

MURRAY E. FOWLER, D.V.M.

Professor Emeritus, Zoological Medicine
School of Veterinary Medicine
University of California at Davis
Davis, California

R. ERIC MILLER, D.V.M.

Director of Animal Health and Conservation
Saint Louis Zoo, Forest Park
St. Louis, Missouri

ZOO & WILD ANIMAL MEDICINE

Current Therapy

4

W.B. SAUNDERS COMPANY

A Division of Harcourt Brace & Company

Philadelphia London Toronto Montreal Sydney Tokyo

Anesthesia of White Rhinoceroses

J. P. RAATH

White rhinoceroses (*Ceratotherium simum*) are routinely anesthetized for marking, sample collection, translocation, and treatments.

Anesthesia of white rhinoceroses is complicated by their sensitivity to opioids; reactions include hypertension, severe respiratory depression under anesthesia, and peculiar anatomic features. As each individual animal becomes more valuable, the need for further research and refining the anesthetic process becomes more important.

THE PLANNING PHASE

Ninety percent of the anesthesia effort should go into the planning phase of the procedure. Risks incurred once a rhinoceros has been darted can be minimized by good planning. A standard checklist should include drug delivery systems, anesthetic combinations, additional drugs and emergency treatments, antidotes, general equipment, and animal monitoring equipment.

Drug Delivery Systems

To ensure deep intramuscular (IM) deposition of the drugs, it is preferable to have a robust darting system in which the drug is discharged only when the collar of the dart hits the skin. The Palmer Cap Chur powder-charged darts and the Kruger National Park (KNP) aluminum acetic acid/bicarbonate darts (see Chapter 76) are effective systems. Air-powered rifles such as the

Tel-Inject or Dan-Inject systems with long needles have also been used successfully and are preferable for darting rhinoceroses in confinement. A push rod for removing darts from the barrel should be included if a rhinoceros to be darted is a different size from the one originally intended. Enough darts for the number of animals to be anesthetized, as well as extras for supplement or antidote, should be taken.

Strong needles 50 to 75 mm in length and 2 mm 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 of the lumen to avoid the formation of a skin plug. A bead or collar on the needle is sufficient to prevent the darts from falling out.

Anesthetic Combinations

Many drug combinations have been used successfully in the anesthesia of white rhinoceroses. Many of the earlier drug combinations such as diethylthiambutene hydrochloride (Themalon) and 1-(1-phenylcyclohexyl)-piperidine hydrochloride (Sernyl) and scopolamine are no longer used. Drug combinations used by the Natal Parks Board of South Africa's combinations are listed in Table 81-1, and those used by the Kruger National Park (KNP) are listed in Table 81-2.

The most important goal during field anesthesia is to obtain recumbency in the shortest possible time.

Keep (1971) of the Natal Parks Board reported that although fentanyl (Janssen Pharmaceuticals) alone will anesthetize white rhinoceroses, large doses were re-

TABLE 81-1. Natal Parks Board, South Africa, Anesthetic Combinations for White Rhinoceroses

Age Group	Etorphine (mg)	Fentanyl (mg)	Hyoscine (mg)	Azaperone (mg)
Adults	3-4	—	25	—
	1-2	30	—	50-80
	3-4	—	—	50-80
Subadults	2	—	12	—
	0.5	20	—	30-40
	2	—	—	30-40
Juveniles	1	—	12	—
	0.25	12	—	15-20
	1	—	—	15-20

TABLE 81-2. Kruger National Park, South Africa, Anesthetic Combinations for White Rhinoceroses

Age Group	Etorphine (mg)	Carfentanil (mg)	Azaperone (mg)	Hyaluronidase (IU)
Adult males	5	4	50	7500
Adult females	4	3	35	7500
Subadults	3	2	20	5000
Juveniles	1.5	1	15	5000
Calves	0.5	0.5	10	3000

quired and the animals remain sensitive to noise.⁸ Fentanyl was used in combination with etorphine because of fentanyl's faster action in reducing down times and preventing the animals from running too far.

In one regimen, hyoscine, a parasympatholytic drug, was included in the darts to induce temporary blindness by causing pupil dilation, with the purpose of stopping the animal sooner under free-ranging conditions. As the combinations used in Table 81-2 stop the rhinoceros in less than 4 minutes, the author does not support this practice, considering the deleterious side effects of parasympatholytic drugs.

Carfentanil (Janssen Pharmaceuticals) has been found to be slightly more potent than etorphine hydrochloride (M99, C-Vet), hence the lower dose rates.

The use of nalorphine (Lethidrone) in small doses in the dart has also been described in black rhinoceroses to counteract the respiratory depression caused by the opioids.

Xylazine (Rompun) has been used for white rhinoceros sedation and anesthesia. Dose rates of 0.48 mg/kg in combination with etorphine are suggested for free-ranging white rhinoceroses, but reluctance to stand after administration of the antidote has been noted. Excellent results have been obtained with xylazine alone at 0.25 to 0.50 mg/kg for the sedation of rhinoceroses in pens.

Under hospital or clinic conditions, rhinoceros anesthesia can be maintained with 2% isoflurane in 100% oxygen at a flow rate of 10 L per minute. For this purpose, an endotracheal tube with an inflatable cuff has to be passed, allowing an effective seal.

Additional Drugs and Emergency Treatments

All additional drugs, such as emergency drugs—for example, respiratory stimulants (Doxapram), antidotes, and antibiotics—as well as vitamin combinations and tranquilizers, must be ready and checked before darting commences. Provisions must include a complete kit to treat accidental human injection with opioids.

Antidotes

Antidotes commonly used to reverse rhinoceros anesthesia include the agonistic antagonists nalorphine and diprenorphine hydrochloride (M5050, C-Vet) and the pure antagonists naloxone (Narcan, Boots) and naltrexone.

General Equipment

Rhinoceroses, being heavy animals, are difficult to manipulate once recumbent. People handling them should always plan for the worst-case scenario and have the following necessary equipment ready:

1. Two soft cotton ropes: one long rope, approximately 30 m long, for the head and a shorter rope of 10 m for the hind foot.
2. Blindfolds and earplugs. Blindfolds can be made of towels with Velcro on the ends. Earplugs should have long strings for getting them in the rhinoceros's ears.
3. Axes. To avoid injury as the rhinoceros stands and walks, it may be necessary to remove some trees/branches around the rhinoceros before administration of the antidote.
4. Shovels. They are used to dig or fill holes on the path of a walking rhinoceros and to remove sharp stumps close to a recumbent rhinoceros.
5. Prodders. Used with discretion, they are successful in stimulating rhinoceroses to rise after administration of the partial antagonist.
6. Inflatable vehicle jacks. They have been used with great success to support rhinoceroses in lateral recumbency.
7. Two way radios: They are essential for maintaining communication between the helicopter and ground crews.

Animal Monitoring Equipment

All monitoring equipment must be in place and ready to be connected to the animal. This includes a pulse oximeter, electrocardiographic machinery, a blood pressure gauge, and a thermometer.

REQUIREMENTS FOR PHYSIOLOGIC MANIPULATIONS

Water is used to cool down rhinoceroses in extreme temperatures, and copious amounts of cold water are necessary. Oxygen supplementation can be given through a nasal catheter or endotracheal tube. It is not difficult to pass an endotracheal tube in rhinoceroses through the nose for oxygen supplementation. The diameter of this tube must be smaller than that of the

trachea, and a commercial bovine stomach tube is adequate for adult white rhinoceroses. It is preferable to attach an intravenous (IV) line by using an ear vein or the large vein on the inner front leg. IV access is useful in emergencies, especially when blood pressure falls.

Personnel Requirements

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

Time Management

Rhinoceros anesthesia is induced in the morning, when temperatures are cool, and at the time of year that the animals are in good condition. In the field, late afternoon darting must be limited to extreme emergencies, because unforeseen circumstances can lead to working in the dark. Rhinoceroses breed all year round, and darting of heavily pregnant animals should be avoided.

Localities

Difficulties are experienced in darting in dense bush from a vehicle, between high trees from a helicopter, and on open plains when darting on foot. Natural obstacles such as cliffs, dongas, and open water pose a threat to ataxic rhinoceroses, and the animals must be steered away from these trouble areas before darting. Accessibility of the ground crew to the rhinoceros is always an important consideration.

THE PROCEDURE

The Approach

Darting from a helicopter is preferred under free-ranging conditions because continuous visual contact is possible and the helicopter can be used to chase other rhinoceroses away from the recumbent animal. When darting is done from a helicopter, both the pilot and marksman must identify the animal. They must take time to herd the animal close to the ground crew to ensure good dart placement. To avoid dart whiplash, the helicopter flies 10 to 30 m behind the animal and at the same speed as the running rhinoceros. Once the rhinoceros is darted, it is advisable to move away and steer the animal from a distance.

When darting is done from a ground vehicle, personnel must never drive directly toward the rhinoceros; rather, they should approach it in decreasing circles. Personnel should also avoid standing on the back of a pick-up truck or breaking the outline of the vehicle, and they should try to prevent bushes from scratching the vehicle or leaving on the back of the pick-up truck loose items that can make a noise. The vehicle follows the darted animal at a distance, and if contact is lost, trackers carrying blindfolds, ropes, and a two-way radio must follow it on foot.

Although white rhinoceroses appear to be very placid, they are extremely powerful and potentially dangerous. When darting is done on foot, it is sensible to have a back-up marksman with a heavy-caliber rifle. The marksman must be sure of a down-wind approach, wear sensible bush clothing, and walk softly, although white rhinoceroses, despite extremely poor eyesight, have acute senses of smell and hearing. Rhinoceroses regularly turn towards the marksman once the dart has been fired. The marksman must therefore be in a safe position and remain immobile after darting. A safe following distance must be maintained, and the ground crew is updated by a two-way radio.

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 subcutaneous deposition of the drug. Preference is given to the gluteal region from the helicopter; the neck area is often exposed in pens.

The Ataxic Phase

It is important to maintain continuous visual contact of the rhinoceros after darting. The ataxic phase is the most likely phase for physical injury; white rhinoceroses characteristically show a reduction in speed; a shortened gait, often dragging their feet, followed by a high stepping gait; standing; and sideways movement. The head is held higher. As soon as ataxia is noticed, the following distance is increased, to avoid further stimulation, and intervention is undertaken only if the animal moves to dangerous terrain.

White rhinoceroses can be stopped toward the end of this phase by allowing them to step into a rope with one hind leg, then securing the rope between the hock joint and the foot. This rope is tied to a vehicle or tree, and the animal is stopped. A blindfold is placed over the animal's eyes, and earplugs are inserted to reduce stimulation. If ataxia has not occurred by a certain set time, it is probable that the dart has malfunctioned. A second dart containing a full dose is fired if the animal shows no reaction in 8 to 10 minutes; one-third to half the dose is given if the animal is affected but does not stop or become recumbent.

Recumbency

The rhinoceros can be assisted into recumbency by pulling on the rope on the hind foot or by pushing the body. Although rhinoceroses tolerate lateral recumbency, sternal recumbency is preferred, except for heavily pregnant females, in which the fetus may elevate the pressure on the diaphragm. A rhinoceros must not be allowed to lie with its head downhill because this will also increase the pressure on the diaphragm.

Rhinoceroses also must not lie on their back legs for extended periods of time, because this results in occlusion of the blood supply and reluctance to stand after administration of the antidote. The rhinoceros's

weight should be shifted from time to time during recumbency. White rhinoceroses sometimes do not become fully recumbent and maintain a dog-sitting position. This is safe for short periods, but because this position places all the weight on the hind legs, it should be avoided during long procedures.

The dart wound is treated immediately with an intramammary antibiotic preparation. It is good practice to insert a catheter into an ear vein to ensure a patent pathway into the blood stream for emergencies, and a saline solution or Ringer's lactate solution is administered.

Monitoring

It is important to keep good records of physiologic parameters for each use of anesthetics to build up sufficient baseline data allowing the determination of acceptable physiologic limits.

TEMPERATURE

A long thermometer is inserted deeply into the anus to ensure accurate measurement of body temperature. The temperature depends on the amount of activity beforehand, the environmental temperature, and the health status of the animal. Temperatures vary from 36° to 39.5°C during field capture operations.

White rhinoceroses are notorious for respiratory depression and ventilate poorly when anesthetized with morphine. Nalorphine, 10 to 15 mg IV, should be administered immediately, because this increases the rate and depth of respiration and improves blood gas values. Initial respiration rates can be as low as 3 to 4 per minute but should increase to 8 to 12 per minute after administration of nalorphine.

Pulse oximeters can be attached to the ear, after the superficial pigmented layers have been scraped off, or to skinfolds of the vulva or prepuce. Reflective probes can also be inserted into the nose to use the reading from the nasal septum. Arterial blood gas values can be determined from samples obtained from the inside ear artery, into which an 18- to 20-gauge catheter has been inserted.

Opioids cause a marked increase in rhinoceros blood pressure. This elevation is caused by increased activity of the sympathetic nervous system, evidenced by a sixfold increase in norepinephrine levels seen in horses anesthetized with etorphine. Blood pressure can be monitored by direct line in the inner ear artery or by placing a cuff around the tail. Mean arterial pressures in excess of 200 mm Hg have been routinely measured but are reduced after the administration of nalorphine.

Six white rhinoceroses darted with 2 mg of etorphine and 30 mg of fentanyl had a mean blood pressure of 183 ± 16 mm Hg, whereas six darted with 3 mg of etorphine and 25 mg of azaperone had a mean arterial pressure of 141 ± 24 mm Hg. A mean arterial pressure ranged between 280 and 210 mm Hg was recorded after a white rhinoceros was anesthetized with 2.8 mg of etorphine.

Although the blood pressure in the rhinoceros is

high under anesthesia with etorphine, it may well be beneficial to the hypoxic animal. If the perfusion is decreased with the persisting low oxygen tension levels, it can be very dangerous. Thus the use of high doses of adrenergic antagonists is questionable. On the other hand, a blood pressure over 200 mm Hg can result in edema and rupture of small vasculature, causing pulmonary hemorrhage.

White rhinoceroses typically show muscle shivering or rising and stiffening of the front quarters. This can be reduced by intravenous supplementation with 10 to 15 mg of detomidine (Domosedan) or by administering small IV doses of benzodiazepine or buterophenone tranquilizers. A disadvantage of these tranquilizers is the reluctance of rhinoceroses to walk after the administration of small doses of nalorphine (see later discussion).

Monitoring depth of anesthesia in rhinoceroses can be difficult. Ear movement, respiration rate, and attempts to rise are indicators. Heart rates also increase as the level of anesthesia becomes lighter, but this may also be an indication of hypoxia.

Supplemental Doses

When supplemental doses are needed, they are administered via the catheter in the ear vein. They are 25% to 33% of the initial anesthetic dosage in the same ratio as administered in the initial dart. If the additional anesthetic is used, it is important to add it into calculations of the antidote dose. Boluses of ketamine after the use of opioids should be used with caution because they may lead to extended apneic phases.

Emergencies

Apnea is especially apparent during the early part of the procedure. Steps to avoid or counteract this are as follows: Insert catheters with an IV line. Administer nalorphine in increments of 15 mg IV or small doses of nalbuphine. Administer 10 to 20 ml of doxapram (Dopram) intravenously. Although doxapram has the immediate effect of increasing respiration rate, it has very limited effect on increasing oxygenation of the blood. If there is still little improvement, abort the operation and administer the full antidote, preferably a pure antagonist such as naltrexone.

Routine oxygen supplementation to anesthetized white rhinoceroses is indicated. A flow rate of 15 L of oxygen per minute must be maintained. If the animal was suffering from apnea and treatment was administered as described earlier, the blood oxygenation should also increase. Poor ventilation will further result in hypercapnia, which will improve only if the respiration rate and depth are increased.

If, in spite of oxygen supplementation, the blood gas values remain low, the flow rate of the oxygen can be increased and the doxapram dose repeated. Fifteen minutes of oxygen supplementation via an endotracheal tube increased the PO₂ level from 35% to 115% in one rhinoceros. A dramatic color change was also observed in the venous blood (personal unpublished data). Con-

tinued low blood oxygenation is an indication to end the procedure and administer the full antidote dose.

Low blood pressure can be caused by decreased heart rate, by decreased venous return, or by excessive peripheral vasodilation. Postural change usually rectifies the problem, but epinephrine is indicated at standard dose rates if this condition persists.

High blood pressure is reduced by the IV administration of nalorphine or by small doses (15 to 30 mg total dose) of a butyrophenone such as azaperone.

Rhinoceros body temperatures exceeding 39°C can be reduced by pouring copious amounts of water on the animal, combined with movement of air over the animal (fans or waving branches). Rhinoceroses can be covered with branches to protect them from direct sunlight, or large volumes of cold intravenous fluids or cold water enemas can be administered. If the temperature continues to rise, consideration should be given for anesthetic reversal.

If rhinoceroses recently drank water before darting, water may flow from their mouths during anesthesia. This condition may necessitate termination of the procedure, because inhalation of the water can lead to pneumonia. Care must be taken that the head is held lower than the body and the nose is pointing downwards.

Fortunately, white rhinoceroses do not generally awaken suddenly but will show prior warning signs. These include increased ear movements, curling of the tail, and increased heart rates. If the animal attempts to rise, a supplemental dose is indicated.

Reversal

Before reversal, all work on the rhinoceros must be completed and all monitoring equipment must be removed. All persons and vehicles are moved away from the rhinoceros, and the helicopter should be ready for take-off.

Heavy animals tend to compromise the arterial blood supply to the undermost muscles, and the venous draining can be completely occluded. This leads to an increase in lactate, which precipitates muscle spasms and reduces the blood flow even further. This can lead to difficulty in standing after a long recumbency. The weight of the animal should be shifted periodically during long recumbencies and the rhinoceros should be placed in lateral recumbency for 5 minutes before reversal. Rhinoceroses that are anesthetized in winter months, in poor condition, and when heavily pregnant take longer to rise than do others.

Diprenorphine at three times the etorphine dose and naltrexone at 40 times the etorphine or carfentanil dose are standard dose rates. If only nalorphine is available, a total of 250 mg is administered to an adult rhinoceros.

The antidote is administered via the catheter in the ear vein, and the ear plugs and blindfold are removed. Personnel should move clear of the animal to allow it to wake up alone and calmly. If a cow and a calf have been immobilized together, they should receive their antidotes simultaneously.

The agonistic antagonists nalorphine and diprenorphine can be used to partially or completely reverse the

anesthesia in white rhinoceroses. Even after complete reversal dosages have been administered, the rhinoceroses remain docile and seminarcoitized for up to 24 hours. Further administration of these antidotes does not improve this condition. Complete reversal occurs if the pure antagonists naloxone and naltrexone are used.

Sometimes it is not possible to place the transport crate close to the recumbent animal, because of habitat restrictions. It is possible to walk a white rhinoceros (up to a few kilometers) from the site of recumbency to more suitable terrain. The path toward the crate should be planned and cleared beforehand, and two persons walk ahead to remove obstacles that may jeopardize the walking rhinoceros. Walking rhinoceroses cannot negotiate sharp turns.

The middle of a 30-m rope is tied around the rhinoceros's blindfolded head. The two loose ends of approximately 15 m each are laid out in front of the rhinoceros, and four or five persons are placed on each rope to act as pullers. The rope on the hind foot must remain during this procedure to act as a brake.

Nalorphine is injected into the ear vein in 50-mg and 30-mg boluses for adults and subadults, respectively. These dosages must be adapted according to the level of anesthesia of the rhinoceros at the time of reversal. Of importance is that rhinoceroses that receive oxygen generally require less nalorphine to walk. Approximately 3 minutes should pass before the rhinoceros is stimulated to stand, by patting on the head or prodding the lip in order to raise the head. Determining whether it is necessary to administer a second bolus of nalorphine requires careful judgment. The head must raise first, and the two front legs must be extended. The rhinoceros is pulled forward until it is standing on all four legs. Still blindfolded, it will walk with an unstable gait and can be guided by lateral pulling and pushing on the horn. A steady pace must be maintained because stopping will result in recumbency.

If the rhinoceros starts running or becomes difficult to control, the brake rope is tied around a tree to stop the animal. Once the rhinoceros has calmed down, the walking can be continued. The full antidote and the tranquilizers can be administered once the rhinoceros is loaded in the crate.

POSTRECOVERY PHASE

Under free-ranging conditions, the rhinoceros is allowed to wander off undisturbed. The helicopter can be used to ensure that the reversed cow and her nonmanipulated calf are reunited. Where circumstances allow, subsequent monitoring from a distance is advised.

COMBINED ANESTHESIA OF COWS AND CALVES

If the cow and the calf are both to be anesthetized, they are darted in quick succession. The cow must be darted first, because the calf will remain with its mother and can often be darted while it is standing next to the recumbent cow. Success has been obtained by darting the cow and calf with a double-barrel dart gun. The

animals should be left undisturbed, allowed to remain calmly together, and become recumbent close to each other. Problems can arise if there is a dart failure with one of the animals or if they separate during the ataxic phase, which occurs most often in dense vegetation.

Therefore, sufficient ground crew to form two teams must be available when this procedure is undertaken.

CONSIDERATIONS IN DARTING RHINOCEROSSES IN CONFINEMENT

The anesthesia of a rhinoceros in a pen is far more controlled. The water trough is drained and the animals are not allowed to wallow 6 hours in advance to avoid regurgitation of water during anesthesia or even drowning during the ataxic phase.

For anesthesia in a boma, 0.25 to 0.4 mg of etorphine (M99) with 10 to 20 mg of azaperone is used if a standing immobilization is required, or 1 to 1.5 mg of etorphine (M99) and 50 mg of azaperone are used if recumbency in adults is required.

To load a rhinoceros into a crate from a pen, allow 10 to 15 minutes after darting until the animal shows a high stepping gait and the tendency to follow moving objects. A white rag tied to a long stick is waved in front of the rhinoceros and slowly moved toward the crate. The rhinoceros will follow the rag with a slow and unstable gait, toward and finally into the crate. (In a similar way, rhinoceroses can be enticed to press their heads against the pen wall when a standing anesthesia is sufficient). Once the rhinoceros is crated, the tranquilizers and antidote are administered through the trapdoor in the crate's roof. During this process, sound and movement should be limited to prevent distracting the animal.

Monitoring after reversal in the pen or crate is im-

portant for the first 12 hours to ensure that no renarcotization takes place.

REFERENCES

1. Allen JL: Immobilization of Mongolian wild horses (*Equus przewalskii przewalskii*) with carfentanil and antagonism with naltrexone. *J Zoo Wildl Med* 23(4):422-425, 1992.
2. Dunlop CI, et al: Temporal effects of halothane and isoflurane in laterally recumbent ventilated male horses. *Am J Vet Res* 48(8):1250-1255, 1987.
3. Goodman AG, Gilman LS, et al: *The Pharmacological Basis of Therapeutics*. New York, Macmillan, pp 485-504, 1991.
4. Hall LW, Clarke KW: *Hall and Clarke Veterinary Anaesthesia*, 8th ed. London, Baillière Tindall, pp 215-218, 1985.
5. Hattingh J, Knox CM, Raath JP: Blood pressure and gas composition of the white rhinoceros at capture. In press.
6. Heard DJ, Olsen JH, Stover J: Cardiopulmonary changes associated with chemical immobilization and recumbency in a white rhinoceros (*Ceratotherium simum*). *J Zoo Wildl Med* 23(2):197-200, 1992.
7. Jaffe RS, et al: Nalbuphine antagonism of fentanyl-induced ventilatory depression: a randomized trial. *Anesthesiology* 68:254-260, 1988.
8. Keep ME: Etorphine hydrochloride antagonists used in the capture of the white rhinoceros, *Ceratotherium simum simum*. *Lammergeyer* 13:60-68, 1971.
9. Kock MD: Use of hyaluronidase and increased etorphine (M99) doses to improve induction times and reduce capture-related stress in the chemical immobilization of the free-ranging black rhinoceros (*Diceros bicornis*) in Zimbabwe. *J Zoo Wildl Med* 23(2):181-188, 1992.
10. Kock MD, la Grange M, du Toit R: Chemical immobilization of free-ranging black rhinoceros (*Diceros bicornis*) using combinations of etorphine (M99), fentanyl, and xylazine. *J Zoo Wildl Med* 21(2):155-165, 1990.
11. LeBlanc PH, Eicker SW, Curtis M, Bechler B: Hypertension following etorphine anesthesia in a rhinoceros (*Diceros simus*). *J Zoo Anim Med* 18(4):141-143, 1987.
12. McKenzie A: *The Capture and Care Manual*. Pretoria, Wildlife Decision Support Services and South African Veterinary Foundation, pp 512-528, 1993.
13. Soma LR: Equine anesthesia: Causes of reduced oxygen and increased carbon dioxide tensions. *Compend Cont Ed* 2(4):57-63, 1980.
14. Taylor PM: Risks of recumbency in the anaesthetised horse. *Eq Vet J* 16(2):77-78, 1984.