


CASE REPORT**Zoo animals**

A retrospective study on the immobilisation of captive chimpanzees (*Pan troglodytes*) at UWEC, Uganda

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Abstract

The study used the records of 188 chimpanzees that were immobilised with medetomidine and ketamine for annual health checks from 1998 to 2020. The initial dose for each animal was estimated as 5 mg/kg ketamine plus 0.05 mg/kg medetomidine administered intramuscularly. When necessary, additional intramuscular top-ups of 5 mg/kg ketamine plus 0.05 mg/kg medetomidine were given. Monitoring started from the moment the animals were on the examination table until they were placed back in their enclosure. All animals were positioned in dorsal recumbency. Physiologic parameters including heart rate (beats per minute), respiration rate (breaths per minute), peripheral oxygen saturation (SpO₂, %) and rectal temperature (°C) were measured. Atipamezole was administered at five times the dose of medetomidine. Time to first sign of sedation, time to recumbency, time from darting to reversal, time to first sign of recovery, time to head up and sternal, and time to standing were also measured.

KEYWORDS

chimpanzee, immobilization, ketamine, medetomidine, retrospective, Uganda

BACKGROUND

Non-human primates, including chimpanzees (*Pan troglodytes*), are often placed under human care for reasons such as habitat loss, rescue from animal trafficking and confiscation as pets. In captivity, these animals may require veterinary interventions, which in turn require chemical immobilisation for the safety of both the personnel and the animal. Remote or hand delivery of parenteral drugs is the prescribed method of immobilising chimpanzees with a number of studies having reported on different drug combinations.^{1–6}

Most commonly, alpha₂-agonists, such as medetomidine, are incorporated with ketamine and have been reported to produce anaesthesia in non-human primates that is characterised by a rapid induction, prolonged and stable immobilisation, excellent relaxation and a calm recovery.^{5–7} This combination is commonly used in captive primates at a dose of 0.03–0.05 mg/kg medetomidine and 3–5 mg/kg ketamine.^{5,6} However, reports on the duration of this anaesthesia are conflicting, with some authors reporting anaesthesia to be short in duration, lasting no longer than 15 minutes in chimpanzees. As a result, subsequent re-dosing or isoflurane administration may be required for longer duration anaesthesia.⁸ Other authors have reported that similar doses have been successfully used in wild animals and produced quick inductions,

stable immobilisations of up to 50 minutes and smooth recoveries.⁹

The main concern when anaesthetising great apes not trained to be handled is the risk to the personnel—the large size and physical strength of species like chimpanzees create the potential for severe human injury as well as the transmission of potentially hazardous zoonotic pathogens through bites and scratches.⁸ Therefore, the use of an effective and safe anaesthetic protocol that produces complete, longer duration immobilisation is of utter importance when working with these species. While there is a body of publications concerning laboratory primates' anaesthesia, there are only a few reports investigating chemical restraint of wild or captive great apes.⁸ This study therefore aimed to report on the retrospective analysis of chimpanzee immobilisation data collected from 1998 to 2020.

CASE PRESENTATION

The study was conducted at the Uganda Wildlife Conservation Education Centre (UWEC) commonly referred to as UWEC-Zoo, located about 3 km from Entebbe International Airport and 40 km from Kampala, the capital city of Uganda. UWEC is a government agency under the Ministry of Tourism, Wildlife and Antiquities and was established in

1952 to house and treat sick, injured, orphaned or confiscated animals. The study used the records of chimpanzee that were immobilised for annual health checks from 1998 to 2020. All non-human primates at UWEC are immobilised annually for routine health checks. These health checks are used to ascertain the physical health status of animals. For example, animals are weighed, dental exam is conducted, blood and faecal samples collected, and any wounds incurred or inflicted by other chimpanzees are treated. Furthermore, animals receive prophylactic treatment such as anthelmintic treatment, disease vaccinations and placement of contraceptive implants. The immobilisation protocol evaluated in this retrospective study was approved by the veterinarians of Uganda Wildlife Conservation Education Centre.

Immobilisations were scheduled in the morning, after a minimum fasting period of 12 hours. Pre-anaesthetic activity level was subjectively assessed as either no activity, low activity, moderate activity, or high activity based on a similar assessment system published by Strong et al. Similarly, the pre-anaesthetic demeanour of the animals was assessed as either being depressed, alert, apprehensive or aggressive. Access to drinking water was provided. The animals were housed individually in small night enclosures. Strict safety precautions were taken at all times. The estimate of bodyweight of each animal for calculation of drug doses was based on the available data of the preceding years together with a subjective visual estimation of current body mass. A combination of medetomidine and ketamine was administered intramuscularly (IM) in the hindleg by a CO₂-driven darting system (Telinject pistol, Vario 1 V, Denmark) using 5 mL compressed gas darts (Telinject, Vario 13-mm darts). Initial doses for all animals were 5 mg/kg ketamine (Alfasan, Kuipersweg, Woerden, Netherlands) plus 0.05 mg/kg medetomidine (Kyron Laboratories, Gauteng, South Africa) based on estimated weight. When necessary, additional IM top-ups of 5 mg/kg ketamine plus 0.05 mg/kg medetomidine were administered. This was done for example when initial darts failed or when signs of arousal occurred. Chimpanzees are intelligent animals with good memories and will often exhibit avoidance behaviour to darting when they have had previous experiences with being darted. To minimise the stress of this in individuals that had been darted on previous occasions, the dart gun was concealed by covering it in a cloth. Additionally, the design of the facility allowed animals to be darted from a hiding point where their view of the person doing the darting was limited as much as possible. It was also important for all personnel involved to remain calm and to speak softly and calmly as not to stress the animals in any way. The perceived stress experienced by the animals was subjectively measured by the pre-anaesthetic demeanour and activity scores. Although the facility does not currently have a system in place to document learning processes with regards to darting, this has been recommended and may hopefully be something that is put in place in future.

Approximately 15 minutes after recumbency was reached and voluntary movement was absent, the animal was transported to a treatment room on a stretcher, weighed and placed on an examination table. Monitoring commenced from the moment the animals were on the examination table until they were placed back in their enclosure. All animals were positioned in dorsal recumbency. Physiologic parameters including heart rate (HR, beats per minute), respiration

LEARNING POINTS/TAKE-HOME MESSAGES

- 2.9–7.1 mg/kg ketamine + 0.03–0.07 mg/kg medetomidine can be successfully used to safely immobilise captive chimpanzees.
- Additional top-up of 5 mg/kg ketamine + 0.05 mg/kg medetomidine can safely be administered to improve or maintain immobilisation in captive chimpanzees.
- Stress and high activity levels before darting may lead to ineffective sedation by immobilising agents and may necessitate the need for higher initial doses or additional top-up doses.
- Immobilisation with medetomidine and ketamine can be safely reversed with administration of atipamezole at five times the dose of medetomidine in chimpanzees.
- Prolonged recoveries may result if animals receive top-up doses of medetomidine and ketamine, and these animals should be monitored accordingly.

rate (RR, breaths per minute), peripheral oxygen saturation (SpO₂, %) and rectal temperature (RT, °C) were measured as often as possible, or at least as close to the beginning and the end of the immobilisation period. HR and RR were measured using a multi-function dual-purpose veterinary stethoscope (3M Littmann Stethoscope, India), and RT using a digital thermometer (Shri-Nathji, India), while SpO₂ was measured using an iHealth fingertip pulse oximeter (iHealth labs, Paris, France). If the SpO₂ of an animal fell below the threshold of 80%, supplemental oxygen was provided via a facemask for a few minutes to assist respiration and improve peripheral oxygen saturation. This is standard protocol for the facility.

At the conclusion of the health checks, the chimpanzees were transported back to their enclosures. Most animals then received atipamezole (Antisedan, Pfizer Animal Health, Finland) by IM injection at five times the dose of medetomidine. When fully recovered, the animals were returned to their groups during the course of the same day.

INVESTIGATIONS

Analysis was done retrospectively on the dataset collected from 1998 to 2020.

OUTCOME AND FOLLOW-UP

The following immobilisation times were measured:

1. Time to first sign (time from darting to first signs of sedation);
2. Time to recumbency (time from darting to final recumbency);
3. Time from darting to reversal (time from darting to when reversals were administered);
4. Time to first sign of recovery (time from injection of reversals to showing first signs of recovery);

TABLE 1 Retrospective results on data collected from captive chimpanzees ($n = 188$) immobilised using ketamine–medetomidine in Uganda from 1998 to 2020.

Parameter	Mean \pm SD	Range	Median (interquartile range)
Estimated bodyweight (kg)	27.24 \pm 15.66	3–55	28 (12, 40)
Actual bodyweight (kg)	28.51 \pm 15.2	4–59	26.05 (15, 41.05)
Actual ketamine dose (mg/kg)	4.72 \pm 0.8	2.9–7.1	4.76 (4.22, 5.13)
Actual medetomidine dose (mg/kg)	0.04 \pm 0.01	0.03–0.07	0.05 (0.04, 0.05)
Time from darting to first sign (minutes)	4.06 \pm 5.09	0.5–38	2 (2, 4)
Time to recumbency (minutes)	8.65 \pm 7.93	0.5–46	5.25 (4, 9.25)
Time from darting to reversal (minutes)	50.7 \pm 31.5	10–157	33 (27, 60)
Time to first sign of recovery (minutes)	9.52 \pm 10.3	0–46	12 (2, 14)
Time to head up and sternal (minutes)	11.86 \pm 10.7	1–46	12 (4, 16)
Time to standing (minutes)	17.59 \pm 15.53	1–62	22 (5, 27)
Heart rate (beats per minute)	81.51 \pm 18.38	48–145	79 (68, 92)
Respiration rate (breaths per minute)	29.56 \pm 12.53	12–99	26 (22, 34)
SpO ₂ (%)	92.76 \pm 5.36	71–100	94 (90, 97)
Rectal temperature (°C)	36.05 \pm 1.28	30–38.8	36.3 (35.5, 36.8)

5. Time to head up and sternal (time from injection of reversals to when the head is lifted, and the body is sternal); and
6. Time to standing (time from injection of reversals to when the animal is standing).

RESULTS

Data from a total number of 188 chimpanzee immobilisations were collected. All immobilising agents were administered into the thigh muscle region. Of the 188 immobilisations, 65 animals required medetomidine and ketamine top-ups, while the remaining 123 immobilisations were sufficient without additional top-ups. The results of the retrospective analysis of the data are presented in Table 1. The ambient temperatures during the periods when animals were immobilised ranged from 20°C to 27°C. Animals ranged in age from 8 months to 50 years, with a total of 109 female immobilisation events, 70 male immobilisation events and nine hermaphrodite immobilisation events. It must be noted that only a single animal at the facility was a confirmed hermaphrodite but that this individual was immobilised numerous times over the course of the data collection period.

As physiological monitoring and data collections occurred at different times after darting during the various immobilisations, only means and standard deviations are reported for heart rate, respiration rate, SpO₂ and rectal temperature.

The pre-anaesthetic activity level and demeanour of the animals are presented in Table 2.

DISCUSSION

The doses reported in this study produced reliable inductions, stable immobilisations and good, uneventful recoveries. They are similar to what have been reported for both captive and free-ranging chimpanzees.^{5,9} This has also been the standard protocol for chimpanzee immobilisations at UWEC for over 20 years and has consistently proven to be reliable. Top-ups

of 5 mg/kg ketamine and 0.05 mg/kg medetomidine when required also proved safe and provided stable immobilisations with no apparent adverse effects. While the cardiovascular effects of medetomidine can be a concern in compromised chimpanzees, the lack of adverse effects in this study may be indicative of the wide margin of safety of ketamine in this species. Although induction times were quite variable, this is likely due to the high rate of animals that required additional top-ups, possibly due to poor dart placement or failure of the dart to fully inject. Interestingly, only six animals of the total 65 immobilisations that took longer to become fully immobilised to a level that was safe for handling and required additional top-ups were assessed as having low activity levels before darting. Additionally, only two out of these 65 immobilisations assessed animal's demeanour as depressed. The remaining animals demonstrated signs of increased activity or increased levels of stress before darting. It has been noted in animals that failure to achieve optimum sedation with alpha₂-agonists, such as medetomidine, may be due to pre-existing stress, fear, excitement or pain. This is due to the fact that stress results in an increase in endogenous catecholamine levels that can interfere with medetomidine-induced reductions in excitatory neurotransmitter release, possibly resulting in ineffective sedation.¹⁰ The levels of excitement and pre-anaesthetic activity may therefore partly be responsible for the need for additional top-ups of medetomidine and ketamine in the current study.

TABLE 2 Pre-anaesthetic activity level and demeanour of chimpanzees immobilised with a combination of medetomidine and ketamine ($n = 188$).

Pre-anaesthetic activity level (n)			
None	Low	Moderate	High
0	25	130	33
Pre-anaesthetic demeanour (n)			
Depressed	Alert	Apprehensive	Aggressive
6	162	5	15

Recovery times were similar as those that have been previously reported when medetomidine was reversed with IM atipamezole in chimpanzees.^{5,9} Not surprisingly, Lewis found that recovery in chimpanzees immobilised with medetomidine–ketamine but reversed with half intravenous (IV) and half IM atipamezole, recovered in less than half the time compared to when atipamezole was given IM only. IV-only administration of atipamezole is generally not recommended because of the risk of rapid changes in cardiovascular function and increased sympathetic activity.^{11,12} Rapid reversal of potentially aggressive species may also pose a danger to handlers and personnel. The atipamezole doses used in the current study were also similar as reported for primate species.^{5,9,13–15} High doses of atipamezole have been reported to result in side effects such as hyper-salivation, diarrhoea and tremors.^{16,17}

The heart rate of a fully conscious chimpanzee has previously been reported as 159–204 beats per minute.¹⁸ The heart rate of free-ranging and captive chimpanzees immobilised with medetomidine and ketamine has been reported as 56–99 beats per minute, while that of captive chimpanzees immobilised with ketamine and xylazine has been reported as 79–91 beats per minute.^{9,18,19} Sleeman²⁰ also reported the mean heart rate range of chimpanzees under various anaesthetic regimens to be 60–200 beats per minute. It therefore appears that the range reported in the current study is clinically normal for healthy chimpanzees. Similarly, respiration rates of 20–60 breaths per minute have been reported to be a physiologically normal range for immobilised chimpanzees.^{20,21} Only six chimpanzees in the current dataset exhibited respiration rates greater than 60 breaths per minute, indicating that some hyperventilation occurred in these animals. Interestingly, all the recorded respiration rates that were greater than 70 breaths per minute were recorded within the first 10 minutes of monitoring the animals. Additionally, the pre-anaesthetic activity level of the six animals that exhibited signs of hyperventilation was moderate to high, with all six animals exhibiting alert demeanour. It can therefore be postulated that pre-anaesthetic stress may have contributed to this initial hyperventilation observed at the beginning of immobilisation. Overall, all the animals displayed signs of stable ventilation with good respiration and good peripheral oxygen saturation maintained throughout immobilisation. A few animals did exhibit low SpO₂ values less than 80%, and in such cases, supplemental oxygen was provided via a facemask for a few minutes to assist respiration and improve peripheral oxygen saturation. This would account for the few instances in which SpO₂ values of 100% were measured. However, the respiration rates of all these animals remained greater than 20 breaths per minute, and none of the animals exhibited prolonged periods or poor peripheral oxygen saturation. Inadequate ventilation, likely due to drug-induced effects, may therefore have only been temporary or alternatively it may be that improper pulse-oximetry probe placement may have resulted in inaccurate readings.

Overall, the combination of 2.9–7.1 mg/kg ketamine with 0.03–0.07 mg/kg medetomidine, administered via projectile dart proved effective in producing rapid and consistent immobilisations in chimpanzees under human care of a wide range of ages and weights. The combination was reliably reversed with IM atipamezole administration at five times the dose of

medetomidine, with no observable adverse effects. Only six chimpanzees took longer than 20 minutes to recover, with one chimpanzee taking up to 62 minutes and another chimpanzee taking 43 minutes to recover. All six animals that took more than 20 minutes to recover had received top-up doses of medetomidine and ketamine so the prolonged recoveries were likely due to the residual effects of ketamine as the ketamine portion of the combination was not reversed.

AUTHOR CONTRIBUTIONS

James Watuwa: data collection, interpretation and writing of manuscript. Racheal Mbabazi, Celsus Sente, Victor Musiime, Barbara Alapo, David Musingo and James Musunguzi: data collection and interpretation. Liesel Laubscher: data collection, analysis, interpretation and writing of manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

FUNDING INFORMATION

Data used for this retrospective study were collected from routine health examinations on chimpanzees. These examinations were funded by the Uganda Wildlife Conservation Education Centre (UWEC), commonly referred to as UWEC-Zoo.

ETHICS STATEMENT

This study was done retrospectively on data collected during routine health examinations, so no ethical approval was obtained. The protocol used for the health examinations was approved by the UWEC research committee.

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MULTIPLE-CHOICE QUESTION

Which two medicines were used in combination to immobilise the chimpanzees?

POSSIBLE ANSWERS TO MULTIPLE-CHOICE QUESTION

- a. Tiletamine + zolazepam
- b. Medetomidine + ketamine
- c. Xylazine + ketamine
- d. Detomidine + ketamine

CORRECT ANSWER

- b. Medetomidine + ketamine