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ANAESTHESIA AND SURGERY OF ZOO AND EXOTIC ANIMALS

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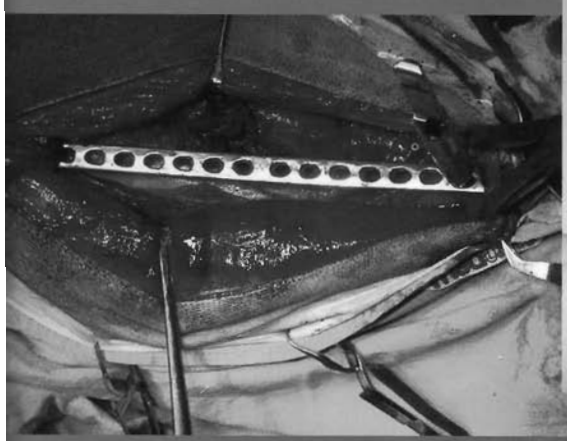

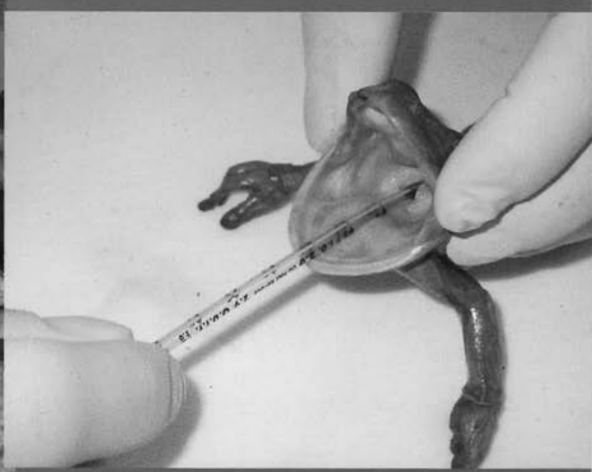

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THE ANAESTHESIA OF DIFFERENT RHINO SPECIES – WHY TEAMWORK IS A CRUCIAL ELEMENT?

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In order to elucidate the problems of poor reproductive performance in captive white rhinoceros *(Ceratotherium simum),* the European Endangered Species Program (EEP) committee has encouraged intensive and serial reproductive monitoring in this species (Schwarzenberger et al. 1999). Although the reasons for these problems have not been identified definitively, a multi-disciplinary, multi-institutional research proposal aims to work on possible solutions. The overall objectives of this project are to use an integrated approach to enhance breeding of southern white rhinoceroses in the EEP (Schwarzenberger et al., 2001, Hermes et al. 2005a, Hermes et al. 2005b). The development of a reliable and safe anaesthesia method was an essential factor in this project. During the period March 1999 to January 2006 more than 180 elective anaesthetic events were performed using a combination of detomidine-HCl (Domosedan®, Orion Corp., Farmos, Finland), butorphanol (Torbugesic®, Fort Dodge Animal Health, Iowa, USA) and additional ethorphine-acepromazine (Large Animal Immobilon®, C-Vet Veterinary Products, Lancs, UK). Anaesthesia was reversed in all cases with an i.v. combination of naltrexone (Trexonil®, Wildlife Laboratories Inc., Fort Collins, Colorado, USA) and atipamezole (Antisedan®, Orion Corp. Farmos Finland) (Walzer et al., 2001). Similar techniques have been applied to the other species of rhino these past years (see Rhino anaesthesia – Quick and dirty guide).

Following a pre-anesthesia evaluation questionnaire (institution veterinarian and rhino keeper) all animals (estimated weight range 2000-3100 kg) were initially sedated with a combination of detomidine-HCl 10-15 mg; and butorphanol 10-15 mg. This combination was injected into the neck muscles caudo-ventral to the ear using a dart pistol and 3.5ml plastic darts with a 60-mm needle (Dan-inject International, Gelsenkirchen, Germany). After 20 minutes anesthesia was induced with intramuscular ethorphine 3±0.6 mg and acepromazine 12±2.5 mg. In safari park settings or when it was deemed difficult to dart an animal twice induction was carried out with an initial combination of all three drugs. In some procedures an additional i.v. bolus application of ketamine 100-300 mg (Narketan®, Chassot AG, Bern, Switzerland) was used to reduce the time to lateral recumbancy, and thus facilitate the correct placement of the animal within the enclosure. A heavy-duty tire inner tube was placed beneath the shoulder in order to alleviate possible compressive trauma. All animals received supplemental oxygen at a rate of 15 l/min through a nasal tube. The mean duration of anesthesia was 76 ±48 min and a total down time in excess of 50 hours has been accumulated during these procedures. Anesthesia was reversed in all cases with an i.v. combination of naltrexone 250 mg and atipamezole 20 mg. Reversal was smooth and without signs of excitation. All animals were standing and alert approximately 2 min following administration of the antagonists.

Once in lateral recumbency, rhino monitoring included measurement of the heart rate by direct cardiac auscultation and Doppler; Respiratory rate by direct observation of thoracic excursions. The percent oxygen saturation of hemoglobin (SpO_2) was continuously monitored

using a hand-held pulse oximeter (Nellcor NP-20, Hayward, California USA). The ideal placement of the probe varied between individuals. Sites used included, the medio-proximal aspects of the front leg, the mammary gland, and using reflective probes the nasal and oral mucosa. Additionally sequential venous blood samples were drawn from auricular veins. Arterial blood samples for monitoring purposes were drawn from the auricular artery. The arterial blood samples were processed immediately with a portable blood gas analyzer (i-Stat®, SDI Sensor Devices Waukesha, Wisconsin USA).

Mean heart rate was 97±47 bpm and in most cases decreased over the duration of the anesthesia. Mean respiratory rate was 6±3 breaths per minute, and in most cases remained stable during the procedure after a phase of initial stabilization (mean 20 min). Both the heart rate and the respiratory rate were influenced by the procedures (ultrasound, electroejaculation, etc.) being carried out and must be evaluated in this context. Mean SpO_2 values were 83.5±13% with supplemental nasal O_2 (measured over the total time frame). SpO_2 gradually increased over the duration of anesthesia in most individuals.

Collection of sequential arterial blood samples from the auricular artery proved difficult under the field conditions but markedly improved with experience. The evaluation of the arterial samples revealed an extremely low mean pH of 7.29±0.08; The arterial carbon dioxide partial pressure (PCO_2) revealed a marked hypercapnia 73±13 mmHg which remained relatively constant in each individual over the complete duration of anesthesia. The arterial oxygen partial pressure (PO_2) varied greatly between individual animals but on the whole demonstrated a mean tissue oxygenation of 67±23 mmHg. In all animals where sequential samples were obtained, PO_2 increased over the duration of the procedure. Oxygen saturation (SO_2), the amount of oxyhemoglobin expressed as a fraction of the total hemoglobin able to bind oxygen, is a useful predictor of the amount of oxygen that is available for tissue perfusion. In all measured samples SO_2 were elevated when compared to the pulse oximetry derived oxygen saturation values. Low SpO_2 values always corresponded to low SO_2 values and should be acted on accordingly. While this partially validates the use of pulse oximetry, severe pitfalls are possible and the reader is referred to Saint John (1992) for a discussion of the limitations. Elevated mean Base Excess (BE) 10 mmol/l and HCO_3 34 mmol/l values demonstrate a primary respiratory acidosis with metabolic (compensatory) alkalosis.

Similar to the experiences in Prezwalski's horses, (Walzer et al. 2000) the combination of ethorphine, buthorphanol, and detomidine provided a safe and reliable method for long term anesthesia in the white rhinoceros. These findings correspond in principle to those described by other authors (Heard et al. 1992; Hattingh et al. 1994; Kock et al. 1995). In our experience the agonistic / sedative properties of buthorphanol seem to outweigh any possible antagonistic properties in this species, although this is unknown. As we already described in the Przewalski horse (Walzer et al. 2000), the pacing – a normal side effect with ethorphine – is greatly reduced due to the addition of buthorphanol and enhances the safety of the procedure in many enclosures. The animals suffer from marked hypercapnia and severe hypoxemia. As observed by Heard et al. 1992, this recorded hypoxemia may be adequate for tissue oxygenation due to higher oxygen affinity of hemoglobin and lower tissue metabolic rate in large mammals. It is possible that our incorporation of butorphanol into the initial dart protocol may have helped partially antagonize some of the respiratory depressant effects of ethorphine and thus improve SpO_2 values in this study. The average arterial carbon dioxide partial pressure measured in our procedures is markedly elevated when compared to those described by Heard et al. (1992) in one animal.

Evaluation has shown, that though anaesthesia is influenced by a multitude of factors (e.g. various procedures, sex, individual animal variation), that there is a significant correlation between the number of procedures and an increase in the average pH, PaO_2 and a decrease of $PaCO_2$. Though the r^2 values are not very high, a marked improvement in the anaesthesia quality can be attributed to experience and the subsequent protocol development and enhancement over time (Walzer et al. 2003).

Prolonged recumbency in rhinos is associated with hypoventilation resulting in hypercapnia and respiratory acidosis. Through the provision of supplemental oxygen the severity of hypoxemia can be limited. Pulmonary shunting and ventilation/perfusion mismatch also likely play a role in recumbent anesthesia of the rhino. It is the authors' opinion that in order to fulfill the necessary monitoring and therapeutic interventions in long-term rhino anesthesia it is essential to establish an anesthesia team with individually clear defined tasks.

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Many zoo rhinos, which are used to humans, are kind and good-natured. They tolerate minor manipulations and will lie down when being rubbed between the legs, stomach, mammary gland, or preputium. Nevertheless, one should always keep in mind that they can be up on their feet in seconds. Chute training can and should be used for minor manipulation such as blood sampling, etc. The following dosages are meant to serve as a guideline. The character of each individual should be considered prior to any procedure.

Sedation

Sedation is indicated for minor manipulations (blood sampling in untrained animals, translocation, etc.). Various drugs can be recommended. They vary with regard to onset and duration of the sedative effect. The choice of drug depends on when and how long a tranquillizing effect is desired.

The following drugs have been used on a variety of occasions: To reduce anxiety, aggression and capture/transport related stress (Atkinson, 2001; pers. com.). The experience with these drugs has shown that they proved highly effective in transports and pre-transport related training. During transportation most animals remained calm, were eating and fewer problems occurred when reaching a new zoo / enclosure / environment, than those which were crated and transported without any drugs. Especially in long distance transportations some of these drugs should be given serious considerations.

The following drugs have been recommended:

Diazepam (Valium®)

0.5-1.0 mg/kg BW per os (Göltenboth, 1995), lasting for 60-90 min.

Azaperone (Stresnil®)

0.05-0.1 mg/kg IM. (Atkinson, 2001; pers. com.), 100-200 mg total dose for an adult IR. Will last for 2-3 hours.

Acepromazine (Vetranquil®, Aceprom®, Combistress®, Neurotranq®)

0.5-1.0 mg/kg BW per os (Göltenboth, 1995), lasting for 4-8 hours.

Detomidine HCL (Domosedan®) 8-14 mg IM total dose for adult white rhino alone or in combination with **butorphanol** (Butomidor®, Torbugesic®) 8-14 mg IM total dose. Onset IM 20 minutes, duration 1-2 hours. Can also be used IV at a reduced dosage of 4-6 mg detomidine + 4-6 mg butorphanol. (Walzer 2002 used in 60 + minor procedures) Can be used as an adjunct in ethorphine anaesthesia (see below). If ethorphine is not available it is possible to to deeply sedate white rhinos with far greater dosages of detomidine and butorphanol (e.g. 25 mg each IM).

Medetomidine (Domitor® and Zalopine®) has been used in combination with butorphanol to perform recumbant anaesthesia. 120 mg butorphanol with 3-4 mg medetomidine hast been used at White Oak, Florida (Scott Citino, pers. Comm. 2005).

Haloperidol USP (Serenace®, Haldol®)

0.05-0.1 mg/kg per os (Atkinson, 2001; pers. com.) (max. 200 mg for an adult male IR), lasts up to 16 hours.

NB! Various formulations of Haloperidol exist – duration of action!

Zuclopenthixol acetate (Clopixol-Acuphase®)

Up to 300 mg for an adult rhino (Atkinson, 2001; pers. com.). Onset of action 1 hour after administration, tranquillisation effect will last for 72 hours.

Perphenazine enanthate (Trilafon LA®, Decentan®)

500 mg (2.800 kg) s.c. (behind the ear) were used in one occasion (Rietschel, 1998). Average dosage for an adult IR: approx. 200-300 mg (50-150 mg in juveniles and sub-adults). The effects are seen 10-16 hours after deep IM injection, peak effect is usually reached after approx. 72 hours. Duration of this form is described as being up to 7 days (Atkinson, 2001; pers. com.).

Anaesthesia

General comments

Monitoring of anaesthesia is essential in rhinos. In procedures in which the animal is recumbent ventilation / perfusion mismatches will occur. Initial respiratory acidosis can furthermore be aggravated through metabolic components. Minimum monitoring requires the use of a dedicated person, and a pulse oximeter. Ideally sequential arterial blood gas analysis should be performed and a capnograph used.

Make sure that both nostril airways are free and off the floor – provide additional oxygen through a nasal tube. Food pellet bag under the head works very well.

NB! Tracheal intubation is possible in black and Indian rhino but extremely difficult and time consuming in white rhinos.

Ethorphine (M99®) and **Ethorphine-acepromazine** (Large Animal Immobilon®)
Is the 'drug of choice' for anaesthesia in rhinos and is often used in combination with detomidine (Domosedan®), butorphanol (Torbugesic®), ketamine (Ketaset®, Narketan®, Vetalar®), and xylazine (Rompun®, Xylazine Injectable®). As pre-medication some of the drugs mentioned above have been used as well.
Others prefer the combination of ethorphine, ketamine, and detomidine (Atkinson, 2001). The combination of butorphanol, detomidine, and ethorphine was successfully used in white rhinos (Walzer et al., 2000, 2001, 2004).

Recommended procedure for white rhinos but also used in Indian, black and Sumatran:
The following combination was successfully used in over 200 white rhino procedures (Walzer et al., 2000, 2001, 2004, 2005):

Butorphanol	10-15 mg per adult animal and
Detomidine	10-15 mg per adult animal

Wait 15-20 minutes, then apply:

LA Immobilon®	0.8-1.4 ml

Dosages depend highly on age, state of health, and nature of the animal. In safari park – large enclosure situations 200 mg ketamine is additionally added to reduce the "pacing effect " of the ethorphine – animals remain "glued" to the ground

Reversal
Reversal was achieved by injecting 250 mg naltrexone (Trexonil®) and 20 mg atipamezole (Antisedan®), given combined IV. Omit the use of atipamezole if you want slight sedation due to the alpha–2 agonist post procedure.

Important considerations before and during anaesthesia

- No stressed, nervous animal should be sedated. The risk of fractured bones, pulled tendons or broken horns is high.
- Stressed animals also need a higher dosage for full anaesthesia. The risks associated with this drug increase. (One 6-year old rhino died under anaesthesia of heart failure. He had been sedated with LA Immobilon® on several occasions before, due to severe foot problems. He needed increasing doses for induction due to aggression, possibly associated with the pain from the foot lesions. In addition he was topped up as well during anaesthesia (Flach, 2000; pers. com.).
- Rhinos tend to push their head between bars when going down. This can be avoided by using appropriate covers of heavy wooden panels. Enough staff should also be available in case of emergency. (The staff has to be experienced and aware of the risks.) The use of adjuncts to the ethorphine anaesthesia also reduces the "head press" effect.
- No slippery substrates should be on the floor for sedation. The animals tend to slip when going down. Rubber mattresses, which cover the whole ground are ideal, sand might prove helpful as well. Straw bales should be available to cover hard edges etc. On wet floors the use of cement powder has proven very useful in reducing slipping.
- No food for at least one day (esp. hay, straw) - minimises the risk of regurgitation. NB! Walzer et al. Do not recommend this as it appears unnecessary.
- Helpful tools:
  Straw bales (to assist in comfort when the animal goes down).
  Ropes (to pull / hold the animal in case this is needed).
  Non-translucent blankets (to cover the eyes as soon as the animal lays down).
- Ear plugs to reduce effect of noise
  In Wild / Safari Parks water
  (To cool the animal if needed. Immobilisation on hot days should generally be avoided.)
- Oxygen (essential in order to ensure adequate supply, especially if the head lies in an awkward position), emergency case (Doxapram®, 10 mg nalorphine, naloxon, antidote), pulsoximeter (clip on the tongue, the ear, vulva).
- Make sure you have the human antidote naloxon (Narcanti®) ready before drawing up Immobilon.

- Injection site: muscles of the neck, between the folds, or the medial side of the leg. Use adequate needle length – at least 55 mm.
- After injecting ethorphine, it takes on average 10 minutes for the animal to become recumbent.
- Ensure intravenous access (ear veins). Eye ointment should be applied before covering the eyes with a blanket. It is often helpful to put cotton wool into the ears to avoid stimulation, especially when working with noisy tools.
- Close monitoring of heart and breathing rate. Some average parameter using this anaesthesia protocol are:
    - Heart rate: 40-90 /min
    - Respiratory rate: 3 -10 /min
    - SpO_2 – mean: 77-98% (should increase with time)
    - $PaCO_2$: 50-75 mmHg
    - PaO_2: 60-120 mmHg
    - HCO_3: 25-35 mmol/l

NB! If HCO_3 values drop during the procedure this is a possible sign of decompensation and at the very least should be monitored carefully and frequently. Consider terminating procedure.

- For surgical work on the feet, straw bales should be available to put the legs on. Hard material should not be used as it might lead to temporary nerve damage as a result of prolonged compression of the neural tissues.
- Reversal takes about 1-2 minutes. Use **naltrexone** and not diprenorphine in this species. Naltrexone is a pure antagonist, one can avoid the risk associated with agonistic action and re-cycling.