POST-MORTEM PROTOCOL

Minimally, it is vital that frozen liver, kidney, fat, skeletal muscle, heart and spleen be saved after death. Frozen gut contents should be saved in cases of suspected toxicosis. If a death is anticipated, veterinary coordinators and researchers should be contacted for updated tissue requests. (See inside the back cover for the names and addresses of pathology coordinators.)

RESTRAINT AND ANESTHESIA

Evan Blumer,VMD

Intensive management of rhinos in captivity necessitates occasional procedures that require restraint of the animal for physical examination, sample collection or medical treatment. The unique anatomy, physiology and temperament of rhinos present many challenges to physical or chemical restraint. However, a number of techniques and facilities have been developed that provide safe options for handling these species. Following is a summary of approaches used by managers both in captivity and in the field. It should be noted that significant variation exists among individual rhinos with respect to the methods outlined below. The following should be used as a guideline only.

PHYSICAL RESTRAINT

A number of approaches to the physical restraint of rhinos have been attempted in recent years.

Box stall/Free stall

A basic box stall is the simplest and often the most effective method for minor restraint of rhinos. Visual inspections and minor physical procedures can be performed with animals in these facilities, and certain individuals can be conditioned to accept more manipulative procedures, such as reproductive examinations and blood sampling. Many institutions have incorporated a box stall within a transfer alley by adding additional gates (at the head and tail) to complete the stall. Several institutions have incorporated a box stall in the corner of a holding pen. The animals are regularly fed inside the stall, and a rear gate can be closed if and when it is considered necessary.

Several principles should be applied in the construction of a box stall. These principles should also be considered when constructing any of the other types of physical restraint devices discussed below.

- The height at the front of the stall should be great enough that the rhinoceros cannot place its chin over the top. If the chin can be placed over the top, the animal may attempt to climb out the front of the stall using its chin for leverage. Additionally, horizontal bars should be avoided in the construction of the front of the stall, as they may provide a step for the animal, which facilitates attempts to climb out the front of the stall and may increase the animal's likelihood of breaking a horn. For these reasons, this author recommends that either smooth surfaces or vertical structures (e.g., steel pipe) be used in the construction of the front portions of a box stall.
- If reproductive examinations and/or rectal palpation procedures will be conducted

A free-stall chute that is incorporated into an enclosure can be particularly effective for relatively non-invasive procedures. Note how the angled entry and safety pipes allow a veterinarian or researcher access to the rear of the animal without the possibility of the animal's backing straight out. (*Photo: Fossil Rim Wildlife Center*)

in the stall, close attention should be paid to the construction of the rear portion of the box stall. Most managers believe that a series of removable vertical structures provide both adequate safety and access to the animal.

- Regardless of the specific design or placement of a rhinoceros restraint device, the most critical factor in the success of physical restraint procedures is conditioning of the animals to a restraint. Whenever possible, placement of a restraint device should be such that it can be incorporated into the daily routine of the animals.

Several other basic designs have been developed for more complete physical restraint of rhinos.

Head/Shoulder Gates

Several institutions have attempted the development of a head/shoulder gate system that further restricts the movement of the animal. This approach consists of an elongated box stall with the addition of a mechanism to restrict forward motion. These mechanisms generally consist of vertical bars that are moved in from the sides or a "yoke" that is lowered from above and fits along the side of the neck in front of the shoulders. Difficulties with this approach generally include problems with the placement of the head/shoulder restraint with animals of varying sizes and a tendency of some individuals to "fight" the head/shoulder restraint.

Restraint Chutes

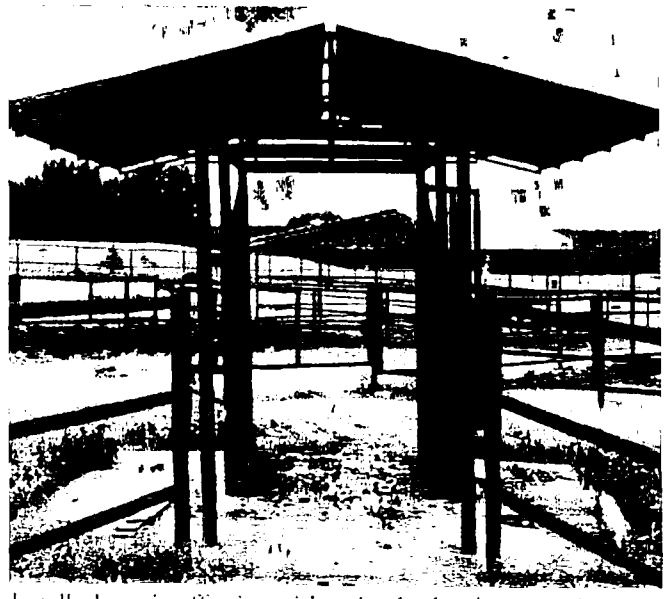
A number of institutions have developed mechanical "squeeze chutes" to further the physical restraint of rhinos. In this design, one or more of the walls are mobile and can be moved to further restrict the area in which the rhino is held. The basic differences between the designs are whether the chutes are adjustable laterally, longitudinally or both and whether the drive mechanism is manual, pneumatic/hydrolic or motor driven. From this author's experiences, the most successful approach to "squeezing" a rhinoceros is to provide a narrow area to prevent lateral movement and to "squeeze" the animal longitudinally from the rear. Methods of powering the drive mechanism are primarily a matter of personal or institutional choice; however, it should be noted that the "squeeze mechanism" should function to restrict the motion of the rhinoceros as opposed to forceably restraining it.

CHEMICAL RESTRAINT

In situations in which the physical restraint of rhinos is not possible or practical, a number of options exist for their restraint through chemical means. Many of the drug regimens outlined below may be used for varying levels of tranquilization (from mild sedation to full anesthesia). Specific decisions as to which regimen is most appropriate must be based on clinical experience, drug availability and the specifics of the case.

Several principles should be followed to increase the safety of chemical restraint procedures for both the animals and personnel:

- When applicable, antagonists to the restraint drugs should be prepared prior to the initiation of the procedure and should be available for rapid administration.
- Careful monitoring of the patient (auscultation, ECG, pulse-oximetry, etc.) will help to rapidly identify problems should they develop and allow early intervention.
- The large size of an adult rhinoceros may result in further complications during anesthetic procedures. Efforts should be made to maintain the animal in sternal



A closed-stall chute is effective with animals that have not been conditioned, although acclimating the animal to the chute is recommended. Both back and front gates in a closed chute design can restrict the rhino's movement by sliding forward. (*Photo: Fossil Rim Wildlife Center*)

recumbency when possible to minimize respiratory complications, and if the procedure is to last more than 30 min, efforts should be made to "pad" the area under the animal (with mattresses, inflated innertubes, straw/hay bedding, etc.) to minimize the effects of pressure on the limbs.

Etorphine

Etorphine (M-99) remains the "drug of choice" for a wide range of restraint procedures with rhinos. The particular sensitivity of rhinos to narcotics results in the ability to induce effects ranging from mild sedation and "standing restraint" to surgical anesthesia. Recently, etorphine has not been available for purchase in North America; however, a new manufacturer is awaiting Food and Drug Administration approval and expects to have a product available for shipment soon.

The particular effect of etorphine varies with the dose, and a desired level of restraint can often be achieved by carefully titrating the dose. Table 19 lists dose ranges for etorphine for the three most common rhinoceros species.

Several additional drugs are often used in conjunction with etorphine to moderate its pharmacological effects. Xylazine or detomidine is often used to improve muscular relaxation during anesthesia (See below.), and hyaluronidase has been used to increase the rate of absorption of the drug following intramuscular injection.

Antagonism of the effects of etorphine can be accomplished through the use of diprenorphine (2 to 3X etorphine dose), naloxone (100X etorphine dose) or naltrexone (50 to 100X etorphine dose). It should be noted that rhinos seem to be particularly sensitive to recycling or "renarcotization" following etorphine anesthesia and antagonism with diprenorphine. This problem seems less likely to occur if naltrexone is used as the antagonist.

Nalorphine

Nalorphine, an additional narcotic antagonist, has been used extensively in both Africa and Europe to moderate the effects of narcotic anesthesia in rhinos. In many cases, especially when elevated narcotic dosages are used to achieve rapid restraint (as in field-capture operations), respiratory suppression may be pronounced. Administration of nalorphine results in an increase in the rate and depth of respiration, increased blood pressure and, depending on the dose, an elevation of the plane of anesthesia. Recent work (Allen & Kock, pers. comm.) has demonstrated that administration of small amounts (10.0 to 15.0 mg IV) of nalorphine leads to a dramatic increase in the rate of oxygen saturation (PO_2) in anesthetized rhinos without significant arousal.

Carfentanil

With the recent unavailability of etorphine, several institutions have begun to experiment with carfentanil as an alternative anesthetic agent. Successful anesthesia has been achieved in black rhinos using 0.9 to 1.2 mg (total dose/adult animal), and in white rhinos using 1.0 to 1.5 mg (total dose/adult animal). As of the time of this writing, carfentanil has not been used to anesthetize a greater one-horned rhinoceros. Most experienced veterinarians believe that carfentanil should be effective in this species at dosages similar to those for white rhinos.

Very few attempts have been made to use carfentanil for standing restraint in rhinos. Although it should be effective for this purpose, the rapid induction seen with carfentanil

TABLE 19. Dose ranges for etorphine anesthesia

Species	Standing Restraint	Full Recumbancy
White rhino	0.5 - 1.0 mg total dose	2.0 - 4.0 mg total dose
Black rhino	0.25 - 0.75 mg total dose	1.0 - 3.0 mg total dose
Greater one-horned rhino	0.5 - 1.0 mg total dose	2.0 - 4.0 mg total dose

Dose ranges listed above are for adult animals in a captive situation. Exact dosage should be determined based on the size of the individual and the conditions in which the procedure is performed.

(when compared to etorphine) may limit the "window" before the animal may become recumbent. At this time, the best dosage recommendation for standing restraint is 25% of the dose used to achieve full recumbency.

Antagonism of the effects of carfentanil can best be achieved with naltrexone at a dosage rate of 100 to 200X the carfentanil dose.

Xylazine and Detomidine

Xylazine (Rompun) and detomidine (Dormosedan) have been used frequently as additions to etorphine and carfentanil anesthetic protocols and independently for more minor chemical restraint. As an addition to narcotic anesthetics, they improve muscle relaxation and may have a synergistic effect that reduces the induction time. Typically, 100 to 150 mg of xylazine or 10 to 15 mg of detomidine is administered per adult rhino either as a pre-medication (15 to 20 min prior to narcotic administration) or mixed as a "cocktail" with the narcotic of choice. Additionally, these drugs may be used alone to achieve mild to moderate sedation or to relieve pain. Dosages of these drugs when used independently must be based on clinical assessment but generally are 2 to 3X those listed above for use with narcotic anesthetics.

Both xylazine and detomidine have depressant effects on heart rate, respiratory rate and blood pressure, and careful monitoring is essential to ensure patient safety. The antagonist yohimbine may be administered (0.1 mg/kg) to counteract the effects of xylazine; however, yohimbine is only marginally effective as an antagonist to detomidine. Although it is not yet widely available in the United States, the antagonist atipamazole is effective with both xylazine and detomidine.

Butorphanol + Detomidine

In recent months, due to the continued unavailability of etorphine, several institutions have begun to use a combination of butorphanol and detomidine to achieve standing restraint in several rhinoceros species. Although a relatively small number of these procedures have been performed, Table 20 lists dosages recommended as "starting points."

Neuroleptics

Several neuroleptic drugs have been used to reduce anxiety and stress during transport and handling procedures. These drugs have the advantage of calming the animal without significant sedation. Azaperone has been used frequently, but dosages vary widely. Use of haloperidol has been reported for only one individual. In that case severe excitation was noted; however, the individual was later diagnosed with a serious neurological disease (encephalomalacia), and the deleterious effects appear to have been unrelated to the administration of haloperidol. Based on its efficacy and safety in a wide range of other species and the successful use of related compounds in rhinos, further investigation into the use of haloperidol for rhinos is warranted.

Long-acting Neuroleptics (LANs)

Several LANs have been used extensively on rhinos in Africa and Europe. Zuclopenthixol acetate (Clopixol - Acuphase) is effective for 2 to 3 days, and perphenazine enanthate (Trilafon) is effective for 5 to 7 days. Unfortunately, these compounds are not readily available in the United States at this time.

TABLE 20. Dose range for combination butorphanol and detomidine anesthesia

Type	Drugs	Comments
Standing sedation	150 mcg/kg butorphanol + 30 mcg/kg detomidine	Sufficient for blood collection, physical exam and minor manipulations
Full recumbancy	300 mcg/kg butorphanol + 60 mcg/kg detomidine	Produces bradycardia and hypoxemia. Treat hypoxemia with 100% oxygen via nasal catheter. Bradycardia has not proven to be clinically significant.
Antagonism	500 mcg/kg naltrexone + 300 mcg/kg yohimbine	Administer IV; effects abolished in 1 to 2 min

Note: Drugs 1 and 2 are given in combination. Further information on this anesthetic protocol may be obtained from Dr. Pat Morris, Associate Veterinarian, San Diego Zoo.

Additional Information

For additional information, please refer to the following references: Kock & Morkel, 1993; Kock & Garnier, 1991; and Rogers, 1993.

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