



Perioperative mortality in cats and dogs undergoing spay or castration at a high-volume clinic



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ARTICLE INFO

Article history:

Accepted 25 May 2017

Keywords:

Shelter medicine
Canine
Feline
Ovariohysterectomy
Castration

ABSTRACT

High volume spay–neuter (spay–castration) clinics have been established to improve population control of cats and dogs to reduce the number of animals admitted to and euthanized in animal shelters. The rise in the number of spay–neuter clinics in the USA has been accompanied by concern about the quality of animal care provided in high volume facilities, which focus on minimally invasive, time saving techniques, high throughput and simultaneous management of multiple animals under various stages of anesthesia. The aim of this study was to determine perioperative mortality for cats and dogs in a high volume spay–neuter clinic in the USA. Electronic medical records and a written mortality log were used to collect data for 71,557 cats and 42,349 dogs undergoing spay–neuter surgery from 2010 to 2016 at a single high volume clinic in Florida. Perioperative mortality was defined as deaths occurring in the 24 h period starting with the administration of the first sedation or anesthetic drugs. Perioperative mortality was reported for 34 cats and four dogs for an overall mortality of 3.3 animals/10,000 surgeries (0.03%). The risk of mortality was more than twice as high for females (0.05%) as for males (0.02%) ($P=0.008$) and five times as high for cats (0.05%) as for dogs (0.009%) ($P=0.0007$). High volume spay–neuter surgery was associated with a lower mortality rate than that previously reported in low volume clinics, approaching that achieved in human surgery. This is likely to be due to the young, healthy population of dogs and cats, and the continuous refinement of techniques based on experience and the skills and proficiency of teams that specialize in a limited spectrum of procedures.

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Introduction

An estimated 6–8 million stray and unwanted dogs and cats enter animal shelters in the USA each year at a cost to taxpayers and charity donors of \$2–3 billion.^{1,2} This is a decrease from 13 million in 1973, a reduction that is attributed primarily to increasing acceptance and access to spay–neuter (spay–castration) surgery. Nevertheless, approximately 3 million unwanted dogs and cats are still euthanized in shelters each year, of which 80% are believed to be healthy and treatable. Whereas national surveys

estimate that 83% of pet dogs and 91% of pet cats are spayed or neutered, only 10% of shelter animals are already sterilized at the time of admission. National surveys are reported to under-represent the 23 million pets estimated to live in underserved communities, of which only 13% have been spayed or neutered and only 23% have been seen by a veterinarian.² The cost of care is a barrier for many families in obtaining spay–neuter services, particularly those in lower income brackets (Chu et al., 2009; Benka and McCobb, 2016; White et al., 2017).

Spay–neuter surgery of dogs and cats gained acceptance by the public and the veterinary profession as a common preventive health procedure as response to pet overpopulation in the 1970s (Scarlett et al., 2002; Kustritz, 2007). Most surgeries were initially performed in private veterinary practices. As demand grew to perform more surgeries, to operate on younger animals, to ensure adopted animals were sterilized prior to leaving shelters and to care for pets in underserved communities, nonprofit and municipal organizations began to offer spay–neuter surgery. The 1990s saw a proliferation of clinics specifically focused on the provision of

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¹ See: ASPCA, 2017. Pet statistics. In: How Many Pets are in the United States? How Many Animals are in Shelters? www.aspc.org/animal-homelessness/shelter-intake-and-surrender/pet-statistics (accessed 25 January 2017).

² See: HSUS, 2017. Pets by the Numbers: U.S. Pet Ownership, Community Cat and Shelter Population Estimates. www.humanesociety.org/issues/pet_overpopulation/facts/pet_ownership_statistics.html (accessed 25 January 2017).

spay–neuter surgery with specialized teams capable of performing dozens of surgeries per day.³ Most of these clinics were operated by non-profit organizations, with a smaller proportion of for-profit and governmental spay–neuter clinics. Clinics utilize various business practices for targeting animals most at risk for reproduction or entering the animal shelter system, including subsidized services or restricting care to clients with certain income levels. Collectively, spay–neuter clinics perform more than a million surgeries per year in the USA (Y.K. Rigdon-Brestle personal communication).

The rise in spay–neuter clinics was accompanied by concern about the quality of animal care provided in high-volume facilities,^{3,4} which focus on minimally invasive time-saving techniques (Miller et al., 2016), high throughput, and management of multiple animals under various stages of anesthesia at the same time. In 2008, a task force convened by the Association of Shelter Veterinarians (ASV) published the first standards of care guidelines for spay–neuter procedures (Looney et al., 2008). The guidelines introduced a new term called high quality high volume spay–neuter (HQHVSN), which was defined as ‘efficient surgical initiatives that meet or exceed veterinary medical standards of care in providing accessible, targeted sterilization of large numbers of cats and dogs to reduce their overpopulation and subsequent euthanasia.’ The guidelines were updated by Griffin et al. (2016), stating that, ‘While recognizing the importance of high-volume spay–neuter services, the ASV remains committed to the delivery of high-quality care to each individual animal.’

The incidence of fatal complications associated with spay–neuter surgery is largely unknown. The few published reports available primarily include procedures performed by veterinarians in private practices or by veterinary students in training programs (Pollari et al., 1992; Pollari and Bonnett, 1996; Brodbelt, 2009; Adin, 2011). The aim of this study was to determine the perioperative mortality rate for cats and dogs in a HQHVSN clinic.

Materials and methods

Clinical procedures

All surgical procedures were performed at an HQHVSN clinic operated by a non-profit organization in Florida, USA (Humane Society of Tampa Bay), using procedures designed to comply with medical care guidelines for spay–neuter programs established by the Association of Shelter Veterinarians (Griffin et al., 2016). A surgical preparation room adjacent to a separate operating room with multiple surgical stations was housed in a dedicated area of a full service non-profit veterinary clinic. The clinic was accredited by the American Animal Hospital Association. Cats and dogs admitted to the spay–neuter clinic included privately owned pets, animals belonging to rescue groups and unowned stray and feral community cats admitted for trap–neuter–return (TNR) surgery. Animals housed in the organization’s animal shelter had spay–neuter surgery in a separate facility. One day each week was typically reserved for 80–100 community cat spay–neuter surgeries performed by a single surgeon. On four days of the week, two surgeons performed spay–neuter surgery for a combined total of approximately 25–45 cats and 13–27 dogs.

Veterinarians performed physical examinations on owned pets on the day of surgery and admitted them if they were judged to be in adequate condition for elective surgery. Although some animals with mild health conditions, such as community cats with upper respiratory infections, were admitted if the benefits of sterilization were deemed to outweigh the risks of delaying surgery, the animals were generally healthy. Animals that were initially too fractious to be safely handled were examined after premedication. Community cats in traps received a visual assessment prior to induction of anesthesia, followed by a physical examination when they were safely immobilized. Anesthesia procedures varied over time and were adjusted to address the needs of individual animals, the preferences of the surgeons, and drug availability. At the time of data collection in September 2016, dogs were typically pre-medicated with butorphanol and dexmedetomidine intramuscularly, followed by intravenous induction with propofol or ketamine and midazolam, endotracheal intubation and maintenance with isoflurane in oxygen. Premedication and induction agents were administered to cats concurrently intramuscularly, including ketamine, dexmedetomidine and butorphanol for pet cats, and ketamine and dexmedetomidine for community cats in traps, followed by maintenance with isoflurane in oxygen by mask or endotracheal intubation. Local anesthesia was provided as a bupivacaine line-block of the incision site for females and cryptorchid males, and a bupivacaine intratesticular block for routine castrations. Anesthesia was monitored with a pulse oximeter and an apnea monitor in conjunction with manual evaluation of heart rate, respiratory rate, mucous membrane color, eye position and jaw tone. Depending on the animal’s age and condition, non-steroidal anti-inflammatory drugs or narcotics were typically dispensed to owners for post-operative analgesia in owned pets, whereas injectable nonsteroidal anti-inflammatory drugs or narcotics were administered to community cats at the time of surgery. Ancillary preventive care treatments including vaccinations, parasite medication and microchip implantation were often performed at the time of surgery. Animals were discharged at the end of the day.

Data collection

Data were collected retrospectively for spay–neuter animals from reports generated from two different electronic medical record software programs from 1 January 2010 to 9 September 2016. Only partial records were available from the legacy software program (Complete Clinic) in use from 2010 through partial year 2015. Variables collected from this first time period included animal identification, species and sex, but not age or ownership status. The software was replaced with a new system (Cornerstone, IDEXX Laboratories) in mid-2015. Variables collected from the second time period included animal identification, species, sex, age, breed and ownership status (private pet, rescue group, community cat). Only procedures coded as routine spay–neuter surgeries were included; cases were excluded from the analysis if there was a record of a concurrent procedure or complicating condition, such as a dentistry, mass removal, amputation, enucleation, dystocia or pyometra.

A written perioperative mortality log maintained in the surgery area was updated with details about any deaths that occurred on the day of surgery or that were reported after discharge from the clinic. For the purpose of this study, perioperative mortality was defined as death that occurred in the first 24 h following the administration of the first sedation or anesthetic drugs. This period was divided pre-operative, intra-operative, post-operative and post-discharge stages. The first three stages occurred in the clinic; post-discharge mortality would only be recorded if the animal was brought back to the clinic following discharge, or if the owner or caregiver contacted the clinic to report a death.

³ See: Fiala, J., 2014. Veterinary Nonprofits: Unfair Competitors or Worthy Charities? Controversy Surrounding Subsidized Practice Plays Out On Public Stage. <http://news.vin.com/vinnews.aspx?articleId=31591> (accessed 25 January 2017).

⁴ See: Ferrell, M., Bayer, A., Heckman, J., 2014. In Defense of Low-Cost, High-Volume Spay/Neuter Clinics. <http://veterinarynews.dvm360.com/defense-low-cost-high-volume-spay-neuter-clinics> (accessed 25 January 2017).

Statistical analysis

Perioperative mortality rates were compared by use of a χ^2 test or Fisher's exact test, as appropriate, and odds ratios with their 95% confidence intervals were calculated (Epi Info Version 7.2.1.0, Centers for Disease Control and Prevention). $P < 0.05$ was considered to be statistically significant.

Results

Spay–neuter surgery was reported for a total of 56,075 cats (29,771 females, 26,304 males) and 37,415 dogs (18,948 females, 18,467 males) in the first time period (1 January 2010–22 March 2015), and a total of 15,482 cats (8255 females, 7227 males) and 4934 dogs (2601 females, 2333 males) in the second time period (23 March 2015–9 September 2016). Age was available for the

20,416 animals in the second time period; a larger proportion of the cats (44%) were admitted as juveniles less than 6 months of age than were dogs (27%) ($P < 0.001$) (Fig. 1).

Perioperative mortality was reported for 34 cats (including two community cats that were euthanized due to poor recoveries from anesthesia) and four dogs, for an overall mortality of 3.3 animals/10,000 surgeries (0.03%) (Table 1). The risk of mortality was twice as high for females as for males and five times as high for cats as for dogs.

Age and ownership status was available only for the 20,416 animals reported in the second time period. Mortality in juvenile cats <6 months of age (1/7486; 0.01%) was not significantly different than mortality in adult cats (5/7996, 0.06%; $P = 0.12$). Mortality in juvenile dogs <6 months of age (0/1646) was not significantly different than mortality in adult dogs (1/3288, 0.03%; $P = 0.5$). Mortality was also not significantly different between pet cats

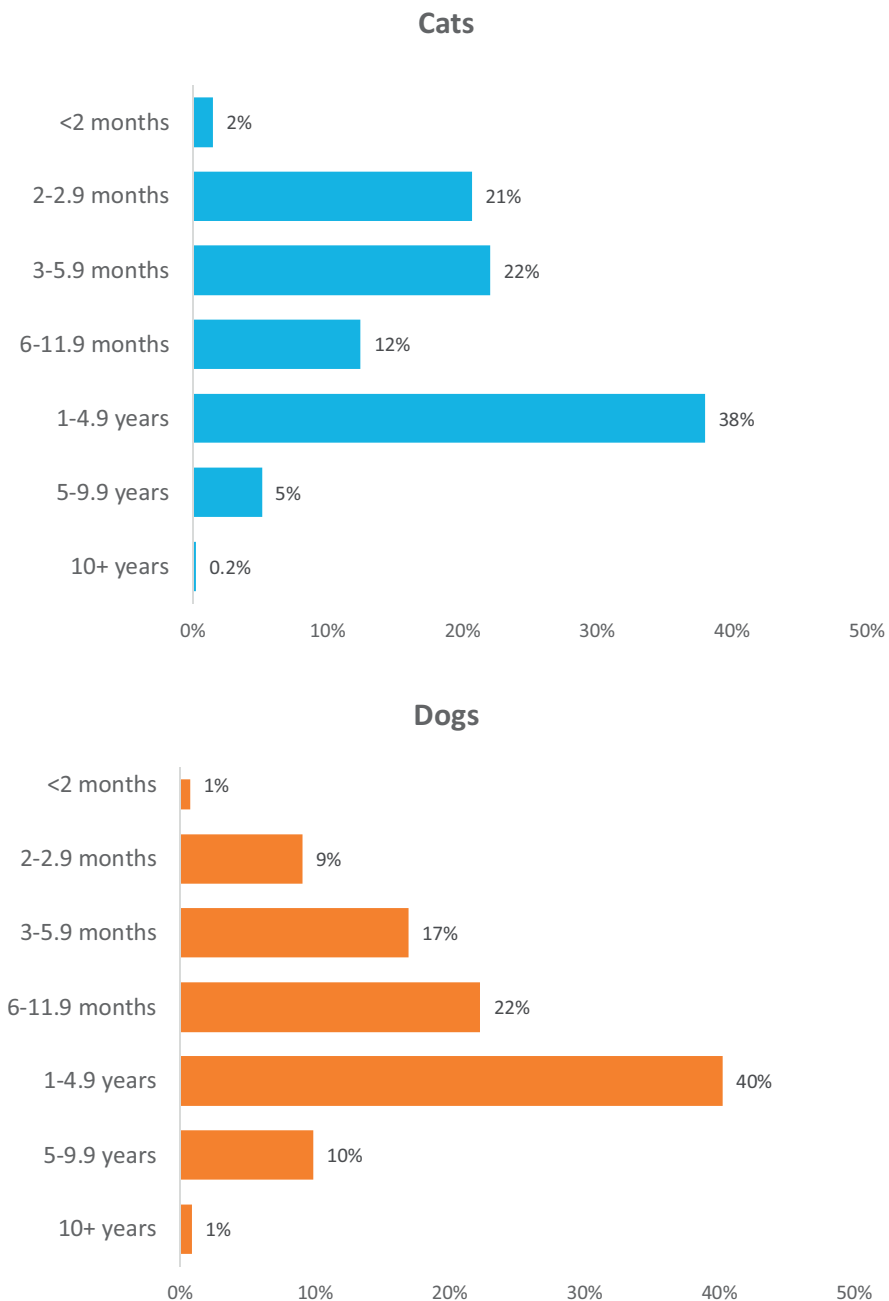


Fig. 1. Age of 15,482 cats and 4934 dogs spayed and neutered at a high-volume clinic in 2015–2016.

Table 1
Risk factors for perioperative mortality in 71,557 cats and 42,349 dogs spayed and neutered at a high volume clinic in 2010–2016.

	Total surgeries	Deaths	Mortality	Odds ratio	Confidence interval	P value
Cats						
Male	33,531	10	0.030%	Referent		
Female	38,026	24	0.063%	2.1	1.0–4.4	0.04
Dogs						
Male	20,800	0	0%	Referent		
Female	21,549	4	0.019%	Undefined	Undefined	0.049
Sex						
All males	54,331	10	0.018%	Referent		
All females	59,575	28	0.047%	2.6	1.2–5.9	0.008
Species						
All dogs	42,349	4	0.009%	Referent		
All cats	71,557	34	0.048%	5.0	1.8–14.2	0.0007
Total	113,906	38	0.033%			

(1/5731, 0.02%), rescue cats (1/840, 0.1%) and community cats (4/8911, 0.04%; $P \geq 0.4$) or between pet dogs (1/4859, 0.02%) and rescue dogs (0/75, $P = 1.0$).

The bulk data retrieval method utilized in this study did not permit a detailed analysis of individual animal characteristics for the total study population, but more details were available in the written mortality log for all 38 mortality cases. In cats, most deaths occurred in the post-operative recovery period ($n = 20$) or in the pre-operative period ($n = 10$) (Table 2). Of the 34 cats that died or were euthanized due to poor anesthetic recoveries, 26 (76%) were community cats admitted in traps for trap-neuter-return surgery. Concurrent conditions in cats recorded on the mortality log include pregnancy ($n = 6$), upper respiratory infection ($n = 5$), scabies ($n = 3$), and suspected diaphragmatic hernia ($n = 2$). All four deaths in dogs occurred in adult pets after surgery and no concurrent conditions were recorded in the mortality log.

Discussion

The mortality for animals served by the HQHVSN clinic was 5/10,000 surgeries in cats and 0.9/10,000 surgeries in dogs. This is approximately a tenth of the rate commonly reported for surgeries in healthy animals performed in low-volume private veterinary practices (Brodgelt et al., 2008a,b; Brodbelt, 2009) and approaches the mortality of 1/10,000 reported for women undergoing hysterectomy for benign conditions (Doll et al., 2013).

Mortality was most likely to occur in the post-operative period for both dogs and cats, a high-risk period that has been reported in previous studies (Brodgelt et al., 2008a,b; Brodbelt, 2009). The reasons for the increased risk during this period are not known, but may be related to factors such as removal from oxygen supplementation delivered during surgery, failure of drug elimination, airway compromise related to intubation or secretions, hypothermia and lapses in monitoring. The second most common interval for mortality in cats was during the pre-operative induction and surgical preparation period, a time during which they undergo rapid physiological changes associated with the loss

Table 2
Timing of perioperative mortality in 34 cats and four dogs admitted for spay and neuter at a high-volume clinic in 2010–2016.

	Cats	Dogs
Pre-operative	10	0
Intra-operative	3	0
Post-operative	20	2
Post-discharge	1	2
Total	34	4

of consciousness. Whereas intensive monitoring of animals is most practical in the operating room during surgery, in high-volume surgery the amount of time animals spend in the pre-operative and post-operative stages of anesthesia is likely to be greater than the amount of time spent in the operating room. Vigilance during all phases of anesthesia is essential for early recognition and response to compromised clinical status (Griffin et al., 2016).

The risk of death was significantly higher for cats than for dogs, as reported previously (Brodgelt et al., 2008a,b; Brodbelt 2009). The written mortality log indicated that three-quarters of feline mortality occurred in trapped community cats. However, since the ownership status of animals reported in the first time period (78% of all feline surgery cases) was not available, it is not possible to determine if community cats were over-represented in overall mortality. Perioperative mortality in trapped community cats undergoing surgery for trap-neuter-return (TNR) in high volume clinics has been reported previously at 0.2% attributed solely to anesthesia and 0.3% overall in Florida (Williams et al., 2002) and 0.4% for all causes in a multi-institutional study (Wallace and Levy, 2006). Cats undergoing surgery in TNR programs are typically anesthetized by intramuscular injection while still in their traps for safe handling reasons (Williams et al., 2002). Potential increased risks for morbidity in trapped community cats include the reduced ability to weigh the cats for accurate drug dosing, lack of pre-anesthetic physical examination, undetected concurrent health conditions, and the potential for fear and distress to complicate response to anesthesia.

Most published reports regarding perioperative mortality in veterinary medicine over the past two decades have focused on anesthesia-related causes, with less information available regarding surgery-specific causes in general, or spay-neuter procedures in particular. Although anesthesia-associated mortality is likely to account for most perioperative deaths, reports limited to anesthetic misadventures represent the minimum perioperative mortality rate. Mortality in healthy animals attributed to anesthesia in low-volume private practices has been reported in 0.1% of cats and dogs in France (Bille et al., 2012), 0.3% of dogs in Spain, 0.05% of cats and 0.07% of dogs in Ontario (Dyson et al., 1998), 0% of cats and dogs in Ontario (Pollari and Bonnett, 1996), and 0.1% of cats (Brodgelt et al., 2007) and 0.05% of dogs in the UK (Brodgelt et al., 2008a,b). One researcher found that surveys limited to review of electronic medical records significantly underestimated the true incidence of complications (Pollari and Bonnett, 1996; Pollari et al., 1996), a factor that could influence several of the previously reported studies. The use of a written mortality log in addition to computer-generated data avoided this potential source of error in the current study.

In human surgery, patient safety is positively correlated with the volume of specific procedures performed by both surgeons and hospitals (Halm et al., 2002; Reames et al., 2014; Mehta et al., 2017; Mowat et al., 2016). Higher volume is associated with lower rates of complications, re-operation, re-admission, mortality and length of stay, leading to recommendations to consolidate procedures to safer, more proficient, high volume facilities.⁵ High volume surgeons utilize fewer healthcare resources via reduced operating room time and total costs per patient (Doll et al., 2013). Surgeon and team experience is part of the explanation, but it has also been shown that the consecutive repetition of specific procedures, without interruption by other procedures, is an independent predictor of reduced mortality (Sahni et al., 2016).

This study had several limitations. Although the mortality rate in the HQHVSN clinic was lower than most reports from private practices, the lack of a universal system for the consistent collection and classification of animal data precludes any direct comparisons. A limited number of variables were available for analysis, particularly in the first time period covered by the Legacy software program. Post-mortem evaluations were not consistently performed in order to confirm the likely cause of death. Due to the progressive uncertainty in assigning a link between surgery and death as post-surgical intervals increased, perioperative mortality was defined as deaths occurring within a single day of surgery. It is possible that some fatal post-operative complications developed after the reporting period or that deaths occurring post-discharge were not always reported by their owners. Mortality was the only complication evaluated in this study. Although mortality is the most serious complication, programs should also be aware of and seek to minimize non-fatal complications. Since this report involved only one facility, the generalizability of the findings to other high-volume clinics is unknown.

Conclusions

High volume spay–neuter surgery was associated with a low mortality rate approaching that achieved in human surgery. This is likely to be due to a relatively young and healthy population of dogs and cats, and continuous refinement of techniques based on experience and the skills and proficiency of teams that specialize in a limited spectrum of procedures. Additional opportunities for improving animal safety, particularly in cats, might be identified in follow-up studies addressing the effect of the surgeon, anesthetic protocol, monitoring, duration of surgery and animal characteristics that were beyond the scope of this study.

Conflict of interest statement

None of the authors of this paper have a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

Acknowledgment

This work was supported by a grant from Maddie's Fund.

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