PROLONGED AND MULTIPLE IMMOBILIZATIONS OF THE SOUTHERN ELEPHANT SEAL USING KETAMINE HYDROCHLORIDE-XYLAZINE HYDROCHLORIDE OR KETAMINE HYDROCHLORIDE-DIAZEPAM COMBINATIONS

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Source: Journal of Wildlife Diseases, 23(4) : 614-618

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-23.4.614

Journal of Wildlife Diseases, 23(4), 1987, pp. 614–618

PROLONGED AND MULTIPLE IMMOBILIZATIONS OF THE SOUTHERN ELEPHANT SEAL USING KETAMINE HYDROCHLORIDE-XYLAZINE HYDROCHLORIDE OR KETAMINE HYDROCHLORIDE-DIAZEPAM COMBINATIONS

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ABSTRACT: Thirty seven southern elephant seals (*Mirounga leonina*) were singularly or repeatedly immobilized with combinations of ketamine hydrochloride (HCl) and xylazine HCl or ketamine HCl and diazepam. Atropine sulphate was included in the drug combinations. To permit experimental procedures the seals were immobilized for periods of 30–330 min. The mean induction dose of ketamine HCl was 8.71 ± 0.25 mg/kg (mean ± SE). The mean induction time was 16.02 ± 2.62 min. For the elephant seals immobilized for periods in excess of 180 min, the mean dose of ketamine HCl used per hr was 3.31 ± 0.13 mg/kg/hr and the mean dose of ketamine HCl used per hr postinduction was 1.31 ± 0.15 mg/kg/hr. The mean dose of diazepam used was 0.09 ± 0.01 mg/kg and the mean dose of xylazine HCl was 0.41 ± 0.01 mg/kg. Elephant seals were weighed on 20 occasions (weight range: 897–1,932 kg) and the relationship between standard length and weight was found to be: Weight = 9.98 length − 2,317.63 ($r^2 = 0.724$). Adverse reactions to seals immobilized only once or twice were not observed. Two seals immobilized on three occasions developed abscesses at the site of injection.

Key words: Southern elephant seal, *Mirounga leonina*, ketamine hydrochloride, xylazine hydrochloride, diazepam, immobilization.

INTRODUCTION

Safe, rapid and repeatable methods of restraining animals in the field are an invaluable tool for wildlife researchers. As more detailed "hands on" studies are being conducted on seals in the Antarctic the development of a safe and effective anesthetic is becoming more important.

Ketamine hydrochloride (HCl), used alone or in conjunction with xylazine HCl or diazepam, has been shown to be a relatively safe method of immobilizing seals for short periods (Briggs et al., 1975; Geraci et al., 1981; Parry et al., 1981; Ryding, 1982; Trillmich, 1983; Gales, 1984; Baker and Gatesman, 1985). Repeated immobilizations of individuals have been reported by Geraci et al. (1981) and Parry et al. (1981).

As part of a study into the role of subcutaneous fat (Gales and Burton, 1987) 37 southern elephant seals (*Mirounga leonina*) were immobilized during the spring and summer of 1985–1986. The study was divided into two parts. The first was conducted on Heard Island (53°01′S, 73°23′E) and required the seals to be immobilized once for at least 30 min. The second part was conducted at the Vestfold Hills, Antarctica (68°30′S, 78°00′E) and required the seals to be immobilized up to three times for periods of over 4 hr. This paper reports the use of ketamine HCl, in conjunction with xylazine HCl or diazepam, to immobilize southern elephant seals in single or multiple episodes for prolonged periods.

MATERIALS AND METHODS

The standard length (straight line measurement from the tip of the proboscis to the tip of the tail) for each seal was estimated and an approximate weight calculated using the regression equation from Ling and Bryden (1981). These weights were used to calculate the drug dose.

Initially, the dose rates of ketamine HCl, diazepam and xylazine HCl were based on those suggested for use in pinnipeds (Briggs et al., 1975; Geraci et al., 1981; Parry et al., 1981; Ryding, 1982; Trillmich, 1983; Gales, 1984; Baker and Gatesman, 1985), but were modified when it became apparent that a deeper plane

of anesthesia was required for rolling the animals over and weighing them. Atropine sulphate was added to the basic drug mixture to decrease secretions into the respiratory tract.

The calculated dose of ketamine HCl (solution strength 186 mg/ml) (Parke Davis, Sydney, Australia) and atropine sulphate (0.65 mg/ml) (Parnell Laboratories, Kirrawee, New South Wales, Australia) was mixed with diazepam (5 mg/ml) (Valium®, Roche Products Pty Ltd, Sydney, Australia) or xylazine HCl (20 mg/ml) (Rompun®, Bayer, Australia) in a 60-ml syringe and was administered intramuscularly in the lumbar region. The technique of administration described by Ryding (1982) was followed. It utilized approximately 300 cm of intravenous drip tubing and a 90-mm × 18-gauge spinal needle. The drugs were flushed through the tubing using up to 50 ml of sterile water. If immobilization had not occurred within 10 min an additional dose of ketamine HCl was administered.

Induction time was recorded as the period between injection and failure of the animal to raise its head when patted on the back. Duration of immobilization was recorded as the interval from the end of induction to the time when the animal regained the ability to resist being handled. Although respiratory rate and heart rate were not systematically recorded, they were checked and any abnormalities noted.

During October and November 1985 14 male and 13 female elephant seals were immobilized on Heard Island. Males were selected from bachelor class animals (n = 5) (Carrick et al., 1962) found on the periphery of the harems, or from subadult animals arriving after the breeding season to begin their annual moult (n = 8). One male weaned pup was immobilized also. The female seals, four of which were preparturient, eight lactating, and one which had already weaned her pup, were selected from the breeding harems. The animals were not weighed.

From February to April 1986 10 bachelor class males were immobilized along the coast of the Vestfold Hills, Antarctica. These seals were part of a predominantly male prebreeding age group of seals that migrate annually to the Vestfold Hills to moult (Ingham, 1957; Tierney, 1977). Two of these seals were immobilized on three occasions, six were immobilized twice and two were immobilized once. The seals were identified with the use of plastic flipper tags (Jumbo Rototags, Dalton Supplies, Henley-on-Thames, England).

To permit experimental procedures, immobilization was maintained for 240 min. After the initial dose of anesthetic the seal was observed and additional doses of ketamine HCl were given to effect. These doses were given by intramuscular injection into the lumbar muscles or intravenous injection into the extradural vein.

The animals were weighed during the immobilization, among other procedures. Five people were required to roll the seals onto a sling constructed of two aluminum poles (external diameter, 50 mm; internal diameter, 42 mm), each 4 m long, between which woven nylon strapping (car seat belt webbing) was slung. A tripod, constructed of hinged aluminum scaffold planking 5 m in height, was erected above the animal lying on the sling in ventral recumbency. A 2.5-ton capacity block and tackle was used to suspend the seal from a 2-ton capacity spring scale with a dial readout (Salter, Staffordshire, England).

RESULTS

The mean induction dose of ketamine HCl was 8.71 ± 0.25 mg/kg (mean ± SE) (range = 5.40–12.50 mg/kg). The mean induction time was 16.02 ± 2.62 min (range = 5–70 min). The mean dose of ketamine HCl used per hr (taken as the total amount of ketamine HCl used divided by the period from injection to recovery) was 3.31 ± 0.13 mg/kg/hr (range = 2.38–3.97 mg/kg/hr) for the seals at the Vestfold Hills and 11.49 ± 0.79 mg/kg/hr (range = 3.75–18.2) for the Heard Island seals. The mean postinduction dose of ketamine HCl used per hr (taken as the difference between the total amount of ketamine HCl used and the induction dose, divided by the duration of immobilization) was 1.31 ± 0.15 mg/kg/hr (range = 0–2.50 mg/kg/hr) for the seals immobilized for prolonged periods. For each mg of ketamine HCl given per kg of seal the average recovery time was 6.22 ± 0.57 min (range = 3.37–16.00) for the Heard Island seals and 18.05 ± 0.86 min (range = 8.30–25.25) for the seals from the Vestfold Hills. The mean dose of diazepam used was 0.09 ± 0.01 mg/kg (range = 0.03–1.02) and the mean dose of xylazine HCl was 0.41 ± 0.01 mg/kg (range = 0.24–0.85).

On Heard Island eight seals required several injections of anesthetic to attain a sufficient degree of immobilization; the remainder (n = 19) required only one injec-

tion. All injections were given intramuscularly. At the Vestfold Hills six seals required up to four injections of ketamine HCl before induction was achieved; the remainder (n = 14) required only one injection. Ten injections of ketamine HCl were administered intravenously, the remaining 60 were given intramuscularly. An average of 3.5 injections of ketamine HCl per seal was required for each anesthetic episode to maintain immobilization for approximately 240 min.

One elephant seal, anesthetized for the second time 13 days after the first immobilization with a dose of 8.20 mg/kg of ketamine HCl and 0.04 mg/kg of diazepam, died 5 min postinjection. The induction time of the anesthetic was less than 30 sec and before death the seal was apnoeic and exhibited a marked bradycardia.

Two seals developed clinical lesions consistent with abscess formation. These were the two seals immobilized on three occasions. On one seal (89) the lesion formed in the area directly overlying the lumbar vertebrae. This was the site of venipuncture for blood sampling and intravenous injection of additional anesthetic. This animal was unable to use its hind flippers for approximately 2 wk. The other seal (167) developed an abscess at the site used for intramuscular injections. The abscesses in both seals healed within 3 wk, but both seals remained at the moult site for considerably longer than other individuals.

Slight muscular tremors were observed to last for approximately 3 min in one seal. Signs of respiratory distress were not observed in any animals and, except for the single mortality, all seals recovered from anesthesia uneventfully.

The average estimated body weight of the seals anesthetized on Heard Island was 465 ± 53 kg (range = 192–1,102 kg). The average body weight of seals weighed at the Vestfold Hills was 1,477 ± 61 kg (range = 897–1,932 kg). The relationship between body weight and standard length for the elephant seals at the Vestfold Hills was: Weight = 9.98 length − 2,317.63 (r^2 = 0.724) where the weight is in kg and the length is in cm. This equation yields weights that are approximately 15% higher than those calculated by Ling and Bryden (1981) for animals of similar lengths.

DISCUSSION

The drug combinations used in this study were relatively safe and practical for repeatedly immobilizing the southern elephant seal for prolonged periods. However, dose rates of ketamine HCl were considerably higher than those recommended for other pinnipeds (Briggs et al., 1975; Geraci et al., 1981; Parry et al., 1981; Trillmich, 1983; Gales, 1984; Baker and Gatesman, 1985). Also, they were higher than those reported for the southern elephant seal (Ryding, 1982). Two reasons are advanced. Firstly, the point of immobilization was considered as a more profound level of anesthesia in this versus other studies. This is reflected in the relatively long induction times. Secondly, in order to roll a seal weighing up to 2 tons onto its back to measure fat thickness and body circumference it must be deeply anesthetized. This physical manipulation itself can effectively reduce the period of immobilization and thus require an increased total dose.

The mean dose of ketamine HCl used per hr and the recovery time per kg of ketamine HCl was significantly higher for the animals on Heard Island than those from the Vestfold Hills (t-test, $P < 0.0005$). The reason for this is that most of the total dose was required for induction, the post induction maintenance dose being low. Prolonged anaesthesia therefore results in reduced hourly dose rates.

The remote method of drug administration (Ryding, 1982) worked well. Despite Ryding's (1982) suggestion that water or air could be used to flush the drug through the tube, water was used in all cases in this study because air was found to leave an unmeasurable residue of un-

injected drug. In temperatures below 0 C care had to be exercised to prevent freezing of the drugs. The large surface area of the tube resulted in the remote system becoming unworkable at temperatures <15 C because ice blocked the tube. The positioning of the needle in the dorsal hip area proved important. If the needle was pressed into the muscle off the vertical it would commonly be dislodged. A second attempt at approaching the seal adds greatly to the difficulty of the procedure. A small barb on the needle would help alleviate this problem.

Despite immobilizing seals for prolonged periods in temperatures as low as −23 C signs of hypothermia were not observed. This is not surprising as ketamine HCl, when used with diazepam, is not known to significantly alter cardiovascular or metabolic function (Soma, 1971; Green, 1979). Furthermore, the natural somnolent behavior of this species during the moult is not dissimilar to the artificially induced chemical immobilization. However, as body temperature was not monitored some change in core or skin temperature may have occurred and future studies should consider monitoring this parameter.

Six elephant seals in this study tolerated two episodes of immobilization without any problems. There was no significant difference between the doses of anesthetic used. Only two seals were immobilized on three occasions and one of these (167) required approximately twice as much ketamine HCl for induction and maintenance as the remaining animals. Because both of these seals also exhibited clinical disease as a possible result of multiple immobilizations, it seems that prolonged anesthetization of the southern elephant seal on more than two occasions is contraindicated, if the intervening period is relatively short. For this reason, the data from the third anesthetic of these two seals was not used in the calculations of mean doses given in the results.

We believe the fatality that occurred in this study (328) was the result of the induction dose of anesthetic being injected intravenously. Although care was taken to avoid this eventuality, the necessary haste with which the animals were injected made it impossible to be sure the needle had not been introduced into a vein. Small maintenance doses of ketamine HCl, when given intravenously, were noted to have an almost immediate effect on other seals. Thus, the rapid intravenous administration of a dose three or four times as large may well have proven fatal.

Intravenous injections of ketamine HCl were not used routinely for "top up" doses during prolonged anesthesia because, despite the reported advantages of rapid onset of effect and lower dose rates, the duration of effects was reduced and the response to injection less predictable. Diazepam and xylazine HCl both proved to be suitable combinative drugs with ketamine HCl. Neither appeared superior, with both effectively preventing any of the reported side effects of ketamine HCl immobilization seen in other pinnipeds (Geraci et al., 1981). However, Ryding (1982) noted no such side effects when using ketamine HCl to immobilize the southern elephant seal, so combinative drugs may not be necessary.

The technique devised to weigh the seals proved appropriate for animals weighing up to 2 tons. However, the equipment was very large and weighed in excess of 100 kg. This, combined with the fact that up to five field assistants were necessary for the weighing procedure, limited the technique's field use. Animals on a beach adjacent to the station were selected to reduce this problem.

The discrepancy that exists between the length/weight relationship found in this study and that reported by Ling and Bryden (1981) highlights the enormous variations in body weight that the male southern elephant seals undergo during the terrestrial phase of their life cycle. Ele-

phant seals at the Vestfold Hills were found to lose an average of 25% of their body weight during the moult (unpubl. data). Therefore, workers estimating body weights of these seals for drug doses should consider the animal's physiological state.

ACKNOWLEDGMENTS

The authors would like to thank the 1985 Heard Island Australian National Antarctic Research Expedition personnel and the 1986 Davis Australian National Antarctic Research Expedition personnel for assistance in the field; K. Jestrimski, Pharmacy section, Royal Hobart Hospital for preparation of the ketamine HCl; and M. Bryden for critically reviewing the manuscript.

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Received for publication 25 February 1987.