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Anesthesia of Boma-captured Lichtenstein's Hartebeest (*Sigmoceros lichtensteinii*) with a Combination of Thiafentanil, Medetomidine, and Ketamine

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ABSTRACT: A dose range was determined for anesthesia of recently boma-captured Lichtenstein's hartebeest (*Sigmoceros lichtensteinii*) (n = 13) with the synthetic opiate thiafentanil (THIA) (formerly called A3080) combined with medetomidine (MED) and ketamine (KET) in the Kasungu National Park, Malawi on 4 to 5 September 1999. The dose range of 11–26 μg/kg THIA (mean ± SD = 21 ± 4 μg/kg) combined with 5–10 mg/kg MED (8 ± 1 μg/kg) plus 0.7–1.4 mg/kg KET (1.1 ± 0.2 mg/kg) was found to be safe and effective for the field conditions associated with this study. The anesthesia produced by this drug combination was very predictable and characterized by a short induction time (3:34 ± 1:20 min : sec), good muscle relaxation, and acceptable physiologic parameters for anesthesia periods ranging from 22:30–35:00 min : sec (31:14 ± 2:50). Within the range of doses used in this study, times to onset of initial effects and recumbency were not dependent on THAI, MED, or KET doses. Anesthesia was rapidly and completely reversed by intravenous injections of naltrexone at 30 times the THAI dosage (0.69 ± 0.19 mg/kg) and atipamezole at about four times the MED dosage (38 ± 14 μg/kg). There was no residual effect from ketamine noted following reversal of THIA and MED and no mortality or morbidity was associated with this anesthetic regimen.

Key words: A3080, anesthesia, atipamezole, hartebeest, ketamine, medetomidine, naltrexone, *Sigmoceros lichtensteinii*, thiafentanil.

Lichtenstein's hartebeest (*Sigmoceros lichtensteinii*) is a conservation dependent species that inhabits savanna and open woodlands in southeastern Africa (Baillie and Groombridge, 1996). It is considered rare throughout its range and is prized within game farms and national parks, which have ongoing conservation programs to protect and propagate it. This species is a fast and agile medium-sized antelope that is difficult to approach (Burroughs, 1993). Hartebeest also will often attack and injure semi-immobilized herd members (Burroughs, 1993). Previous reports of anesthetic techniques for this species combined etorphine and a sedative/neuroleptic such as azaperone or xylazine, but the induction time with these combinations ranged from 8–10 min, which can allow animals to become lost in dense bush prior to recumbency (Pienaar, 1973; Grootenhuis et al., 1976; Kupper et al., 1981; Burroughs, 1993). Prolonged induction also predisposes hartebeest to secondary hyperthermia and excessive muscle exertion that can lead to capture myopathy (Basson and Hofmeyr, 1973). Thiafentanil (THAI) (formerly called A3080) is a synthetic fentanyl derivative with a rapid pronounced opiate agonist activity. It has a much shorter duration of action than carfentanil or etorphine and is only slightly less potent than carfentanil (Stanley et al., 1988, 1989; McJames et al., 1993). Thiafentanil has been demonstrated to shorten induction times when compared to carfentanil in cervids by 26–65% (McJames et al., 1993). Induction times were dose-dependent in studies using THAI in impala (*Aepyceros melampus*) (Janssen et al., 1991, 1993) and in elk (*Cervus elaphus*) (Stanley et al., 1989; McJames et al., 1993). Narcotic antagonists such as naltrexone hydrochloride (NAL) provide rapid and complete reversal of THAI with no reports of renarcotization (Stanley et al., 1988, 1989; Janssen et al., 1993).

Medetomidine hydrochloride (MED) is an imidazole based compound with potent

selective and highly specific agonist activity at both pre- and post-synaptic α_2-adrenoreceptors (Virtanen et al., 1988; Virtanen, 1989). It has an α_2-binding affinity of 10 times that of the commonly used sedative xylazine (Virtanen et al., 1988; Jalanka and Roeken, 1990). Medetomidine is a potent sedative and analgesic with anxiolytic properties (Virtanen, 1989; Jalanka and Roeken, 1990) and at high doses, it has hypnotic or anesthetic effects (Virtanen, 1989). Medetomidine has been shown to provide good myorelaxation with minor physiologic changes in Arabian oryx (*Oryx leucoryx*) (Greth et al., 1993), and when combined with ketamine hydrochloride (KET), has been demonstrated to be effective in a broad range of non-domestic hoofstock (Jalanka and Roeken, 1990). Ketamine produces a synergistic effect when combined with MED (Jalanka and Roeken, 1990) and has been observed to potentiate synthetic opiates (Silvestris and Heck, 1984; Snyder et al., 1992). A combination of etorphine and MED was shown to provide adequate immobilization of Arabian oryx for at least 3 hr (Ancrenaz et al., 1996). A potent and selective α_2-adrenoreceptor antagonist atipamezole hydrochloride (ATI) is highly effective in reversing sedation/anesthesia induced by MED or MED-KET combinations (Virtanen, 1989; Jalanka and Roeken, 1990).

The objective of this study was to determine if the rapid induction potential of THAI could be combined with the potent selective α_2-agonist effects of MED and the synergistic effect of KET to produce a predictable, rapid, balanced field anesthetic regimen for Lichtenstein's hartebeest. The goal was to produce a rapid, smooth anesthetic induction in hartebeest followed by an anesthetic period characterized by good myorelaxation and maintenance of physiologic parameters within acceptable ranges and rapid and complete reversal with NAL and ATI, without the undesirable sequelae of renarcotization or resedation.

This study was conducted on 4 to 5 September 1999 in the Kasungu National Park in Malawi (12°58′S, 33°10′E). Thirteen adult and sub-adult hartebeests (four males and nine females) were studied during a concurrent capture operation for relocation to Liwonde National Park in Malawi. The hartebeests were first herded into a capture boma by helicopter and allowed to calm down for several hours. All animals were in good physical condition, and their pelage and muscle mass was judged to be good for the season and available native vegetation. No obvious signs of disease were seen in the animals. All animals appeared to adapt to the boma and appeared to be relatively calm prior to commencing the study.

The anesthetics used in this study were THIA (A3080, 10 mg/ml, Wildlife Pharmaceuticals, Pty, Karino, South Africa), MED (20 mg/ml, Wildlife Pharmaceuticals) and KET (200 mg/ml, Wildlife Pharmaceuticals) formulated as sterile injectable solutions in multi-dose vials. The dose of THAI, MED, and KET were adjusted based upon a visual evaluation of each animal's weight and success of previous anesthetic procedures. The drugs were delivered by a CO_2 powered remote injection device delivering a 3-ml plastic air pressurized dart with a 40 × 2 mm collared needle (Dan-Inject SA, Skukuza, South Africa) to insure a deep intramuscular injection.

The study was completed over 2 days during daylight hours. All darting was done from outside the capture boma. Once a hartebeest was recumbent and herd mates separated themselves from it, it was carried to a central location outside the boma for monitoring. Initial data collected included time from dart delivery to first signs of drug effect, the time from dart delivery to recumbency, and the time from recumbency to the start of physiologic monitoring (lag time). Physiologic data collected included: heart rate, respiration rate, oxyhemoglobin saturation (SpO_2), indirect arterial blood pressure (systolic, diastolic, and mean), end tidal

CO_2 ($ETCO_2$), and rectal temperature. Heart rate was determined by auscultation of the heart (verified by pulse oximeter and indirect blood pressure monitors), respiration rate by counting chest excursions (verified by $ETCO_2$ monitor), SpO_2 by the use of a portable pulse oximeter (Nellcor-200®, Nellcor, Inc., Haywood, California, USA) with the sensor placed on a shaved portion of the ear or on the tongue, indirect blood pressure by the use of a portable blood pressure monitor (Dinamap Compact Monitor T®, Critikon, Tampa, Florida, USA) with the cuff placed on the metacarpus, $ETCO_2$ by the use of a handheld $ETCO_2$ monitor (7000 Vet/Cap Monitor®, Sensor Devices, Inc., 1801 Airport Road, Suite A, Wauksha, Wisconsin, USA) with its gas sampling port attached to a 10.0 mm endotracheal tube placed in one nostril, and temperature by the use of a thermistor (Dinamap Compact Monitor T®) placed in the rectum. The degree of muscle relaxation and anesthesia quality was subjectively evaluated. Physiologic data were collected initially when the animal first arrived at the monitoring site and then at 5 min intervals for 20 min. The hartebeest were weighed immediately prior to reversal of the anesthetic agents, using a portable hanging scale and sling.

The hartebeest were carried back into the boma, and anesthesia was reversed using intravenous injections of NAL (Trexonil®, 50 mg/ml, Wildlife Pharmaceuticals) at 30 times the THIA dose and ATI (Antisedan®, 5.0 mg/ml, Orion Corp., Orion-Farmos, Turku, Finland) at approximately four times the MED dose. The time interval from injection of reversal agents to standing and completeness of the reversal were recorded. Animals were observed for signs of renarcotization or resedation for 24 hr post-reversal.

The weight range for the study group of Lichtenstein's hartebeest was 138–245 kg (mean ± SD = 176 ± 29 kg). Thiafentanil doses ranged from 11–26 μg/kg (21 ± 4 μg/kg), MED dosages ranged from 5–10 μg/kg (8 ± 1 μg/kg), and KET dosages ranged from 0.7–1.4 mg/kg (1.1 ± 0.2 mg/kg).

The time to first signs of drug effect was uniformly rapid, 1:34 ± 0:35 (min : sec), as was the time to recumbency, 3:34 ± 1:20. Time to first signs of drug effect and time to recumbency were not dependent on doses of THIA, MED, or KET within the range of doses used in this study (linear regression analysis; SigmaStat for Windows Version 2.03, SPSS Inc., Chicago, Illinois, USA). All inductions were similar with each animal quickly developing variable degrees of progressive ataxia that rapidly proceeded to sternal recumbency. Several animals initially exhibited chewing motions, teeth grinding, and some muscle tenseness, but this generally resolved and animals were well relaxed after 5–10 min of recumbency. All animals exhibited excessive salivation during the monitoring period. No instances of aggression from herd mates to darted animals were observed.

The lag time from recumbency to when physiologic monitoring began (time 0) had a narrow range of 3:30–7:29 (5:10 ± 1:13). These relatively uniform lag times allowed for standardization of time points during physiologic monitoring and for comparison of physiologic variables between individual animals.

Measured physiologic parameters remained relatively stable over the 20 min monitoring period so data for each parameter over 20 min are presented as the mean and standard deviation: respiratory rate, 17 ± 6 respirations per minute; heart rate, 60 ± 12 beats per minute; SpO_2, 81 ± 9%; $ETCO_2$, 50 ± 8 mmHg; indirect systolic arterial pressure, 177 ± 30 mmHg; indirect diastolic arterial pressure, 85 ± 19 mmHg; and indirect mean arterial pressure, 121 ± 22 mmHg. Mild to moderate hypoxemia, mild hypoventilation, and mild arterial hypertension were evident throughout the monitoring period. The animals were moderately hyperthermic with rectal temperatures at time 0 ranging from 38.9–41.6 C (40.2 ± 0.8 C) and at the end

of the monitoring period ranging from 38.7–42.4 C (39.9 ± 1.0 C). There was no statistical difference between starting and ending rectal temperatures (*t*-test, $P = 0.378$).

All animals were considered to be in an adequate plane of anesthesia for transport, examination, and for minor clinical procedures such as venipuncture throughout the monitoring period. All animals were safe for assistants to handle, did not struggle or fight, and were subjectively rated as having good generalized muscle relaxation. There was no incidence of regurgitation or other life threatening occurrence during the study. The length of individual anesthetic procedures ranged from 22:30–35:00 (31:14 ± 2:50).

Anesthesia was rapidly and completely reversed in all hartebeest by intravenous injections of NAL at 30 times the THAI dose, 0.36–1.03 mg/kg (0.69 ± 0.19 mg/kg), and ATI at about four times the MED dosage, 22–61 μg/kg (38 ± 14 μg/kg). All animals made smooth and rapid recoveries, with time from administration of antagonists until animals were standing ranging from 0:53–2:51 (1:50 ± 0:37). Hartebeest were judged to be normal within 5 min post-reversal. No signs of renarcotization or resedation were observed for at least 24 hr post-reversal. No morbidity or mortality was associated with this anesthetic trial.

An essential characteristic of a field anesthetic technique is a rapid, smooth, predictable induction (Kreeger, 1996) to prevent long-range movement and potential animal loss and to reduce capture-associated hyperthermia, stress, myopathy, and injury. This is especially true for non-domestic ungulate species in which chemical immobilization is considered difficult or high risk, such as hartebeest. The combination of THIA, MED, and KET at the doses described, consistently produced very rapid onset and induction of anesthesia in boma-confined Lichtenstein's hartebeest. The dose range of THIA, MED, and KET used in this study was very narrow, consequently, a dose-response effect on induction time was not apparent in this study. Rapid induction is also important in this species to reduce the risk of intra-specific aggression triggered by behavioral changes during induction. The induction was also very predictable with animals showing variable degrees of ataxia that quickly progressed to sternal recumbency. The early onset of anesthetic signs along with the anxiolytic qualities of MED is valuable in preventing injury and stress-related sequelae during chemical capture.

One of the authors (Grobler) used THIA, MED, and KET at similar doses used in this study to immobilize three (one male and two female) free-ranging Lichtenstein's hartebeest by helicopter darting. Mean times to onset of effects and time to recumbency were 1:10 ± 0:01 and 3:14 ± 0:04 respectively which, again, emphasizes the rapid effects of this drug combination even in helicopter-chased animals. The procedures on these three hartebeest went smoothly, and they were rapidly and completely reversed by injections of NAL and ATP.

Chemical capture of non-domestic ungulates with potent opiates alone, such as THIA, is often characterized by poor muscle relaxation with consequent hyperthermia, muscle fasciculations or trembling, and compromised ventilation (Burroughs, 1993; Janssen et al., 1993). Medetomidine is known to produce good muscle relaxation in other species (Jalanka and Roeken, 1990; Greth et al., 1993) and, when combined with THIA and KET in this study, induced good generalized muscle relaxation and provided safe handling conditions. The initial chewing motions, teeth grinding, and muscle tenseness seen in some animals during this study probably resulted from the effects of THIA occurring more rapidly than those of MED. Five to 10 min after induction, bruxism stopped and all animals became very relaxed, indicating that the sedative effects of MED had reached a peak.

Heart rate, respiratory rate, SpO_2,

$ETCO_2$, and arterial blood pressure remained relatively constant over the 20 min monitoring period. Animals experienced mild to moderate hypoxemia as suggested by depressed oxyhemoglobin saturation values and mild hypoventilation as suggested by elevated $ETCO_2$ values. Mild arterial hypertension was also evident over the monitoring period as suggested by elevated indirect blood pressure values. Mild to moderate hypoxemia, hypoventilation, and hypertension should be anticipated with the use of this anesthetic combination since both THIA and MED are reported to cause respiratory depression and hypertension (Jalanka and Roeken, 1990; Janssen et al., 1993). Alterations in physiologic values were not considered clinically significant and/or life threatening in this study.

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