ANAESTHESIA OF THE WHITE RHINO

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INTRODUCTION

White rhino are routinely anaesthetized for marking, collection of samples, translocation and treatments. Today many conservation bodies and private individuals build on the initial successes achieved by especially the Natal Parks Board, and continuous research refines these procedures.

The anaesthesia is complicated by the white rhinos' sensitivity to opioids, severe respiratory depression under anaesthesia, hypertension due to opioids and peculiar anatomical features. As each individual animal becomes more and more valuable the need for further research and refining the anaesthetic process becomes more important.

THE PLANNING PHASE

REMOTE DRUG DELIVERY SYSTEMS

Darts

It is preferable to have a robust system where the drug is discharged only once the collar of the dart hits the skin to ensure deep intramuscular deposition of the drugs. The Palmar Cap Chur powder-charged darts or the KNP aluminium acetic acid/bicarbonate darts are good examples.

Always ensure you have enough darts for the number of animals as well as extras ready for top ups or antidote. The Tel-Inject or Dan-Inject systems with uncollared needles are suitable for darting rhino in bomas.

Needles

Strong needles of at least 50mm length and 2mm in diameter are recommended. If the needle opening is in front, it is suggested that the point of the needle be bent over the middle line to avoid the formation of a skin plug. A bead or collar on the needle is sufficient to prevent the darts from falling out.

COMPOUNDS AND COMBINATIONS USED IN THE ANAESTHESIA OF WHITE RHINOS

In field situations:

The most important factor during field anasthesia is to obtain recumbancy in the shortest possible time. Combinations of fentanil and etorphine, with or without hyoscine have been used with good results (Table 1).

The preferred combinations for field anaesthesia are:

> 0,5-4mg M99 (calf - adult bull) with 10-100mg Azaperone. To enhance uptake, 7500 I.U. Hyaluronidase is used and this results in the animal standing within 2-3 minutes post-darting.

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Table 1: Compounds and combinations used in the anaesthesia of white rhinos

	ETORPHINE	FENTANYL	HYOSCINE	HYALASE	AZAPERONE
	mg	mg	mg	I.U.	mg
AD	3-4	-	25	-	-
	1-2	30	-	-	60-80
	3-4	-	-	7500	60-100
SUB	2	-	12	-	-
	0.5	20	-	-	30-40
	2	-	-	7500	30-40
JUV	. 1	-	12	-	-
	0.25	12	-	-	15-20
	1	-	-	7500	15-20

Once down, the rhino receives:

1) 5-15mg Nalorphine I.V.
2) 10-20mℓ Dopram.
3) O_2 supplementation.

In the boma:

For boma anaesthesia, 0,25-0,4mg M99 with 10-20mg Azaperone is used if a standing immobilisation is required or 1-1,5mg M99 and 50mg Azaperone if a recumbency in adults is required.

To load a rhino from a boma, allow 10-15 minutes after darting with 0,25mg M99. The animal will show a high stepping gait and the tendency to follow moving objects.

A rag tied to a long stick is waved in front of the rhino and slowly moved towards the crate as the rhino follows. Once in the crate the tranquillizers and antidote are administered. During this process, it should be very quiet and no movement or sound made to distract the animal.

ANIMAL MANIPULATION

Rhino are heavy animals and difficult to manipulate once recumbent. One should always plan for the worst case scenario and have all equipment handy. The list should include:

1. Ropes: Preferably soft cotton ropes. One long rope *ca* 20m for the head and a shorter rope of 10m for the brake on the hind foot.
2. Blindfolds and earplugs: Blindfolds can be made of towels with velcro on the ends. Earplugs should have long strings hanging out to avoid them being forgotten in the rhino's ears.
3. Axes: It may be necessary to remove some trees/branches around the rhino before administration of the antidote to avoid injury once the rhino stands and walks.
4. Shovels: They are used to dig/fill holes on the path of the walking rhino, or to remove sharp stumps in close proximity to the recumbent rhino.
5. Prodders: They are used with much success on rhino when used with discretion, stimulating them to rise after administration of the partial antagonist.

ANIMAL MONITORING

1. Pulse Oxymeters: Later models also indicate heart rate with an audible beep which allows personnel to continue with their work while hearing a continuous monitor.
2. ECG's: If a Pulse Oxymeter is not available, an ECG can assist if they have an audible beep or monitor, but machines giving only printouts are of little value as a monitoring device.
3. Blood pressure gauge: This may be either direct line using the inner ear artery or via a cuff around the tail.
4. Thermometer: It should be long enough to ensure a good reading.

PHYSIOLOGICAL MANIPULATION

1. Water: This is used to cool down rhino in extreme temperatures, but copious amounts are necessary to obtain any effect.
2. O_2 Supplementation: It is not difficult to pass an endotracheal tube on rhino via the nose through which O_2 can be supplemented. The diameter of this tube should be far less than that of the trachea. A commercial bovine stomach tube is adequate.
3. Intravenous line: It is preferable to attach an IV line using an ear vein or the large vein on the inner front leg. This is useful in emergencies, especially when blood pressures falls.

PERSONNEL

It is important to have enough personnel that are well informed and to whom specific tasks have been designated.

TIME MANAGEMENT

The best season for rhino capture is autumn, when mornings are cool and animals are still in good condition following the summer. Rhinos breed all year round and one should avoid darting heavily pregnant animals. Late afternoon darting should be avoided.

LOCALITIES

Difficulties are experienced when darting in dense bush from a vehicle, between high trees from a helicopter and on open plains when darting on foot. Efforts should be made to ensure continuous visual contact once an animal is darted. Natural obstacles such as cliffs, dongas and open water pose a threat to ataxic rhino and the animals must be steered away from these trouble areas prior to darting. Accessibility of the ground crew to the rhino should always be a consideration.

COMBINED ANAESTHESIA OF COWS AND CALVES

The cow should be darted first as the calf will remain with it's mother, and can often be darted while standing by the recumbent cow. However, the opposite is not true. The author has obtained good success by darting the cow and calf in quick succession using a double barrel dart gun, then pulling away completely allowing the two animals to remain together and become recumbent in very close proximity.

THE APPROACH

By helicopter

Once the desired rhino is identified it is best to move in quickly, dart and back off immediately. Take time to herd the animal to a suitable site to ensure a good dart. The helicopter should fly behind the animal *ca* 20m away and at the same speed to avoid dart whiplash.

From a vehicle

Never drive directly towards the rhino, but rather close in, in decreasing circles. Avoid standing on the back of a pick-up or breaking the outline of the vehicle. If the rhino rushes off after darting, do not chase the animal. Try to prevent bushes scratching the vehicle or loose items on the back of the pick-up truck that can make a noise.

On foot

Although white rhino appear to be very placid, they are extremely powerful and potentially dangerous. It is sensible to have a back-up person with a heavy calibre rifle. Be sure of a down-wind approach and wear sensible bush clothes. Walk very softly, white rhino have extremely poor eyesight but their sense of smell and hearing is acute.

DART SITE AND ANGLE

A well vascularized muscle area should be selected for dart placement. The darts must be placed at right angles to the skin to avoid sub-cutaneous deposition of the drug. Preference is given to the gluteal region from the helicopter while the neck area seems to work best in a boma situation.

THE ATAXIC PHASE

Set yourself a time limit for ataxia to occur before responding to probable malfunction of the dart. White rhino characteristically show a reduction in speed, a shortened gait often dragging their feet, followed by high stepping gait, standing and sideways movement. Towards the end the head is held higher. As soon as ataxia is noticed, increase the following distance to avoid further stimulation and only intervene if the animals move to dangerous terrain. White rhino can be stopped during this phase by allowing them to step into a rope and securing it to one hind leg. This rope is tied to a vehicle or tree and the animal is stopped. A blindfold should be placed over the animal's eyes to reduce stimulation.

White rhino are often stopped by pressing against a tree or in a bush. It is the most likely phase for physical injury.

RECUMBENCY

The rhino can be assisted into recumbency by pulling on the rope on the hind foot or by pushing the body. Although they tolerate lateral recumbency, sternal recumbency is preferred with the exception of heavily pregnant females. The pressure from the foetus on the diaphragm may be elevated by sternal recumbency. Animals should not lie downhill, and any objects such as dangerous stumps or rocks should be removed.

The rhino should be blindfolded and earplugs inserted. Special care should be given to their position to especially avoid them lying on their back legs too long as this results in occlusion of the blood supply and later reluctancy to stand. It is good management to shift their weight from time to time during recumbency.

The dart wound should be treated immediately with an intra mammary antibiotic preparation. It is good practice to insert a Jelco into an ear vein to ensure a patent pathway into the bloodstream for emergencies. A saline or ringers lactate drip can be attached to the Jelco to ensure its patency.

MONITORING

It is important to keep good records of physiological parameters to build up data of acceptable limits. Parameters that are routinely monitored are:

Temperature:

This should not exceed 39°C and can be reduced by pouring copious amounts of water on the animals or by covering them with branches.

Respiration rate and depth:

White rhino are notoriously poor ventilators (as will be discussed). It is good practice to administer 10-15mg of Nalorphine I.V. immediately as this increase the rate and depth of respiration and has a positive effect on blood gas values. A primitive but good method to monitor this is to allow the blood to drip from the Jelco into the ear. As blood colour is directly correlated to oxygenation, one quickly learns to interpret this.

Routine oxygen supplementation to anaesthetized white rhino is now indicated. This supplementation is done via the endotracheal tube passed through the nose. It is attached via a demand valve to a cylinder or by allowing free flow into the nostril. Fifteen minutes of oxygen supplementation via an endotracheal tube increased the PO_2 level from 27% to 115% in one particular rhino. A dramatic colour change was also observed in the venous blood. (Personal unpublished data)

Initial respiration rates can be as low as 3-4 per minute but should increase to 8-12 per minute after the Nalorphine.

Pulse oxymeters have been attached to the ear or skinfolds of the vulva or prepuce in the rhino. Reflective probes can also be inserted into the nose, using the reading from the nasal septum.

Blood pressure:

As will be discussed, the opioids have a marked increase in rhino blood pressure. This can be monitored by direct line using the inner ear artery or by placing a cuff around the tail.

Mean Arterial Pressures of up to 200mm Hg have been routinely measured but are reduced after the administration of Nalorphine.

Struggling:

White rhino typically show muscle shivering, or rising of the front quarters. This can be reduced by supplementation with 10-15mg Demosedan or by administering a benzodiozepine such as Diazepam and Mederantil.

Signs of recovery:

It is difficult in rhino to monitor depth of anaesthesia. Ear movement, respiration rate and attempts to rise are some of the better indicators.

TOP-UPS

Should the anaesthesia be of long duration and top-ups needed, they are given via the Jelco in the ear vein. They should comprise of $^1/_4$-$^1/_3$ of the initial immobilization dosage in the same ratio. It is important to include them when calculating the antidote ratio. Be careful of boluses of ketamine on top of opioids as this may lead to extended apnoeic phases.

EMERGENCIES

Apnoea

This is especially apparent during the early part of the procedure. Steps to avoid/counteract this should be:

a. Insert Jelco.
b. Nalorphine in increments of 15mg I.V.
c. Dopram 10-20ml I.V. Although Dopram has the immediate effect of increasing respiration rate, alone it has very limited effect on blood gasses.

If there is still little reaction, abort the operation and administer the full antidote.

Low Blood Oxygenation

If the animal was suffering from an apnoea and treatment was administered as set out above, the blood oxygenation should also increase. However, further routine supplementation of O_2 is indicated. If in spite of the routine oxygen supplementation the blood gas values remain low, the flowrate of the oxygen should be increased and the Dopram dose repeated. A continuation of this problem should result in an abortion of the operation and administration of the full antidote.

Low Blood Pressure

This can be caused by decreased heart rate, decreased venous return or by excessive peripheral vasodilatation. Adrenalin is indicated at a doserate of

Hyperthermia

Cooling the animals down with copious amounts of water, covering them from the sun and allowing wind flow or waving of branches are the limited possibilities for counteracting this problem.

Water regurgitation

It sometimes happens that rhino recently drank water before darting and have water flowing from their mouths during anaesthesia. This may lead to inhalation and pneumonia and care should be taken that the head is held lower than the body and the nose is pointing downwards. This may also necessitate abortion of the operation.

Premature awakening

Fortunately, as a rule, white rhino do not suddenly awake but will show prior warning signs. Should the animal struggle to get up, a top-up dose is indicated.

REVERSAL

Under field conditions

Before reversal, ensure that all work is completed on the rhino and that all monitoring equipment has been removed from the immediate area. Move all persons and vehicles away and behind the rhino and make sure that the helicopter is ready to take off before administration of the antidote.

If the rhino has been in sternal recumbency for an extended period of time, roll it onto it's side for 5 minutes and massage the legs to ensure good bloodflow.

The antidote is administered via the Jelco in the ear vein and the ear plugs and blindfold are removed.

Move well clear and out of sight of the animal to allow it to awaken alone and calmly.

If a cow and a calf have been immobilized together, they should receive their antidotes simultaneously.

Walking a white rhino

It is often not possible to place the transport crate close to the recumbent animal due to habitat restrictions. Fortunately it is possible to walk a white rhino, (up to a few km's!) from the site of recumbency to more suitable terrain.

This is conducted by tying the middle of a rope around the rhino's blindfolded head. The two loose ends of *ca* 15m are laid out in front of the rhino and 4-5 men are placed on each rope to act as pullers.

A second rope of 10m is tied with a slip knot around one hind leg. This rope acts as a brake and 2-3 strong men should handle this rope.

The path in front should be discussed and cleared and 2 persons should walk ahead to remove loose branches and rocks that may jeopardize the walking rhino.

POST RECOVERY PHASE

Allow the rhino to wander off undisturbed. If possible the helicopter can be used to ensure that the cow and calf are brought together again. Animals reversed with diprenorphine or nalorphine alone will remain groggy for almost 24 hours. Naltrexone is the current reversal agent of choice for white rhino.

CONSIDERATIONS WHEN DARTING IN A BOMA

Avoid any loose objects in the bomas that may cause injury during the ataxic phase. Drain the water from the trough to prevent drowning.

Very low doserates of M99 (0,2-0,4mg) can be used and animals enticed to headpress against the fence. Most treatments and manipulations can be administered in this fashion.

DISCUSSION

Six white rhino darted with 2mg etorphine hydrochloride and30 mg fentanyl had a mean blood pressure of 183 ± 16 while six darted with 3mg etorphine and 25mg Azaperone had a mean arterial pressure of 141 ± 24.

A mean arterial pressure ranged between 280 and 210mm Hg after a white rhino *Diceros simum* was anaesthetized with 2,8mg of etorphine hydrochloride.

The high blood pressure is due to an increased activity of the sympathetic nervous system, as a six fold increase in norepinephrine levels was seen in horses anaesthetized with etorphine. This was also blocked by pretreatment with a ß adrenergic blocking agent propanolol.

Keep[8] reported that fentanyl alone will anaesthetize white rhino, but that large doses were required and that they remain sensitive to noise. The inclusion of fentanyl in the dart was due to its faster action, reducing down times and preventing the animals from running too far.

Hyoscine was included in the darts by Keep[8] to reduce the down time of the rhino and to facilitate loading. The effect of this drug was to dilute the pupils and impair vision, slowing the animal down. The author strongly believes that, with the successes obtained by using hyalase, the use of this compound is no longer indicated.

The use of Nalorphine in small doses in the dart has also been described in black rhino to counteract the depression caused by the opioids.

The technique of walking a rhino has also been described in black rhino.

Animals in winter months, in poor condition and heavily pregnant take longer to rise than when in good condition.

Keep[8] reported that it was ineffective to administer more antidote within two hours after the animal was reversed, but this is different if Naltrexone is used after reversal.

Heavy animals tend to compromise the arterial blood supply to the undermost muscles and their venous draining can be completely occluded. This will lead to an increase in lactate which can precipitate muscle spasms and reduce the blood flow even further, resulting in a vicious cycle. This may lead to difficulty in standing after a long recumbency, hence the suggestion of weight shifting and rolling to lateral recumbency prior to reversal.

During lateral recumbency in horses, the bloodflow to the ventral lung is slightly reduced due to vascular resistance. This maldistribution of bloodflow is directly correlated to body mass. However, the ventilation of the top lung is dramatically favoured. This leads to a ventilation to perfusion mismatch, which will contribute to the decreased blood oxygenation. Due to the physical characteristics of the lung, providing an interface between a gas and a liquid, the lung is not a homogenous unit and is more susceptible to gravitational influences. Therefore there is a linear reduction in the bloodflow from the bottom to the top of the lung. The top part of the lung will thus be ventilated but poorly perfused and will have no gas exchange and this dead space ventilation is equal to anatomically dead space.

Furthermore, there is a reduction in the functional residual capacity (FRC) of the lung under general anaesthesia, (this means the total volume of gas remaining in the lung after normal exhalation and thus the volume of gas available for gas exchange) contributing to the hypoxia. The reasons for the reduction in the FRC can be pulmonary congestion leading to a reduced alveolar space, a decrease in the elastic recoil of the lung resulting in a decrease of compliance, and the closure of small airways and atelectasis. These areas of atelectasis will thus be perfused but not ventilated, contributing to the V/Q mismatch.

A right to left pulmonary vascular shunt arises under anaesthesia that further contributes to the low blood oxygenation. These pathophysiological shunts are caused by alterations in ventilation, a reduction in ventilation of the lower portion of the lung, or actual collapse of the alveoli. The latter are probably caused by the reduction in the FRC, the absence of a periodic large breath, or abdominal contents which compress the diaphragm resulting in inadequate lung expansion. This closure of the small airways and alveolar collapse in the ventral portions of the lung shift the tidal volume further upwards, where the perfusion is even worse.

Alveolar ventilation is equal to the total ventilation minus the dead space ventilation. The dead space is made up of anatomical dead space in the conducting passages, while the physiological dead space is due to the ventilation to perfusion mismatch. As tidal volumes decrease in relationship to fixed anatomical dead space, alveolar ventilation will decrease, contributing to hypoxia and hypercapnia. It can be speculated that these conclusions are directly applicable to the white rhino.

Although the blood pressure in the rhino is high under etorphine anaesthesia, it may well be beneficial to the animal with hypoxia. If the perfusion is decreased with the persisting low PO_2 levels, it can be very dangerous. This places a question on high doses of adrenergic antagonists. On the other hand, a blood pressure over 200 mm Hg can result in rupture of small vasculature and oedema and bleeding in the lungs.

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