administered by the Sabah Wildlife Department (Malaysia). The procedures were carried out in order to perform semen collection via electro-ejaculation, using well-established methods, and to examine and sample bilateral corneal opacities.[7]

The first procedure was carried out in April 2005; ambient temperature was 30–34°C and relative humidity was 100%. The animal's weight (530 kg) was determined with a platform scale and, with the exception of bilateral corneal opacities, the animal appeared clinically healthy. Sedation was induced with a combination of 5 mg (0.0094 mg/kg) butorphanol tartrate (Torbugesic, Fort Dodge Animal Health, Fort Dodge, Iowa 50501, USA) and 5 mg (0.0094 mg/kg) detomidine hydrochloride (Domosedan, Orion Corp., Farmos, 02200 Espoo, Finland) administered intramuscularly below the base of the ear with a CO_2-propelled, 3-ml remote dart system and a 1 × 55-mm needle (Daninject ApS, Børkop, 33805, Denmark). Ten minutes after the administration of the initial sedatives, the animal became markedly quiet, but remained standing and could not be approached. Twenty-five minutes later, 0.74 mg (0.0014 mg/kg) etorphine and 3 mg (0.0057 mg/kg) acepromazine (Large Animal Immobilon, Fa. Richter, 4600, Wels, Austria), with an additional 1.5 mg (0.0028 mg/kg) detomidine and 1.5 mg butorphanol (0.0028 mg/kg), were administered intramuscularly per dart in the neck. Forty minutes after the initial darting, the animal became sternally recumbent, and an additional 0.4 mg (0.00075 mg/kg) etorphine, 1.5 mg (0.0028 mg/kg) acepromazine, and 30 mg (0.057 mg/kg) ketamine (Ketamidor, Fa. Richter, 4600, Wels, Austria) were administered intramuscularly. A peripheral venous catheter (18 G) was placed in an ear vein, and a constant flow (approximately 2 ml per kg per hour) of lactated ringers solution was provided. The animal was rolled into a right lateral recumbent position. During the entire time the animal was recumbent, oxygen was supplied via nasal insufflation at a rate of 15 L/min. Anesthesia monitoring included evaluation of respiratory rate (RR) through observing thoracic excursions and heart rate (HR), by auscultation, apex palpation, and pulse oximeter probe. Peripheral hemoglobin oxygen saturation (SpO_2) was measured using pulse oximetry (Nellcor NP-20, Nellcor Incorporated, Pleasanton, California 94566, USA), with the probe placed on the ear after scraping the skin of the inner and outer pinna. During this first procedure, arterial blood gases could not be analyzed, as the analyzer (i-stat, Abbott Gesm. b.H., 1160, Vienna, Austria) could not be maintained within its operating temperature range (16–30°C) under the field conditions. At 56 min after initial dart application, and subsequent to rectal evacuation, the animal suddenly stood up and attempted to attack. Using the i.v. line in the peripheral venous access, 0.12 mg (0.00023 mg/kg) ethorphine and 30 mg (0.057 mg/kg) ketamine were administered intravenously, and the animal once again became laterally recumbent. Subsequent to this critical incident, the procedure was uneventful, and a sufficient plane of anesthesia was easily maintained with small, supplemental intravenous ketamine administrations. The total dose of each drug given up to this time was butorphanol (0.0122 mg/kg), detomidine (0.0122 mg/kg), etorphine (0.00215 mg/kg), acepromazine (0.0085 mg/kg), and ketamine (>0.057 mg/kg). Following electro-ejaculation and ocular sampling, detomidine was reversed, at 96 min after the initial dart, with 20 mg (0.038 mg/kg) atipamezole (Antisedan, Orion Corp., FI 02200 Espoo, Finland), and ethorphine and butorphanol with 150 mg (0.28 mg/kg) naltrexone (Trexonil, Wildlife Laboratories Inc., Fort Collins, Colorado 80524, USA) i.v. mixed in the same syringe. Recovery was uneventful and rapid, with the animal standing 2 min after intravenous antagonist administration.

In October, a second procedure was performed on the same male. The ambient temperature was similar to April, with 31–33°C and 100% relative humidity. The animal still weighed 530 kg. Dosages were allometrically scaled from white rhinoceros reference data. An intramuscular combination of detomidine (0.019 mg/kg) and butorphanol (0.019 mg/kg), followed 20 min later by etorphine (0.0023 mg/kg) and acepromazine (0.009 mg/kg), was administered. Following induction, the depth of anesthesia was managed with small, supplemental intravenous dosages of 50 mg ketamine (0.094 mg/kg) and a single intravenous dose of 0.12 mg (0.00023 mg/kg) etorphine. Oxygen was supplemented during the

Table 1. Summary of initial anesthesia procedure in a captive, 530 kg Sumatran rhinoceros.

Time	Drug 1	Dose	Drug 2	Dose	Comments	SpO_2	HR	RR
0:00	Butorphanol	5 mg	Detomidine	5 mg				
0:25	Butorphanol	1.5 mg	Detomidine	1.5 mg				
	Etorphine	0.74 mg	ACP[a]	3 mg				
0:40					Sternal recumbency			
0:42	Etorphine	0.4 mg	ACP	1.5 mg	i.m.	93%	145	
	Ketamine	30 mg			i.m.			
0:50					Manipulation begins, place PVC[b] in ear vein			
0:56					Animal stands and attacks			
0:59	Ketamine	30 mg	Etorphine	0.12 mg	i.v. using PVC access			
1:03						84%	80	4
1:11	Ketamine	20 mg	Detomidine	1 mg	i.v. using PVC access			
1:13					Elektro-ejaculation	95%	90	7
1:30					Aspiration eye liquor			
1:36	Naltrexone	150 mg	Atipamezole	20 mg	i.v. using PVC access			
1:38					Stands			
1:45					Returns to enclosure			

[a] ACP = acepromazine.
[b] PVC = peripheral venous catheter.

entire procedure using a nasal tube delivering 15 L/min, and a constant flow (approximately 2 ml per kg per hr) of lactated ringers solution was provided in order to keep the peripheral venous access open. Arterial blood samples were drawn from an auricular artery with a heparinized syringe and immediately placed in a cartridge (CG4+ Abbott Gesm. b.H. A-1230 Vienna, Austria) and analyzed with an ice-cooled (25–27°C), portable, hand-held clinical blood gas analyzer (i-stat). As in the first procedure, anesthesia was reversed 100 min after initial darting with 150 mg (0.28 mg/kg) natrexone and 20 mg (0.038 mg/kg) atipamezole intravenously. Recovery was uneventful, and the animal was standing after 2 minutes.

RESULTS

Anesthesia characteristics and progression in this novel species were similar to that in other rhinoceros species. Induction and reversal was smooth and without any excitation. Procedures 1 and 2 are summarized in Table 1 and 2, respectively. The course of HR, RR, and SpO_2 during the second procedure is summarized in Figure 1. The depth of anesthesia was managed with very small, supplemental intravenous doses of ketamine. Blood gas values demonstrate respiratory acidosis with hypercapnea and hypoxia (Table 3). The respiratory depressive effect of ethorphine in this species is clearly demonstrated in the second procedure with the drop of PaO_2 and the rise in $PaCO_2$ in blood gas sample 3, taken 8 min after 0.12 mg (0.00023 mg $kg^{(-1)}$) etorphine had been administered intravenously. Following reversal, the animal was returned to its enclosure within 30 min. Subsequent behavior was unremarkable.

DISCUSSION

The combination of butorphanol and detomidine, supplemented after 20 min with ethorphine and acepromazine, has proven a satisfactory and easily controlled anesthetic protocol in the small Sumatran rhinoceros species. However, the dosages used in the initial protocol were inadequate. This same protocol has been used successfully by the authors in over 200 white rhinoceros anesthetic procedures.[14] Anesthesia characteristics and progression in this novel species were the same as that in other rhinoceros species. Induction and reversal was smooth and without any excitation. The depth of anesthesia can be managed with very small, supplemental intrave-

Table 2. Summary of second anesthesia procedure in a captive, 530 kg, Sumatran rhinoceros.

Time	Drug 1	Dose	Drug 2	Dose	Comments
0:00	Butorphanol	10 mg	Detomidine	10 mg	i.m. per dart
0:13					Sternal recumbency
0:22	Etorphine	1.2 mg	ACP[a]	5 mg	
0:36	Ketamine	100 mg			i.v.
0:40					Lateral recumbency, manipulation begins
0:46	Ketamine	50 mg			i.v. using PVC[b] access
0:52	Ketamine	50 mg			i.v. using PVC access
0:54					Electro-ejaculation
1:05	Etorphine	0.12 mg	ACP	0.5 mg	i.v. using PVC access
1:40	Naltrexone	150 mg	Atipamezole	20 mg	i.v. using PVC access
1:42					Animal stands

[a] ACP = acepromazine.
[b] PVC = peripheral venous catheter.

nous doses of ketamine hydrochloride. Blood gas values demonstrated respiratory acidosis with hypercapnea and hypoxemia. Although the animal received 100% O_2 via a nasal tube throughout the entire procedure, PaO_2 declined over the course of time. This is indicative of shunting and, possibly, increased dead space ventilation due to ventilation-perfusion mismatching. Pulse oximetry-derived peripheral hemoglobin oxygen saturation values (SpO_2) were low throughout most of the procedures, dropping as low as 84% in one instance. As observed previously, this hypoxemia may be adequate for tissue oxygenation, due to higher oxygen affinity of hemoglobin and lower tissue metabolic rate in large mammals.[6] The respiratory depressive effect of ethorphine in this species is clearly demonstrated in the second procedure with the drop of PaO_2 and the rise in $PaCO_2$ in blood gas sample 3, taken at 1:13 min (Table 3). This sample was taken 8 min after 0.12 mg (0.00023 mg/kg) etorphine had been administered intravenously. This is consistent with findings in anesthetic procedures in other rhinoceros species.[2,6,9,13] However, it is to be noted that $PaCO_2$ values in unrestrained white rhinoceros (mean 49 mm Hg)

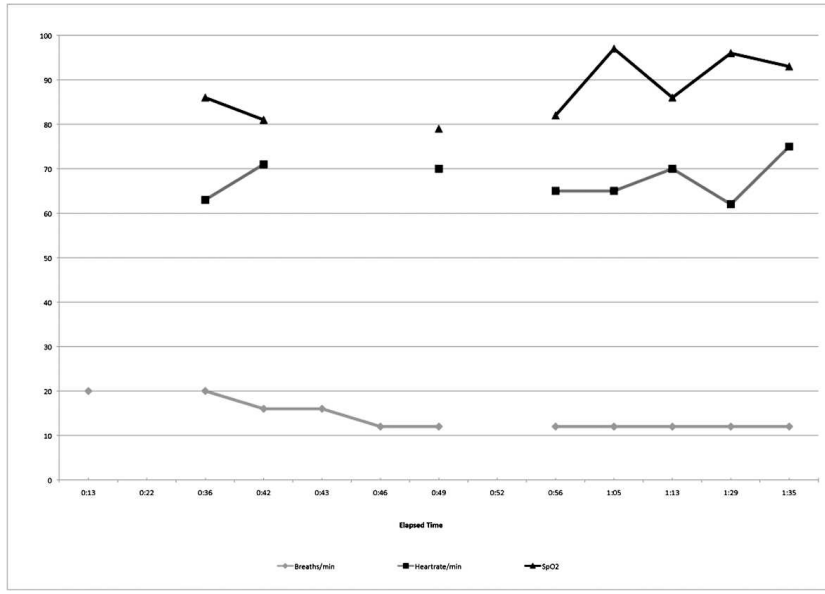

Figure 1. Course of the respiratory rate (RR), heart rate (HR), and the peripheral hemoglobin oxygen saturation (SpO_2%) during the second anesthetic procedure in an adult Sumatran rhinoceros. Time is the elapsed time after the initial drug administration.

Table 3. Arterial blood gas values collected during the second anesthetic procedure in an adult Sumatran rhinoceros. Time is the elapsed time after the initial drug administration.

Time	pH	$PaCO_2$ mm Hg	PaO_2 mm Hg	Beecf mmol/L	HCO_3 mmol/L	TCO_2 mmol/L	SO_2%	Lactate mmol/L
0:49	7.302	62.4	71	5	31	33	91	0.62
1:05	7.272	65.8	93	3	30	32	96	1.47
1:13	7.233	67.1	64	1	28	30	87	2.93
1:35	7.253	63.7	68	1	28	30	90	2.53

are higher than those reported in horses.[3] The use of the synthetic agonist-antagonist opioid butorphanol, in combination with ethorphine to potentially alleviate the respiratory depressive effects at the μ receptor, is controversial.[5] A previous study in white rhinoceros could not demonstrate a positive effect of butorphanol on ventilation in these circumstances.[17] The study results, however, must be treated with care, as significant size differences between the study and control groups were noted by the authors, and blood sampling between the two groups occurred at different times during anesthesia.[17] However, in these authors' view, under a similar protocol, the addition of butorphanol has reduced etorphine dosages and lessened the effect of respiratory depression in rhinoceroses and in wild equids.[15] The co-administration of opioids is generally an active area of research that needs further clarification.[5] In order to gain a significant increase in PaO_2, it would certainly be beneficial to ventilate the animal. However, this is logistically difficult in remote settings. In procedure 2, HR increased slightly (82–96 bpm) subsequent to electro-ejaculation, and possibly due to the increase in $PaCO_2$, after intravenous ethorphine administration. Similarly, lactate increased during the procedure. The authors believe this is due to the muscle contractions during rectal electro-stimulation.

The unsatisfactory first anesthesia was due to a spontaneous decision, motivated by fear of possibly killing one of the few Sumatran rhinos in captivity, to reduce the dose from the previously allometrically calculated values. This clearly demonstrates the danger of deviating from calculated dosages on "gut feeling." Based on the admittedly very limited experience in the Sumatran rhinoceros, but taking into account the similarity of the procedure and experience in the three other rhinoceros species, the authors suggest, based on the second procedure, the following combination for general anesthesia in an adult animal: 10 mg detomidine (0.019 mg/kg, i.m.) and 10 mg butorphanol (0.019 mg/kg, i.m.), followed 20 min later by 1.2 mg etorphine (0.0023 mg/kg, i.m.) and 5 mg acepromazine (0.009 mg/kg, i.m.). Reversal is achieved with 150 mg naltrexone (0.28 mg/kg, i.v.) and 20 mg atipamezole (0.038 mg/kg, i.v.).

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Received for publication 14 July 2009