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RESEARCH PAPER

Chemical immobilization of Weddell seals (*Leptonychotes weddellii*) by ketamine/midazolam combination

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Abstract

Objective To provide reliable, effective immobilization for Weddell seals under extreme field conditions using an injectable ketamine/midazolam combination.

Study design Observational study.

Animals Thirty adult Weddell seals (12 male, 18 female) in Erebus Bay, Antarctica, body mass (mean ± SD) 412 ± 47 kg, aged 9–27 years.

Methods Seals were immobilized with a target dose of 2 mg kg^{-1} ketamine hydrochloride and 0.1 mg kg^{-1} midazolam hydrochloride (IM), based on visually estimated body mass. When required, maintenance doses were administered at a target of 0.5 mg kg^{-1} ketamine hydrochloride and 0.025 mg kg^{-1} midazolam hydrochloride (IV).

Results Complete immobilization was achieved in 33 of 40 injections (14 of which were repeat events on the same individual). Time to immobilization averaged 12 ± 4 minutes, with a duration of initial immobility of 38 ± 19 minutes. Total immobilization time varied by handling protocol, including condition assessment and muscle biopsy (Protocol 1, 60 ± 13 minutes), condition assessment and instrument attachment (Protocol 2, 154 ± 13 minutes), and condition assessment, muscle biopsy and instrument retrieval (Protocol 3, 48 ± 8 minutes). Overall, a total immobilization time of 114 ± 60 minutes was accomplished with 4 ± 4 maintenance doses, and an average recovery time of 36 ± 17 minutes. Most effects of the anesthetic combination were unrelated to mass, age, sex or total body fat. However, leaner seals had longer duration of initial immobility (% and kg total body fat) and recovery times (kg fat). Apnea events were uncommon and treated effectively with doxapram. No animals died.

Conclusions and clinical relevance Reliable and effective field immobilization of Weddell seals was accomplished with a low dose of ketamine hydrochloride and midazolam hydrochloride, utilizing IM injection initially and IV maintenance methods.

Keywords anesthesia, doxapram, ketamine, *Leptonychotes weddellii,* midazolam, Weddell seal.

Introduction

The Weddell seal, *Leptonychotes weddellii*, is the southernmost breeding mammal and has been the focus of many studies of diving physiology, reproductive biology, and population ecology in an extreme environment. Sedation of seals in their natural environment, including large phocid species in the Antarctic, is not a novel concept (e.g., Cline et al. 1969; for review see Gales 1989). Immobilization of

ice seals has been accomplished successfully with varying combinations of injected chemicals (e.g., Gales & Burton 1987; Phelan & Green 1992; Tahmindjis et al. 2003) and/or inhalation gas anesthesia methods (e.g., Zapol et al. 1979; Bodley et al. 2005; Gales et al. 2005). The particular combination of a large mammal, deep polar climate, extended duration required for scientific sampling and potential for parasympathetic cardio-respiratory dive reflex in phocids (Gales & Burton 1987; Phelan & Green 1992) has led to varying degrees of success.

This study required 30–180 minutes of immobilization to complete three different sampling protocols that included combinations of tracer injection, multiple tissue sampling, data collection, and data logger attachment/removal. The extensive sampling and multiple protocols were utilized to achieve the goals of a larger study on the effects of aging on the health and behavior of Weddell seals. Temperatures in Erebus Bay, McMurdo Sound, Antarctica, can drop well below −30 °C in the summer field season, instantly freezing injectable drugs and constraining the use of gas-based anesthetic machines unless complex thermal management measures are implemented for equipment and animals. While gas (e.g., isoflurane) anesthesia has been shown to provide reliable light to medium sedation levels in Weddell (Bodley et al. 2005) and Crabeater seals (*Lobodon carcinophagus*, Tahmindjis et al. 2003), field units can be cumbersome (45 kg) and typically only function for a few hours at temperatures down to −20 °C (Gales et al. 2005). Inhaled sevoflurane using an open drip method has been used successfully for periods of just over an hour in warmer temperatures (−4 to −12 °C; Kusagaya & Sato 2001), however, this protocol may be problematic with increased handling times and/or colder temperatures. Previous reports of chemical immobilization using combinations of a dissociative agent (ketamine or tiletamine) with a benzodiazepine (diazepam or zolazepam) met with some success but were frequently inconsistent with undesirable effects, including death (Hammond & Elsner 1977; Gales & Burton 1987; Phelan & Green 1992). We report on the success of injectable ketamine with the benzodiazepine midazolam for induction and maintenance of immobilization in Weddell seals.

Materials and methods

As part of a larger study of the effects of aging in Weddell seals, this research took place on the fast sea-ice of Erebus Bay, Antarctica (77.7°S, 166.5°E), between 16 October and 10 December 2007. Ambient conditions ranged widely between and within days, with temperatures of −30 to 8 °C depending on cloud cover, wind speed (0–12 meters second^{-1}) and humidity level (18–72%). All equipment and personnel (n = 4–6) were transported approximately 20 + km daily from the McMurdo field station to the seal haulouts, located at tidal cracks or breathing holes in the sea ice, by skidoo and/or Pisten Bully. Sheltered areas were chosen whenever possible, but the site was dictated by the availability of appropriate seals such that the majority of activity took place in the open environment. A portable, nylon geodesic dome was erected when possible (low wind conditions) to provide a shelter for procedures longer than 2 hours (e.g., Protocol 2, outlined below).

Study animals

The objectives of the larger study focused on the physiological and behavioral transitions that accompany aging in this southernmost breeding mammal. Therefore, adult males and nonpregnant (as determined by imaging ultrasonography), nonlactating females were chosen between the ages of 9–27 years, determined from pre-existing, uniquely numbered flipper tags (Cameron & Siniff 2004). Flipper tags could be read on individual seals by slow, on-foot approach. Whenever possible, seals were chosen to represent equal numbers of each year class to ensure equal distribution along the desired age continuum. A total of 30 animals (M = 12, F = 18) were handled in 44 sampling events. Of these 30 seals, 14 (all F) were sampled twice to satisfy the experimental design of the larger project (Table 1).

Once chosen, seals were gently encouraged to move a short distance (25–50 m) to reduce disturbance to the larger group of breeding/reproductive animals and to increase peripheral blood circulation, after which they were restrained via head bag for induction of sedation (Sterling 1966). Animals were subject to one of three sampling Protocols. Protocol 1 (M = 11, F = 5) had an average procedure time of 60 ± 13 minutes, which included body mass, standard morphometrics, blood, muscle biopsy, ultrasound measurement of blubber depth, and photogrammetry (digital and thermal). These individuals were sampled on a single occasion. Protocol 2 (F = 14) averaged 154 ± 13 minutes to

