

Total Injectable Anesthesia of Dogs and Cats for Remote Island Veterinary Sterilization Clinic

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Abstract

Background: Sterilization clinics may occur in remote places where anesthesia machines and compressed oxygen are unavailable. This study evaluated the efficacy of total injectable anesthesia in dogs and cats presented for sterilization on Isabela Island, Galápagos, Ecuador.

Results: A total of 100 animals were sterilized; 26 female cats (FC), 22 male cats (MC), 28 female dogs (FD), and 24 male dogs (MD). FC were anesthetized with dexmedetomidine (20 mcg/kg), ketamine (8 mg/kg) and hydromorphone (0.1 mg/kg) IM. MC were anesthetized with dexmedetomidine (15 mcg/kg), ketamine (5 mg/kg) and hydromorphone (0.1 mg/kg) IM. Inadequate anesthesia in cats was treated with alfaxalone (1mg/kg) IM. All cats were administered meloxicam at 0.3mg/kg SQ. FD were anesthetized with dexmedetomidine (15 mcg/kg), ketamine (7-10 mg/kg) and hydromorphone (0.1 mg/kg) IM. MD were anesthetized with dexmedetomidine (15mcg/kg), ketamine (5 mg/kg) and hydromorphone (0.1 mg/kg) IM. All dogs had IV catheter and endotracheal tube placed. If SpO₂<90%, dogs had assisted ventilation via Ambu bag. Inadequate anesthesia in dogs was treated with alfaxalone (1mg/kg) IV. All dogs were administered meloxicam at 0.2 mg/kg SQ. Following surgery, atipamezole (0.05-0.1mg/kg) IM was administered to any patient that did not have voluntary movement. All patients survived and were discharged. Less than 25% of cats and male dogs required supplemental anesthesia. Fifty seven percent of female dogs required supplemental anesthesia. More than 89% of patients (in any group) required atipamezole administration. One cat recovered with agitation and hyperthermia (41.1C/ 106F). Some dogs required ventilatory assistance to remain normoxemic while anesthetized.

Conclusion: Total injectable anesthesia can be accomplished for remote location sterilization clinics with minimal morbidity.

Introduction

Unwanted reproduction in dogs and cats negatively affects communities by contributing to: the spread of disease, aggression to humans, nuisance behavior (e.g. getting into garbage) and predation of other species (e.g. wild birds). Sterilization of both pet and feral dog and cats is often needed in remote or underdeveloped areas, where access to veterinary medicine is limited or absent. Spay-neuter programs are offered in a variety of styles in these locations via mobile clinics, but access to facilities and equipment is variable. The Association of Shelter Veterinarian has offered guidelines to assure consistent care to dogs and cats presented to these clinics(1) (2). Unfortunately, these guidelines assume access to equipment that might not be possible in some remote locations, such as compressed gasses (e.g. oxygen) or anesthesia machines(1) (2).

The Galapagos Islands are an archipelago off the coast of Ecuador. While renowned for their interesting and diverse wildlife, many of the islands have large populations of intact dogs and cats that predate indigenous and sometimes endangered wildlife species (e.g. birds, turtles, marine iguanas)(3–6). Isabela Island is the largest of the Galapagos Islands, but has a population of only about 1800 people (7), and is

accessible primarily by boat. While it is a permanent home to some, and a tourist destination for others, it does not have a human medical facility. Therefore, on islands such as this, getting all the equipment necessary for a sterilization clinic presents a significant logistical issue. From the planning stages, it was considered improbable to be able to transport an anesthesia machine and/or oxygen tanks (or the ability to refill them) to Isabela Island. Therefore, by necessity, the team was required to plan the clinic with use of injectable anesthetics only. While anesthesia in high volume, low cost spay/neuter clinics has been studied (8, 9), the majority of those studies were done in non-remote places and in locations where resources are available if needed, even though not routinely used (e.g. anesthetic machines/oxygen). Conversely, there is a paucity of information regarding anesthesia management and complications in remote location spay/neuter clinics where rescue use of oxygen and or inhalant anesthetics are not available. The goal of this study was to document the anesthetic protocols used in a remote location spay neuter clinic as well as any complications that occurred. We hypothesized that it is possible to anesthetize dogs and cats in a remote location for OVH and neuter procedures with minimal morbidity.

Materials And Methods

In June of 2016 a team of 14 volunteers from the USA who all work within the veterinary community traveled to Isabela Island, Galapagos, to provide sterilization for any dog or cat (pet or feral). The team consisted of nine veterinarians, one licensed veterinary technician, two veterinary assistants, and two general assistants. Of the 14 members, one veterinarian and one general assistant were fluent in Spanish.

A local organization, the Intercultural Outreach Initiative, provided advertisement for the clinic as well as a building equipped with electricity and cold water. All equipment and supplies were transported by the volunteers via boat to the island.

Informed consent in writing was provided by the owners or guardians for all animals that were sterilized. At least one translator was present with each owner/guardian during the consent process. Following admission, each patient has a physical examination by an attending veterinarian, who decided if the patient was healthy enough for anesthesia and sterilization. Each animal was weighed with a hanging luggage scale. Four anesthetic protocols were developed by a veterinary anesthesiologist (LPP) for each species and gender (Table 1). Dogs and cats were sterilized in order of arrival. All animals deemed healthy enough for surgery were sterilized within the hours of the clinic over one week. The total number of animals sterilized (100) was not chosen, but rather was the result of patients presented to the clinic and those deemed appropriate for surgery.

Table 1
Anesthetic Drug Dosages

Procedure	Initial Anesthetic Drugs	Rescue Anesthetic Drugs	Adjunct Analgesics	Reversal
Cat OVH	Dexmedetomidine: 20 mcg/kg IM Ketamine: 8 mg/kg IM Hydromorphone: 0.1 mg/kg IM	Alfaxalone 1 mg/kg IM or Dexmedetomidine 5mcg/kg + ketamine 4 mg/kg IM	Meloxicam: 0.3 mg/kg SQ	Atipamezole 0.05 mg/kg IM
Cat Neuter	Dexmedetomidine: 15 mcg/kg Ketamine: 5 mg/kg Hydromorphone: 0.05 mg/kg	Alfaxalone 1 mg/kg IM or Dexmedetomidine 5mcg/kg + ketamine 4 mg/kg IM	Meloxicam: 0.3 mg/kg SQ	Atipamezole 0.05 mg/kg IM
Dog OVH	Dexmedetomidine: 15 mcg/kg IM Ketamine: 7– 10 mg/kg IM Hydromorphone: 0.1 mg/kg IM	Alfaxalone 1 mg/kg IV	Meloxicam: 0.2 mg/kg SQ	Atipamezole 0.1 mg/kg IM
Dog Neuter	Dexmedetomidine: 15 mcg/kg IM Ketamine: 5– 7 mg/kg IM Hydromorphone: 0.1 mg/kg IM	Alfaxalone 1 mg/kg IV	Meloxicam: 0.2 mg/kg SQ	Atipamezole 0.1 mg/kg IM

Alfaxalone, Alfaxan, 10 mg/ml, Jurox, Rutherford, NSW, Australia

Atipamezole; 5 mg/ml, Pfizer Animal Health, NY, NY, 10017

Dexmedetomidine hydrochloride, 500 mcg/ml; Pfizer Animal Health, NY, NY, 10017

Hydromorphone HCL, 1 mg/ml, Baxter Healthcare Corporation, Deerfield IL

Ketamine; 100 mg/ml, Fort Dodge Animal Health, Fort Dodge, Iowa, 50501

Meloxicam 5 mg/ml, (Boehringer Ingelheim Vetmedica, St Joseph MO 64506

Additional considerations for the protocols included behavior of feral patients, potential parasite burdens/occult disease, and the lack of anesthesia machines or medical oxygen.

Following IM drug administration and induction of anesthesia, each patient was assessed every 5 minutes for physiologic stability by monitoring HR, RR, mucus membrane color, and pulse oximetry (SpO₂) (Nonin 8500, Nonin Medical, Inc. Plymouth, Minnesota) however, not all data was consistently

recorded. One oscillometric blood pressure (BP) monitor (Cardell 9402, Sharn Veterinary In, Tampa, FL 33618) was available, and BP was intermittently assessed at the discretion of the anesthesiologist (LPP), but the values were not consistently recorded. All dogs had an endotracheal tube placed and an Ambu bag was used to provide assisted ventilation for all dogs where SpO₂ < 90%. All dogs had an appropriate sized cephalic catheter aseptically placed for additional drug administration. Cats were administered additional drugs IM. Any patient that was deemed too light, or had voluntary movement before or during surgery, was administered additional drugs. All patients were appropriately shaved and aseptically prepared for surgery. All surgeries were performed by a DVM. Up to 4 animals were sterilized simultaneously, on separate tables at least 2.5 meters apart. Pregnancy status was recorded during surgery. Following surgery, each patient was administered atipamezole if they did not have spontaneous movement after surgery and/or extubation. All patients were observed until fully recovered (sternal with head up). Time from injection of anesthetic to start of surgery, duration of surgery, total patient time (from injection of anesthetic drugs to full recovery), and recovery rectal temperature were recorded for each patient.

Results

A total of 100 patients were sterilized. Temperature in the connected surgery and recovery rooms ranged from 79.2–83.4 F (26.2–28.8 C). Signalment and pregnancy status for all patients are presented in Table 2.

Table 2: Signalment and pregnancy status of all patients

Age and weight are presented as median and range.

Group	n	Reported Age (yr)	Pediatric (< 16 weeks)	Weight (kg)	Pregnant
Feline OVH	26	0.5 (.17 – 3)	10 (38%)	2.2 (1.1–3.5)	3
Feline Neuter	22	1 (0.25–4.5)	6 (27%)	2.5 (1.2–4.5)	n/a
Canine OVH	28	1.3 (.25 – 7)	1 (4%)	12.5 (3–25)	2
Canine Neuter	24	1.4 (.17 – 3)	5 (21%)	14.7 (2.3–25)	n/a

All patients survived anesthesia and surgery and were discharged. Many of the dogs required assisted ventilation to remain normoxemic (SpO₂ > 90), however, the number of dogs needing ventilatory assistance was not recorded. Time from anesthetic injection to start of surgery, surgery time, total patient time, and rescue drugs required are presented in Table 3.

Table 3: Duration of anesthesia, surgery, total clinic time, and rescue drugs

Times are presented as median and range

Group	n	Time from drug injection to start of surgery (min)	Surgery time (min)	Number of times additional drugs needed*	Total patient time (min)
Feline OVH	26	15 (7–35)	26 (12–46)	7/26 = 27% Alfaxalone IM n = 6 (once) Alfaxalone IM n = 3 (twice) Dexmedetomidine + ketamine IM n = 1 (once)	55 (35–120)
Feline Neuter	22	11 (3–22)	2 (1–6)	1/22 (1.2%) Dexmedetomidine + ketamine IM n = 1 (once)	35 (14–69)
Canine OVH	28	24 (13–37)	34.5 (21–60)	16/28 (57%) Alfaxalone IV n = 12 (once) Alfaxalone IV n = 2 (twice) Alfaxalone IV n = 1 (thrice)	72 (56–107)
Canine Neuter	24	25 (17–31)	18 (10–40)	2/24 (8%) Alfaxalone IV n = 2 (once)	58 (38–120)

* Rescue drugs were given when initial dosing was insufficient to maintain anesthesia.

The need for reversal with atipamezole, Reversal drug requirements, duration of recovery from reversal and recovery temperature are presented in Table 4.

Table 4 Reversal drug requirements, duration of recovery from reversal and recovery temperature

Time and temperature are presented as median and range

Group	n	Time from reversal to recovery (min)	Patients requiring reversal	Temperature at recovery (F/C)
Feline OVH	26	12 (3–60)	24/26 (92%) Atipamezole IM n = 24 (once)	99.1 (95.7–106.0) F 37.3 (35.4–41.1) C
Feline Neuter	22	20 (4–50)	22/22 (100%) Atipamezole IM n = 21 (once) Atipamezole IM n = 1 (twice)	101.9 (99–102.7) F 38.8 (37.2–39.3) C
Canine OVH	28	12 (4–30)	25/28 (89%) Atipamezole IM n = 24 (once) Atipamezole IM n = 1 (twice)	102.6 (97.3–104.1) F 39.2 (36.3–40.1) C
Canine Neuter	24	14 (8–83)	22/24 (92%) Atipamezole IM n = 20 (once) Atipamezole IM n = 2 (twice)	102.3 (101.2–104) F 39.1 (38.4–40.0) C

Following OVH, one of the cats had an agitated recovery and was hyperthermia (106F/41.1C). The first three dogs being neutered had dysphoric recoveries. Subsequent dogs had the ketamine dosage reduced to 5 mg/kg which resulted in no further dysphoric recoveries. Three dogs having an OVH had dysphoric recoveries and were treated with 0.01 mg/kg IV acepromazine IV (Acepromazine, Vedco Inc, Saint Joseph Missouri) which resolved the dysphoria. Two dogs being neutered had seizure-like activity during induction. Seizure activity was treated in both dogs with IV alfaxalone at 1–2 mg/kg; both stopped seizing and recovered uneventfully. The remaining dogs and cats recovered well, with no overt signs of pain/discomfort.

Antibiotic, anthelmintic, and TGH (to go home) analgesia were also provided for many patients of this project, but that data is outside the scope of this paper.

Discussion

The data presented here supports that anesthesia for spay/neuter clinics can be accomplished in remote locations where anesthesia machines and/or oxygen is not available. Furthermore, this study has evaluated anesthetic protocols that produced rapid unconsciousness, but allowed for reversal and rapid recovery of patients. This is important in many remote locations, as there are few if any recovery cages/holding areas, some of the patients are feral, and the longer the patient remain in the clinic's care, the less patients that can be seen per day. Total patient time in the clinic was approximately 1 hr, with cat neuters requiring the shortest stay and dog OVH requiring the longest.

Surgery time ranged from 1 min to 1hr. This made estimation of IM drugs needed difficult. Not surprisingly, 1% of cats being neutered needed rescue anesthetics while 57% of dogs undergoing an OVH required additional anesthetics. In cats that were inadequately anesthetized during surgery, alfaxalone IM provided a rapid deepening of anesthesia. Intramuscular alfaxalone has been evaluated in cats for physiologic stability and PK/PD profiles (10, 11). When administered to cats at 5 mg/kg IM, cats showed good physiologic stability, but recovery was considered behaviorally poor (10). In a different study, IM alfaxalone at the same dosage was shown to reach peak concentration (Tmax) in ~ 22 min (11) The cats in this study did not show any unpleasant recovery characteristics, likely due to the smaller dosage used in this study (1 mg/kg IM). Intramuscular alfaxalone worked rapidly enough to be considered a good choice for rescue anesthesia during a surgical procedure in a cat. Based on the Tmax of ~ 22 min, it was unexpected, but repeatable that the dose and route was sufficient. This was likely due to being used in combination with other CNS depressants. If a cat was considered too responsive to continue surgery, stimulation was stopped and IM alfaxalone was administered. Subjectively, IM alfaxalone appeared to work faster than IM dexmedetomidine + ketamine. For dogs too responsive for surgery, alfaxalone IV provided suitable conditions for canine OVH and neuter anesthetic maintenance. This agrees with data showing that following premedications, a constant rate infusion (CRI) of alfaxalone produced suitable anesthesia conditions for dogs undergoing OVH (12). However, in both the Suarez study and in this one, many of the dogs required assisted ventilation to remain normoxic (12).

Due to the lack of boarding space, and the potential for patients to be unsupervised outside, any animal that was not able to walk was administered atipamezole. While the loss of analgesia was considered, there is evidence in cats that reversal with atipamezole did not affect post-operative analgesia in cats that also received an opioid and ketamine as was used in this study(13). Additionally, all the animals received an NSAID to supplement analgesia. The vast majority of patients required reversal of dexmedetomidine with atipamezole (89–100% of groups). In the first three dogs that were neutered, the reversal resulted in an agitated/dysphoric recovery. Ketamine at anesthetic dosages are associated with a high incidence of agitation in the recovery period in humans and veterinary patients (14, 15). Anesthesiologists often combine administration of ketamine with other CNS depressants such as benzodiazepines and alpha-2 adrenergic agonists to balance the risk of an agitated recovery from anesthesia (15). Thus, the most likely reason for the agitation following administration of atipamezole in those dogs (and in some cats) was loss of CNS depression from dexmedetomidine, which was balancing the behavioral effects of ketamine in the relatively shorter neuter procedures. Immediately following the three dysphoric dog neuter recoveries, the anesthesiologist decreased the dosage of ketamine from 7 mg/kg to 5 mg/kg and none of the subsequent neuters had dysphoric recoveries. The majority of patients were efficiently reversed with one dose of atipamezole. Only four patients required second doses (feline neuter (n = 1), canine OVH (n = 1), canine neuter (n = 2). Following OVH, three dogs had demonstrated dysphoric recoveries. All three dogs were treated with acepromazine which successfully calmed them. In retrospect, it might have been possible to decrease the ketamine dose in OVH dogs too, and use then more alfaxalone for intraoperative maintenance. However, of the 28 canine OVH performed, only three had dysphoric recoveries (11%).

Body temperature during recovery ranged from 95.7–106 F (35.4–41.1 C). Inspection of Table 4 showed that the majority of patients remained normothermic. This was likely due to the combination of a warm surgery /recovery environment, the lack of cold anesthetic gases, and the rapid time of surgery/ anesthesia. One cat did become significantly hyperthermic (106F, 41.1C). Hydromorphone has been implicated in post anesthesia hyperthermia in cats (16), but it is unclear in this cat if the agitation was the cause or the result of the hyperthermia. The cat was monitored during recovery and both the hyperthermia and agitation resolved without treatment.

Two dogs being neutered had seizure-like activity during IM induction of anesthesia. Both dogs showed convulsive type behavior with loss of responsiveness, but neither dog became incontinent during the episode. Ketamine administration does enhance seizure like electroencephalogram waveforms (17), and it has been implicated in causing seizures in a variety of veterinary species (15). Therefore it is possible that both dogs did have seizures following high dose ketamine administration. However, it is also possible that unbalanced absorption of ketamine and dexmedetomidine following IM administration might have resulted in an exaggerated Stage 2 plane of anesthesia (involuntary excitement) which appeared seizure-like and the loss of consciousness was due to anesthesia induction. Both of those dogs muscle movement stopped after IV alfaxalone administration and both dogs recovered uneventfully.

Based on pulse oximetry, all the dogs and cats remained normoxemic. However, many of the dogs required assisted ventilation with an Ambu bag and endotracheal tube to maintain normoxemia. Placing and securing an endotracheal tube did not appreciably increase total patient time and proved important in patients where anesthesia was being maintained with injectable drugs, a situation that can result in hypoventilation or apnea. While all of the patients survived to discharge from the clinic, this project did not consistently assess of the physiologic variables that are important during anesthesia, such as ventilation, blood pressure, etc. Physiologic assessment of dogs and cats anesthetized and sterilized with these protocols needs to be done.

Although pain scoring was not recorded, all patients were evaluated at recovery and before discharge for pain/discomfort. Aside from the dysphoric recoveries, the remaining patients appeared comfortable at extubation and again at discharge.

Limitations of this study included: variability within each group in patient age and size, variability with four different surgeons, and varying health of patients. However, since this type of variability is expected in a remote-clinic setting, the overall success of the anesthetic plans with the variability is promising.

Conclusion

Total injectable anesthesia is feasible for remote location sterilization of dogs and cats with minimal morbidity.

Declarations

Ethics approval and consent to participate: This manuscript did not have an ethics panel approval, since it is a retrospective evaluation of veterinary clinical practice (commonly used drugs and commonly performed surgeries).

Consent for publication: All authors have reviewed the manuscript and agree to consent for submission

Availability of data and material: All data generated or analyzed during this study are included in this published article.

Competing interests: Lysa Posner is a Section Editor for BMC Veterinary Research

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Authors' contributions

Lysa Pam Posner: PI, patient care, data collection, data interpretation, manuscript preparation

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Diane Deresienski: patient care, data collection, manuscript preparation

Kristie Mozzachio: patient care, data collection, manuscript preparation

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Gregory Lewbart: patient care, data collection, manuscript preparation

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Abbreviations

FC: female cat

MC: male cat

FD: female dog

MD: male dog

SQ: subcutaneous

OVH: ovariectomy

IM: intramuscular

IV: intravenous

HR: heart rate

RR: respiratory rate

SpO₂: saturation of hemoglobin by oxygen

TGH: to go home

PK/PD: pharmacokinetics/ pharmacodynamics

DRI: constant rate infusion

CNS: central nervous system

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