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SERIAL CHEMICAL RESTRAINT FOR TREATMENT OF DECUBITUS ULCERS IN TWO NEONATAL WHITE RHINOCEROSES (*CERATOTHERIUM SIMUM*)

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Abstract: Two neonatal white rhinoceroses (*Ceratotherium simum*) at two zoological institutions were medically managed for wounds characterized by extensive multifocal necrosis of the skin and subcutaneous tissue, associated with decubitus ulcers throughout the body. Wounds resulted from prolonged recumbency due to inability to stand in one case and causes unconfirmed in the other. Both calves were born in cement stalls during winter. Using either butorphanol (i.v. or i.m.) alone or in combination with detomidine (i.m.), serial chemical restraint was conducted over a 6-wk period to facilitate wound care. Anesthesia was well tolerated in both calves, and lesions responded well to medical treatment.

Key words: Rhinoceros calf, *Ceratotherium simum*, pressure necrosis, decubitus, anesthesia, angular limb deformity.

INTRODUCTION

Clinical care and wound treatment of neonatal nondomestic megavertebrates such as the white rhinoceros (*Ceratotherium simum*) entails many challenges. For instance, physical limitations and stress associated with restraint often dictate longer treatment intervals, and housing constraints limit the ability to keep these animals in contaminant-free environments. The intractability of these species often necessitates anesthesia to facilitate adequate therapy, but there is a paucity of information in the literature regarding anesthesia of neonatal rhinoceroses. Numerous references are available regarding wound care in horses and other domestic animals; however, much of that information is not directly applicable to rhinoceroses. This case report describes successful serial chemical immobilization and treatment of severe decubitus ulcers in two white rhinoceros calves.

CASE REPORTS

Case 1

A male white rhinoceros was born in February 2005 at *The Wilds,* in Cumberland, Ohio. On visual examination, an approximately 45-degree valgus deformity of the left metatarsophalangeal (MP) joint was noted and appeared to prohibit the calf from standing despite repeated attempts. An abrasion developed over the left medial MP joint within 5 hr, despite the addition of extra bedding materials. The calf was assisted to a standing position and supported for several minutes at 2–3 hr intervals. Bottle feeding was initiated at 9 hr, with addition of the dam's colostrum at 12 hr. On day 2, the calf was still recumbent. Laboratory tests showed a complete blood count within normal ranges, a dramatically elevated creatinine kinase (CK) of 27,370 U/l, and a subnormal total serum protein (4 g/dl).[5] Qualitative failure of passive transfer (FPT) tests were performed, including a zinc sulfate (Equi-Z™, VMRD Inc., Pullman, Washington 99163, USA) and sodium sulfite turbidity (Bova-S™, VMRD, Inc., Pullman, Washington 99163, USA), which suggested IgG levels between 400 and 800 mg/dl and 200 and 400 mg/dl, respectively. A quantitative measurement IgG was 243 mg/dl (Radioimmunodiffusion Assay, Equine Test Plate, Antech Laboratories, Fishers, Indiana 46038, USA). Although none of these assays are validated for rhinoceroses, partial failure of passive transfer was presumed based on the collective evaluation of test results when compared to parameters established for domestic species.[9,13] Due to the elevated CK, the etiology of the angular limb deformity was suspected to be traumatic parturition. The calf was bottle-fed over a period of 39 hr. During each feeding, the calf was assisted to stand and physical therapy performed on the deviated MP joint. Splinting the joint was considered as a possible tactic; however, this treatment was not utilized because the calf showed steady progress toward standing and the feasibility of a beneficial splint was questionable. The calf was first able to stand and walk independently on day 3, and began to nurse from the dam at that time.

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By day 4, the abrasion over the MP joint had rapidly progressed to skin and soft tissue necrosis with resultant sloughing, creating a full-thickness ulceration 6 cm in diameter. Submandibular edema and a narrow horizontal ulceration across the dorsum of the left carpus were noted. The umbilicus appeared slightly moist, but was otherwise normal. Culture swabs were collected from the umbilicus and limb lesions for aerobic culture. Results indicated heavy *Enterobacter* sp. and scant gamma *Streptococcus* sp., both of which were considered probable contaminants. Prophylactic antibiotic therapy with ceftiofur sodium (Naxcel, Pharmacia & Upjohn Co., Kalamazoo, Michigan 49001, USA; 3.5 mg/kg i.m., s.i.d.) was initiated, and a 5-day course of flunixin meglumine (Vedagesic™, Phoenix Scientific Inc., St. Joseph, Missouri 64503, USA; 60 mg i.m., s.i.d.) treatment was initiated for analgesia and anti-inflammatory action. Lesions were gently scrubbed with dilute chlorhexidine gluconate 2% solution (Chlorhexidine solution, Phoenix Scientific Inc.), flushed with sterile saline, treated with topical silver sulfadiazine cream (Silvadene, BASF Corp., Mount Olive, New Jersey 07828, USA), and bandaged.

By day 6, bone was exposed in the MP lesion, and skin began to slough from several other contact points. Pressure sores were identified bilaterally over the humeroulnar, carpal, femurotibial, and MP joints as well as over the ventral chest and mandible (Fig. 1a–d). A medical team from a nearby human wound center was invited for consultation and provided valuable insight for treatment of the ulcers. Butorphanol (Torbugesic, Fort Dodge Animal Health, Fort Dodge, Iowa 50501, USA; 0.07mg/kg i.m.) was administered to facilitate treatment. This dosage resulted in light anesthesia with occasional movement in response to stimuli. Depending on condition of the wound, topical treatment consisted of some or all of the following, in the order that they are described: chlorhexidine antiseptic scrub and sterile saline lavage of all lesions, surgical debridement of lesions with devitalized tissue, chemical cautery of exuberant granulation tissue using silver nitrate (Grafco®, Graham-field Health Products, Atlanta, Georgia 30360, USA), collagen wound dressing with alginate (Promogran, Johnson & Johnson Medical, Arlington, Texas 76004, USA) to assist with granulation tissue in clean ulcers that could be bandaged, matrix wound dressing (Fibrocol, Johnson & Johnson Medical) for clean ulcers that had undermined dermis along the wound margins, silver sulfadiazine cream for all lesions, and protective bandaging of all lesions. Butorphanol effects were reversed with naltrexone hydrochloride (Trexonil, Wildlife Pharmaceuticals, Fort Collins, Colorado 80524, USA; 20 mg, 3.7 mg/kg, i.m.). This procedure was repeated on day 8.

On day 10, butorphanol (0.03 mg/kg, i.m.) and detomidine (Dormosedan, Pfizer, Exton, Pennsylvania 19380, USA; 0.07 mg/kg i.m.) were administered in combination to provide a deeper level of anesthesia and muscle relaxation. Detomidine effects were antagonized with yohimbine HCL (Wildlife Pharmaceuticals; 0.125mg/kg, i.m.) and butorphanol with naltrexone HCL (10mg, 1mg/mg butorphanol, i.m.). This protocol was repeated every 48–72 hr over a 4-wk period, for a total of 12 procedures; the animal's weight increased from 80 kg to 125 kg during that time. Anesthetic data is provided in Table 1. Overall, this protocol provided a light surgical plane of anesthesia, with occasional minor response to stimuli. For all procedures, constant use of a pulse oximeter (Heska Corp., Fort Collins, Colorado 80525, USA) on the pinnae or tongue showed SpO2 values from 91–99% without supplemental oxygen administration. Heart rate ranged from 60–100 beats per min, respiratory rates were 16–44 breaths per min, and rectal body temperatures were 37.3–38.5°C. Mean ±SD time from injection to recumbency was 5.7 ± 2.6 min and to full anesthetic effect was 7.5 ± 3.3 min. Complete recovery to standing was noted 4 ± 2.8 min after antagonist administration, and no lingering sedation was noted. Time from anesthetic injection to reversal was 49 ± 20 min. Anesthesia was supplemented on one occasion (0.01 mg/kg butorphanol and 0.01 mg/kg detomidine i.m.) when the animal began to arouse 60 min post-injection.

On day 13, the primary topical wound therapy was changed to a commercial neomycin preparation in which the antibiotic is potentiated by a third-generation chelating agent[12] (Tricide, Molecular Therapeutics, Riverbend Laboratories, Athens, Georgia 30360, USA). For each anesthetic procedure, lesions were lavaged with 2 l total of Tricide using a garden sprayer. During each procedure, bandages were changed on the distal limbs, while the lesions over the humeroulnar and femurotibial joints and mandible were largely left open due to difficulty in maintaining bandages in these areas. Healing progress was consistent and was monitored through weekly photographs and measurements. The largest wound measured 7.5 by 12 cm over the left carpus (Fig. 1b). A final treatment was administered under anesthesia on day 41, when only the two wounds over the humeroulnar joints remained open and measured less than 1 by 1 cm. The calf would not tolerate substantial wound cleaning without sedation. Although healing slowed once regular

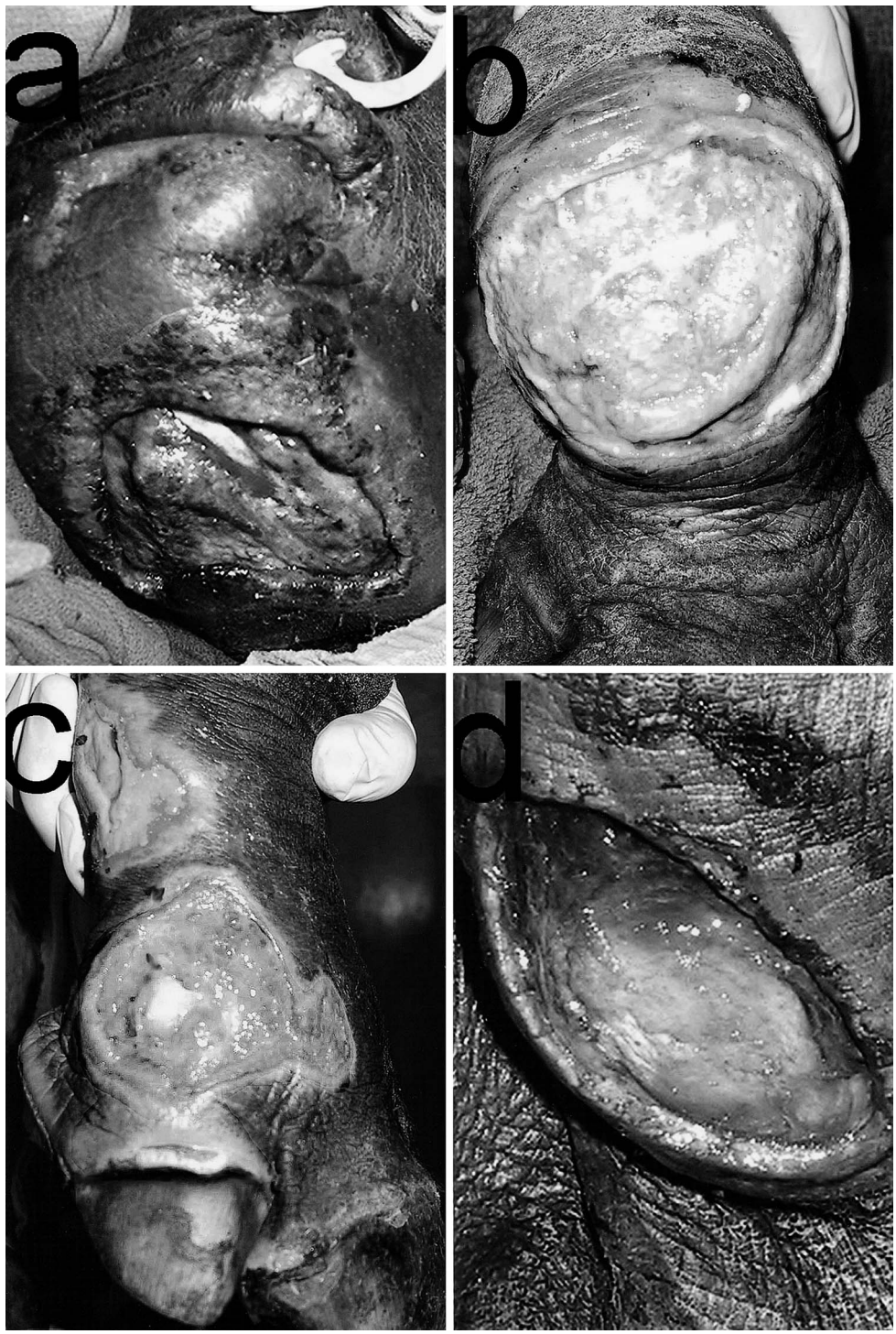

Figure 1. Decubitus ulcers 6–12 days post-onset in a neonatal white rhinoceros (*Ceratotherium simum*). a. Ventral mandible. b. Left dorsal carpus. c. Medial left rear distal limb. d. Left ventral elbow.

Table 1. Anesthetic data collected from two rhinoceros calves following administration of butorphanol alone (i.v. or i.m.) and in combination with detomidine (i.m.)

Drug administered	Dosage (mg/kg)	No. of procedures	Effect	Time to effect (min)	SpO2 (%)	HR (b.p.m.)	RR (b.p.m.)	Duration of procedure (min)
Butorphanol i.m., Case 1	0.07	2	Heavy sedation/light anesthesia	7–14	91–98[a]	98–102	16–24	61–73
Butorphanol i.v., Case 2	0.13–0.15	10	Heavy sedation/light anesthesia	0.5–1.5	72–90[b]	80–148	16–36[c]	16–38
Butorphanol + detomidine i.m., Case 1	0.03 + 0.07	12	Surgical anesthesia	3–13	91–99[a]	60–100	16–44	32–101[d]

[a] Portable pulse oximeter, Heska Corp., Fort Collins, Colorado 80525, USA, on tongue or pinnae.
[b] Nellcor N20-PA; Nellcor Corporation, Pleasanton, CA 94588, USA, on pinnae.
[c] A respiration rate of 60 breaths/min was recorded during one procedure and excluded from this range.
[d] Supplemental drug was administered for one of these procedures.

therapy was discontinued, all lesions had resolved by day 80.

The valgus deformity was assessed with ultrasonography and radiography on day 20, and these tests revealed no significant findings. The fetlock abnormality resolved without treatment and was undetectable by day 58.

Case 2

A male white rhinoceros was born in November 2002 at the *Fossil Rim Wildlife Center,* in Glen Rose, Texas. Neonatal examination on day 1 revealed a healthy calf with slight cloudiness of the right eye. Upon re-examination on day 4, a corneal ulcer was confirmed with fluorescein dye staining, and a 10-cm-deep laceration of the left elbow was detected. Procaine Benzathine penicillin (300,000 IU/ml; HanFords U.S. Vet, Syracuse, New York 13021, USA; 3 million IU, 50,000 IU/kg, s.c.) was administered for systemic antimicrobial therapy. The corneal ulcer was treated topically. Over the next 4 days, daily wound treatment included chlorhexidine scrub and lavage, topical cephapirin sodium (Cefa-lak; 200 mg/10 ml syringe; Fort Dodge Animal Health) and bandaging. Despite treatment, the lesion of the left elbow enlarged and new lesions developed over bony prominences. On day 8, new lesions included decubitus ulcers over the right humeroulnar joint and over both femurotibial joints. Although never observed, repeat abrasion on concrete from crawling beneath exhibit fencing was suspected. Serum chemistry panel and protein electrophoresis were interpreted as normal with excellent passive transfer[9,13] (IgG = 2,500 mg/dl; Radioimmunodiffusion Assay, Equine Test Plate, Jorgensen Laboratories, Bellingham, Washington 98226; IgG = 2,200 mg/dl; Serum Protein Electrophoresis, Texas Veterinary Medical Diagnostic Laboratory, College Station, Texas 77841, USA). Topical treatment consisted of local debridement, wound cleaning with chlorhexidine scrub, and wet to dry bandaging until a healthy granulation bed was achieved, and then use of a hydroactive dressing (DuoDERM; ConvaTec, Princeton, New Jersey 08543, USA). Protective bandaging including cast padding, and foam was used to reduce wound pressure. On day 9, systemic therapy was changed to oral sulfamethoxazole/trimethoprim (SMZ; 960 mg tablets; Phoenix Scientific Inc.; 1,920 mg, 30mg/kg, p.o., s.i.d., for 14 days).

Beginning on day 13, butorphanol (0.10–0.15mg/kg, i.v.) was administered to facilitate described wound treatment. Effects of butorphanol were reversed with naltrexone (5:1 naltrexone:butorphanol dose, i.v.). The treatment procedure was repeated using chemical restraint 10 times over a 5-wk period; the animal's weight increased from 66 to 159 kg during that time. Anesthetic data for those procedures is provided in Table 1. This dosage induced heavy standing sedation to recumbency. For all procedures, constant use of a pulse oximeter (Nellcor N20-PA; Nellcor Corp., Pleasanton, CA 94588, USA) on the pinnae showed SpO2 values from 72 to 90% (average 84%) without supplemental oxygen administration. Heart rate ranged from 80 to 148 beats per min, respiratory rates were 20 to 32 breaths per min, and rectal body temperatures were 37.2–38.9°C. Mean ± SD time for full anesthetic effect was 43 ± 31 sec. Complete recovery was noted in 28 ± 14 sec after antagonist administration, and no lingering sedation was noted. Time from anesthetic injection to reversal was 24 ± 6 min.

The last treatment was administered under se-

dation on day 54, when only the left elbow ulcer remained open and measured less than 1 by 1 cm. The calf would not tolerate substantial wound cleaning without sedation. All lesions were closed by day 60.

DISCUSSION

The development of decubitus ulcers resulting from excessive recumbency has been documented in many domestic species.[15] Factors associated with the development of such lesions in animals include prolonged recumbency, thin body condition, moist skin, thin skin, and exposure to hard floor surfaces.[3,4,16] Angular limb deformity does not appear to be a substantial factor in the development of decubitus ulcers in foals, presumably because this condition typically does not cause prolonged recumbency in foals. Decubitus ulcers occur more commonly as sequellae to recumbency-inducing conditions such as maladjustment syndrome and septicemia in foals, and severe laminitis in adult horses.

The dramatic occurrence of skin and soft tissue necrosis in these two rhinoceros calves suggests that neonatal rhinoceros may be particularly susceptible to pressure necrosis. Captive individuals may be at particular risk because they are frequently born on hard substrates. Both calves in this report were born in winter on concrete flooring. Furthermore, rhinoceros skin may be more prone to ischemic lesions due to the highly vascular makeup of their skin,[2] since the extent of deep-tissue involvement associated with pressure necrosis is correlated with the extent of vascularity of the affected region.[6]

The severity of the lesions in these cases might have been life threatening if the progression of the lesions had not been halted. Both cases responded well to treatment over similar time periods, suggesting that large ulcers in rhinoceros calves will heal by second intention provided wounds are debrided and kept clean and infection is prevented.

There are few references available regarding anesthesia of rhinoceros calves, and no reports of detomidine-butorphanol anesthesia in rhinoceros calves were found in an extensive review of the literature. Reports include field anesthesia of free-ranging calves with etorphine,[7,14] repeated sedation with butorphanol followed by isoflurane anesthesia in a white rhinoceros calf,[8] and butorphanol for serial sedation of a black rhinoceros calf undergoing leukemia therapy.[10] The routine use of butorphanol and azaperone in adult rhinoceroses has been described as a safe alternative to more potent opiods,[11] and there are anecdotal reports of combined butorphanol and detomidine sedation in adult rhinoceroses.[1,17]

Anesthetic regimens in both of these cases proved safe and effective. In case 2, pulse oximeter readings were frequently indicative of hypoxemia (SpO2 $<$ 90%), however, these reading were not supported with blood gas values. Since the readings from this calf were never $>$90%, even when standing and at the start of procedures, the measurements were monitored as trends rather than as a precise reflection of oxygenation status. The calves remained bright and strong throughout the entire treatment period and did not suffer adverse affects from the serial anesthetic procedures. In case 1, the calf did not tolerate injections well, therefore, reliable i.v. injection was not feasible. Butorphanol and detomidine administered in combination i.m. resulted in ideal anesthesia given the ease of administration, depth of anesthesia, degree of muscle relaxation, desirable physiological parameters, and reversibility. Naltrexone and yohimbine produced complete reversal and did not interfere with repeat anesthesia at 48-hr intervals. The calf in case 2 was more tractable and could be manually restrained for routine i.v. injections. Intravenous butorphanol administration provided a safe, rapid, and efficacious level of sedation or light anesthesia for treatment purposes and was effectively reversed with naltrexone. In both cases, avoiding the use of an anesthetic machine simplified the procedures and reduced stall side equipment and activity, thereby minimizing the dam's apparent stress.

CONCLUSIONS

Successful resolution of extensive decubitus ulceration in two rhinoceros calves was possible with serial anesthesia for wound care. Challenges surmounted include handling of large intractable animals with protective dams for intensive and repeat medical therapy, and maintaining clean wounds in animals housed in a barn setting. Rhinoceros skin anatomy and physiology may predispose these animals to the development of decubitus ulcers, and precautions can be taken to eliminate risk factors. Ideally, rhinoceros parturition should take place on natural substrates or on a bedded stall. Calves that are recumbent for any reason should be kept on deep bedding. Decubitus ulcers should be treated early and frequently, with protective bandaging where possible to pad underlying tissues and reduce contamination that may interfere with healing, and with antiseptic measures including lavage and antibiotic therapy. A variety of wound therapy products are readily available for use on different wound stages, provided the area can be bandaged.

Should the need arise, rhinoceros calves may be safely, effectively, and repeatedly anesthetized using butorphanol or combinations of butorphanol and detomidine.

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