

Updates in African Rhinoceros Field Immobilization and Translocation

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Drugs for Field Immobilization

White Rhinoceros

In general, choose a dose that provides the lightest plane of anesthesia that is safe for completing the procedure. There are essentially two options for immobilizing white rhinoceros (*Ceratotherium simum*).

1. Potent Opioid + Sedative + Mixed Opioid Agonist-Antagonist (Table 98.1)

Intramuscular (IM) etorphine is combined with IM azaperone or midazolam, and the respiratory depressant effects of etorphine¹⁻³ are partially reversed with IM or intravenous (IV) diprenorphine or butorphanol.⁴⁻⁹ This option is currently used for most white rhinoceros field immobilizations, particularly if animals are in good condition and the terrain is challenging. Butorphanol is routinely administered at 10–20 mg per mg etorphine IV once the rhinoceros is recumbent. This improves blood gas values and thereby indirectly reduces muscle tremors.⁹⁻¹¹ Tracheal or intranasal oxygen supplementation in combination with butorphanol may improve hypoxemia.¹² When butorphanol is administered in the dart, the animal may stop but remain standing; this medication should be used only with experienced staff. Diprenorphine at 0.1–0.2 mg per mg etorphine IV⁸ may be given as an alternative to butorphanol after the animal is recumbent.

2. Mixed Opioid Agonist-Antagonist + Sedative (Table 98.2)

Combining IM butorphanol with either medetomidine or azaperone^{6,13} is a good alternative when immobilizing a compromised white rhinoceros. For adult white rhinoceros, 160 mg butorphanol + 10 mg medetomidine gives standing sedation in 6–8 minutes and recumbency at 12–15 minutes. The large volume of drugs may be a limiting factor with this combination. Standing animals can be pulled down with ropes, or 200–400 mg ketamine can be administered IV to induce recumbency. Reversal is achieved with administration of IV naltrexone and atipamezole.⁶ If the rhinoceros

needs to be “walked” (see explanation later), give 1 mg atipamezole per mg medetomidine IV. This combination with oxygen supplementation at 10 L/min usually results in good blood oxygen levels. For a deeper level of anesthesia, IV ketamine may be given.⁶

Newborn or very small calves may be adequately restrained with approximately 20 mg butorphanol IM. For older calves, use 0.1 mg etorphine IM for every month of age up to 1 year, combined with IM butorphanol at 10–20 times the etorphine dosage in milligrams. When darting cows and calves, the cow is darted first and the calf 2–3 minutes later, or once the cow is recumbent.

Black Rhinoceros

Etorphine is still the drug of choice at approximately 4 mg IM for an adult male or female black rhinoceros (*Diceros bicornis*) in good condition.¹⁴ Adults of the subspecies *D. bicornis bicornis* may need 5 or even 6 mg of IM etorphine.^{14,15} Younger animals are given a scaled-down dose according to their size, and, for animals in poor condition, be prepared to reduce the dose by 25% or more.

Thiafentanil is being used as an alternative in a 50:50 combination with etorphine IM or by itself.¹⁴ The dose is the same as etorphine, induction is slightly faster, and the animals are less inclined to stay on their feet. Muscle relaxation is generally good, but respiratory depression may be more profound.

Approximately 60 mg of IM azaperone is usually added to etorphine or thiafentanil for immobilizing an adult black rhinoceros, although doses as high as 200 mg may be used. Lower doses are preferred if the rhinoceros is to be translocated. IM midazolam is gaining favor as an alternative to azaperone at 20–40 mg for an adult (D. Grobler, personal communication, 2017). Alternatively, 100 mg xylazine IM for an adult is still being used.

Hyaluronidase (2500–7500 IU) added to the immobilizing mixture reduces the induction time by a minute or two, and this significantly reduces the risk in rugged terrain.^{14,15}

TABLE 98.1 Suggested Intramuscular Dosages When Using Etorphine and Butorphanol in Combination With a Sedative in White Rhinoceros (*Ceratotherium simum*)

Age	Etorphine (mg)*	Butorphanol (mg) (20× Etorphine Dose)
1 month	—	20
3 month	0.2	4
6 month	0.5	10
1 year	1	20
2 year	2	40
3 year	3	60
4 year	4	80
Adult	4.5	90
Large Adult	5–6	100

*Use etorphine and butorphanol (butorphanol either in dart or intravenously once the animal is down) in combination with one of the sedatives listed below (midazolam or azaperone preferred):

Age	Midazolam (mg) (10 × Etorphine Dose)	Azaperone (mg)	Detomidine (mg)	Medetomidine (mg)
1 month	—	—	—	—
3 month	2	8	0.6	0.5
6 month	5	15	1.25	1
1 year	10	20	2.5	2
2 year	20	40	5	4
3 year	30	50	7	6
4 year	40	60	8	8
Adult	45	60	10	9
Large Adult	50	60	12	10

TABLE 98.2 Suggested Intramuscular Dosages When Using Butorphanol in Combination With a Sedative in White Rhinoceros (*Ceratotherium simum*)

Age	Butorphanol (mg)*	Medetomidine (mg) OR	Midazolam (mg) OR	Azaperone (mg)
1 year	35	2	10	20
2 years	70	4	20	30
3 years	110	6	30	40
4 years	140	8	40	50
Adult	160	10	45	60
Large adult	180	12	50	80

*Use butorphanol and medetomidine, midazolam OR azaperone. Medetomidine is the sedative of choice because it may be easily reversed.

Managing an Immobilized Rhinoceros

Time Use and Priorities

The first priority is to stabilize an immobilized rhinoceros quickly, and the first 5 minutes after induction are of

particular importance. The most important considerations are ensuring there is a patent airway, the animal is breathing and blood oxygenation is adequate, there is adequate blood flow to the muscles of the legs, and the body temperature is not excessively elevated (Table 98.3).²

TABLE 98.3 Cardiopulmonary Parameters in Resting Non-Immobilized, Captive Healthy White Rhinoceros (*Ceratotherium simum*)

Parameter	Mean ± SD	Range
Heart rate (beats/min)	39 ± 0.8	32–42
Respiration rate (breaths/min)	19 ± 0.6	16–23
Rectal temperature (°C)	36.8 ± 0.1	36.6–37.2
Corrected Indirect systolic pressure (mm Hg)	160 ± 2.9	146–183
Corrected Indirect diastolic pressure (mm Hg)	104 ± 0.7	88–117
Corrected Indirect mean pressure (mm Hg)	124 ± 2.2	108–135
S _a O ₂ (%)	97.2 ± 0.1	96.6–98
Arterial pH	7.391 ± 0.007	7.346–7.431
ETCO ₂ (mm Hg)	45.1 ± 0.7	41.7–48
P _a O ₂ (mm Hg)	98.2 ± 1.4	90.2–108.6
P _a CO ₂ (mm Hg)	49 ± 0.9	44.4–53.7
Base excess (mmol/L)	3.5 ± 0.4	1.9–5.9
HCO ₃ ⁻ (mmol/L)	29.3 ± 0.4	27.3–32.2

From Citino SB, Bush M: Reference cardiopulmonary physiologic parameters for standing, unrestrained white rhinoceros. *J Zoo Wildl Med* 38(3), 375–379, 2007.

Body Position and Blood Circulation to the Limbs

A rhinoceros in sternal position has better blood oxygenation,¹⁰ but the lateral position supports improved circulation to the leg muscles, is better for cooling, gives access to the udder, penis, and prepuce, and allows oral examination. Whatever the position, make sure both nostrils are patent and any fluid can freely run out of the mouth and nose. Depending on the circumstances, decide the best position for the animal and be prepared to pump the animal's legs every 15 minutes to assist circulation, especially before walking a rhinoceros into a crate.¹⁴

Monitoring Breathing and Response to Hypoxemia and Apnea

Respiratory depression is the biggest challenge and should be the main focus of patient monitoring.^{10,12,16} A rate of 6–12 breaths/min should be the aim, but slower breathing (4–6 per minute) if deep and regular may be sufficient. Oxygen saturation (SpO₂) levels should be monitored. A pulse oximeter¹⁷ is an essential tool for rhinoceros immobilization; an SpO₂ greater than 80% is usually adequate for short procedures, with levels greater than 90% ideal. The value of a pulse oximeter lies in observing trends, and readings must be evaluated in conjunction with the rate and depth of breathing, arterial blood color, heart rate, and blood pressure. Clip-on or reflectance sensors can be applied to the ear (after both sides have been scraped with a

blade), anus, vulva, prepuce, nasal mucosa, eyelid, nictitating membrane, buccal mucosa, and tongue.¹⁴

Using oxygen in the field is currently standard practice, and, when given intranasally, it rapidly improves blood oxygen levels in both species. In white rhinoceros, it is most effective when given together with butorphanol and/or diprenorphine. It is of particular value in animals that have undergone marked exertion and also in females that are heavily pregnant and in animals that are compromised or in poor condition. It is usually given at approximately 10–15 L/min, although higher flow rates may be initially indicated.

White Rhinoceros

If breathing is unsatisfactory, partially reverse with 40 mg butorphanol and/or 1.2 mg diprenorphine IV; this may be repeated, but the animal may attempt to stand.

Black Rhinoceros

If ventilation is depressed, administer 5 mg butorphanol IV immediately; this may be combined with 100–200 mg of IV doxapram. Some veterinarians give 2.5 mg butorphanol IV when they get to the rhinoceros and another 2.5 mg IM. Butorphanol should be administered with caution because black rhinoceros may stand suddenly if given too much butorphanol.

For both species, if breathing stops, immediately inject IV diprenorphine or naltrexone at calculated reversal dose, put the rhinoceros in lateral recumbency, and apply pressure to the abdomen, using your knee, to compress abdominal

contents and shift the diaphragm forward. Reversal drugs may be repeated until breathing resumes and the animal recovers from anesthesia.

Muscle Tremors

Muscle tremors are rarely a problem in black rhinoceros but are frequently very marked in white rhinoceros,² particularly if they are in the lateral position. Apart from being caused indirectly by hypoxemia and acidosis,¹¹ tremors also increase oxygen consumption and heat generation,⁷ which requires immediate intervention by giving butorphanol and/or low-dose diprenorphine and oxygen.

Monitoring Heart Rate and Blood Pressure

Hypoxemia is associated with a sympathetic response that increases the heart rate. Etorphine also causes hypertension and tachycardia in rhinoceros. Azaperone results in lower blood pressure when combined with etorphine.⁷ Butorphanol and/or low-dose diprenorphine administration lowers heart rate, especially if combined with supplemental oxygen to counteract hypoxemia.^{3,7}

Hyperthermia

To prevent hyperthermia, try to immobilize rhinoceros when ambient temperatures are less than 25°C. Aim for a quick induction and minimize exertion. Once the rhinoceros is recumbent, provide shade with a large beach umbrella and douse with copious cool water, using a handheld sprayer and leaf blower for evaporative cooling of the animal. A thermoimaging camera is valuable to indicate the hotter parts of the animal to focus cooling efforts. Never put a wet rhinoceros in a closed crate in hot, humid conditions without air flow, because heat stroke and shock may occur quickly.

The normal resting values for white rhinoceroses are given in Table 98.3.¹⁶

“Walking” a Rhinoceros

Rhinoceros must be securely blindfolded and have their ears plugged and a rope attached to the head and also to one of the hind legs to be used as a brake (Fig. 98.1). Eight people are typically needed to “walk” a rhinoceros, with two (or three in the case of a white rhinoceros) supporting the animal on either side and two on each of the ropes.¹⁴

White Rhinoceros

For animals that only need to be loaded for translocation, it is ideal to keep them standing after placing the blindfold, so they may be guided directly into a crate. If you need to walk a white rhinoceros, do not use more than 20–40 mg azaperone in the immobilizing mixture and avoid α_2 agonists. If a rhinoceros has received butorphanol at 20 mg



• Figure 98.1 “Walking” a white rhinoceros (*Ceratotherium simum*).

per mg of etorphine, it may usually be stimulated to stand and walk by prodding; if unsuccessful, incremental doses of diprenorphine (1 mg IV) may be administered. Alternatively, if immobilized with etorphine and azaperone, give 10% of the standard diprenorphine reversal dose (1.2 mg for adults) IV immediately after the animal becomes recumbent, to facilitate walking the rhinoceros (D. Cooper, personal communication, 2016). This approach results in a slightly more alert animal, making walking easier, especially uphill. If α_2 agonists have been used for immobilization, give incremental doses of atipamezole IV, starting at 1 mg for every 1 mg medetomidine; keeping in mind that at 5:1, the effects of medetomidine will be fully reversed.

Black Rhinoceros

First roll the animal on its side for a minute or two and pump the legs; then put the rhinoceros into sternal recumbency, and administer 5 mg butorphanol IV. Wait 2–5 minutes for the drug to have an effect and then stimulate the rhinoceros by rocking it or using a prod. If the rhinoceros does not stand up, give an additional 5 mg butorphanol IV and wait 2–5 minutes before stimulating again. Ten milligrams butorphanol is usually sufficient, but as much as 20 mg may be needed. Black rhinoceros that have been immobilized with a 50:50 mix of etorphine and thiafentanil may also be walked with similar doses of IV butorphanol. As with white rhinoceros, keep the dose of azaperone low if you plan to walk a black rhinoceros or alternatively use midazolam.

Nalorphine is still used to walk black rhinoceros at 10–20 mg IV instead of butorphanol, and some people are comfortable walking black rhinoceros with a very low dose of diprenorphine 0.25–0.4 mg IV.

Reversal of Immobilization

White Rhinoceros

For full reversal in the field, use IV naltrexone at 20–30 times the etorphine dose in milligrams; if medetomidine has

been used, use IV atipamezole at 5 times the medetomidine dose. Diprenorphine will not result in complete reversal in white rhinoceros and should not be used.

Black Rhinoceros

Use either IM or IV naltrexone at 20–30 times or diprenorphine IV at 2.4 times the etorphine dose.

Transporting Rhinoceros

Airlifting Rhinoceros

It is now accepted practice to airlift immobilized black and white rhinoceros by their feet out of inaccessible terrain (Fig. 98.2). They may hang safely for up to 30 minutes. Once the rhinoceros is stable, it is blindfolded and earplugs are inserted. Endless round soft polyester slings (strength of 2000 kg) are attached to each foot, and the other ends are brought together in a D-shackle, which is then hooked to a 20-m slinging chain attached to a helicopter's cargo hook. The helicopter slowly lifts the rhinoceros, and a person on the ground checks that the slings are correctly positioned before the helicopter flies off. Great care is needed when the rhinoceros is placed back on the ground, and a firm mattress may be positioned under the rhinoceros' spine as it descends.² In the case of white rhinoceros the equipment is the same, except a strap is used to support the head. The head strap is attached to hold the head horizontally or angle it slightly downward to allow any fluid to drain out (D. Cooper, personal communication, 2017).



• **Figure 98.2** A black rhinoceros (*Diceros bicornis*) being airlifted by helicopter. (Photo credit: H.O. Reuter.)

Transporting by Vehicle

White Rhinoceros

After the rhinoceros is in the transport crate, etorphine is partially reversed using diprenorphine IV at 2–3 times the etorphine dose in milligrams. This keeps the animal partially sedated. If used in the immobilizing combination, α_2 agonist drugs may be partially reversed, if required, by giving a lower ratio atipamezole to effect, starting with 1 mg atipamezole IV to 5 mg medetomidine.

For short distances, 80 mg zuclopenthixol IM provides adequate tranquilization. Thereafter, azaperone at 80–120 mg IM for adults may be used every 3–4 hours as needed. For long trips, or if post-offloading sedation is important, 100–150 mg zuclopenthixol IM may be used for adults. At higher dosages, rhinoceros will be heavily sedated and lie down frequently.

Rhinoceros should be transported facing toward the rear. Do not allow the rhinoceros to lie down during transport for more than 30 minutes at a time, particularly very large animals. The circulation to leg muscles may be restricted, resulting in irreversible muscle damage.

When using recommended drug combinations, head pressing is seldom a problem in white rhinoceros. A metal plate rising at an angle from the floor of the crate in front of the feet of the rhinoceros to the level of the shoulder may be used to prevent rhinoceros with long horns from leaning against the horn, which often results in horn loss. If head pressing is a problem, 3–5 mg naltrexone IM may be helpful if sufficient sedation has been given. It may be repeated after a few hours if required.

Black Rhinoceros

It is very challenging to transport black rhinoceros. If not adequately sedated, they traumatize themselves in the crate, and, if too heavily sedated, they injure themselves by straining against the front of the crate or by collapsing in an unnatural position. An experienced veterinarian should always travel with black rhinoceros, observe them frequently, and maintain the appropriate level of sedation.

Except when rhinoceros are moved very long distances between countries, almost all translocated black rhinoceros are currently immobilized in the field, transported to the new area, and released back into the field within 24 hours. The results are generally good, provided the immobilization is relatively stress free, animals are kept adequately sedated during the trip (stopping as little as possible), and they are released quietly into an area where there is adequate browse and sufficient water.

The challenge is to keep them adequately sedated for the length of transport, and the best option at this stage is to only partially antagonize etorphine with diprenorphine and/or butorphanol. The result is improved by also administering a short-acting tranquilizer or sedative (azaperone, diazepam, or midazolam) and the long-acting phenothiazine tranquilizer, zuclopenthixol acetate. In addition, a

blindfold and earplugs may be very effectively used to keep a rhinoceros calm, and a blindfold makes it easier to quietly inject a rhinoceros in a crate. Adult black rhinoceros bulls are particularly challenging. Two techniques are currently used:

1. Give 100–250 mg of the long-acting tranquilizer zuclopenthixol IM and then walk into the crate with IV butorphanol given at 20 mg per mg of etorphine or thiafentanil used in the immobilizing dose. 1,2 mg diprenorphine is usually added to the butorphanol to prevent pushing and head-pressing; this is sometimes necessary to repeat (IM or IV) after about 10 minutes if the animal continues to push. Additional tranquilization on the road is usually 20 mg midazolam IM or 60–100 mg azaperone IM, and later a low dose of etorphine (0.1–0.2 mg IM) might be necessary. Long transports have been accomplished using this technique with the rhinoceros sleeping much of the way. Some people prefer to give as much as 60–80 mg butorphanol for an adult black rhinoceros, but head pressing may be a problem and additional diprenorphine (0.3–0.6 mg IV or IM) might be necessary to alleviate this. Additional tranquilization on the road is usually 20 mg midazolam IM or 20 mg butorphanol IM/IV or 60–100 mg azaperone IM.
2. The alternative technique is to apply a cloth blindfold tightly to the head of the rhinoceros² and plug the ears with cotton wool, and then walk the rhinoceros into the crate, with 1.2–1.8 mg diprenorphine IV. The animal will be quite awake with this dose of diprenorphine, but because it cannot see, it will stand calmly in the crate. Midazolam or diazepam (10–15 mg IV) injected 10 minutes before waking up may also improve the quality and duration of the sedation. If the rhinoceros struggles to stand in the crate, it may be stimulated by removing the earplugs or by prodding it on the forehead after waiting 60 seconds after drug injection. An additional dose of diprenorphine (0.2–0.5 mg IV) may be used if needed to reverse sedation. After approximately 4 hours, the effects of the immobilizing dose of etorphine will start to wear off and 60 mg azaperone and a very low dose of etorphine (0.05–0.1 mg) may be administered IM every 2 hours as needed to maintain sedation. The rhinoceros should be closely monitored, and if there is a lot of ear movement, indicating that it is lightly sedated, then more azaperone and etorphine is administered. A good response is generally seen within 10 minutes.

Transporting Orphan Calves

Calves are immobilized with a low dose of IM etorphine and azaperone depending on size, age, and condition, and then partially reversed with 1–2 mg butorphanol IV until stable. Place a blindfold (a bra works well) and plug the ears with cotton wool and tape them closed. Monitor small calves during transport using a pulse oximeter on the tongue or

lip, because depth and rate of respiration are hard to see in a moving vehicle. If dehydrated, administer polyionic fluids and dextrose and then use 1–2 mg of midazolam IM or IV to transport, repeating the dose if necessary. Ideally, plan to have the midazolam wearing off (approximately 1 hour from last injection) on arrival at the orphanage. Attempt to bottle-feed the calf immediately on arrival, while in the vehicle or crate, before reversing with IM or IV naltrexone and removing blindfold and earplugs. This technique may save hours of struggling and works well for both black and white rhinoceros calves as young as 2–3 weeks (M. Toft, personal communication, 2017).

Off-loading

White Rhinoceros

When off-loading or waking up a white rhinoceros in the field, use IV naltrexone at 20–30 times the etorphine dose in milligrams. Before reversal, remove all vehicles and personnel. In the case of a cow and calf, put the calf right next to the mother, facing the female. Reverse the calf first and then the mother. Retreat quietly and monitor to ensure they do not get separated.

Black Rhinoceros

They are much calmer at night; therefore arrange off-loading when it is dark, if feasible. Lights are unnecessary and usually confuse the animal when used. A red headlamp works very well. If dark and the rhinoceros is heavily sedated, put the crate on the ground; then remove vehicles and administer diprenorphine or naltrexone IM and immediately open the door.

During the day when a black rhinoceros is released from a crate, it will inevitably attack the crate and any vehicles in the vicinity and risk seriously injuring itself. To prevent this, one may either:

1. Inject the rhinoceros in the crate with an immobilizing dose of etorphine and azaperone. When it is about to collapse, open the front door of the crate and hold the rhinoceros with ropes (either attached to the hind foot and/or put across its chest) until it falls. Alternatively, let the rhinoceros become recumbent in the crate and then pull it out. If this option is used, a rubber mat on the floor of the crate makes it much easier to pull out the rhinoceros (J. Joubert, personal communication, 2017). The crate, vehicles, and people must all be removed from the area before the rhinoceros is reversed with IM/IV diprenorphine or naltrexone. Some people rub the animal's muzzle with its own dung and leave some of the dung close to the head before waking up (M. Toft, personal communication, 2017). This is also the technique used for releasing a cow and calf combination both in the day and night. Place the immobilized calf close behind the cow and wake them up with naltrexone or diprenorphine IM.

- Alternatively, inject a low dose of etorphine (0.3–0.5 mg for an adult) IM and wait until the rhinoceros is heavily affected; then inject a full dose of diprenorphine or naltrexone IM and immediately open the crate door. The rhinoceros will wander off before the antidote antagonizes the etorphine.

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