

Outcomes of elective gonadectomy procedures performed on dogs and cats by veterinary students and shelter veterinarians in a shelter environment

Rachael E. Kreisler VMD, MSCE

Stephanie L. Shaver DVM

John H. Holmes PhD

From Animal Health Institute, College of Veterinary Medicine, Midwestern University, Glendale, AZ 85308 (Kreisler, Shaver); and Center for Clinical Epidemiology and Biostatistics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA 19104 (Kreisler, Holmes).

Address correspondence to Dr. Kreisler (rkreis@midwestern.edu).

OBJECTIVE

To determine complication rates for elective gonadectomy procedures performed by veterinary students on dogs and cats in an animal shelter, characterize these complications, and compare rates with those for shelter-employed veterinarians (SEVs).

DESIGN

Retrospective cohort study.

ANIMALS

10,073 dogs and cats for which gonadectomy was performed by a veterinary student ($n = 3,048$ surgeries) or SEV (7,025 surgeries) at an urban animal shelter over a 16-month period.

PROCEDURES

Electronic medical records for included dogs and cats were reviewed and data collected regarding patient signalment, duration of gonadectomy, surgeon type (student or SEV), and types of surgical complications recorded (including death or euthanasia) during the period from anesthetic induction to 72 hours after surgery. Complication and mortality rates were compared between veterinary students and SEVs.

RESULTS

No significant differences were identified between students and SEVs regarding rates of overall complications for both species, minor complications for both species, major complications for both species, and overall complications for dogs or cats specifically. The most common complications were self-limiting, with no long-term consequences, for both students and SEVs. Differences in mortality rates between students and SEVs could not be definitively determined owing to low numbers of nonsurviving patients.

CONCLUSIONS AND CLINICAL RELEVANCE

With judicious case selection and as a part of a surgical training program, complication rates for veterinary student-performed gonadectomy procedures for dogs and cats were no different from those for SEV-performed gonadectomy procedures. We believe such information regarding patient outcomes will allow shelter staff to make informed decisions and help them in discussions with stakeholders who may have concerns about student participation. (*J Am Vet Med Assoc* 2018;253:1294–1299)

As the veterinary profession and veterinary teaching institutions become increasingly specialized and the nature of evaluated patients becomes more complex, opportunities for practical clinical education of veterinary students have decreased. The use of purpose-bred animals for student surgical laboratories has become less acceptable to educators owing to controversy regarding terminal surgeries.^{1,2} Student surgical laboratories are also expensive to run,

representing a considerable drawback for already financially strained veterinary colleges. In light of these pressures, veterinary educators have increasingly turned to animal shelters and service learning, which combines learning objectives with community service, to provide the caseload for student surgical experience.^{3–6}

The rates and types of surgical complications associated with procedures performed by veterinary students in shelter environments are important to determine so that specific concerns associated with such training can be identified and addressed. In a study⁷ of fully trained veterinarians performing various elective surgeries in private small animal practice, postoperative complication rates ranged from 1% to 24%, with major complication rates ranging from 1% to 4%.⁷ A similar major complication rate (3.3%) was

ABBREVIATIONS

ASA	American Society of Anesthesiologists
CI	Confidence interval
PRR	Proportional reporting ratio
SAM	Shelter animal medicine
SEV	Shelter-employed veterinarian
STS	Soft tissue surgery
TNR	Trap, neuter, and release

identified in a study⁸ of third-year veterinary students performing ovariohysterectomy. However, to the authors' knowledge, no studies have been reported regarding surgical complication rates for veterinary students in a shelter environment, nor have comparisons between students and fully trained veterinarians been reported. The purpose of the study reported here was to characterize and compare complication rates (including mortality rates) associated with gonadectomy procedures between veterinary student and SEV surgeons in an animal shelter environment.

Materials and Methods

Study design

The study was designed as a retrospective cohort study undertaken at a large urban shelter in the Northeastern United States, where elective surgeries were performed by both veterinary students and SEVs. The students performing the surgeries at the shelter originated from 2 senior rotations and a structured extracurricular program involving students of all years. The study protocol was approved by the University of Pennsylvania Institutional Review Board.

Animals

Electronic medical records of dogs and cats with an intake date at an urban animal shelter between June 1, 2012, and September 30, 2013, were searched to identify patients for inclusion in the study. Dogs and cats were included if their surgery had been performed by a veterinary student or SEV and were excluded if their surgery had been performed by a veterinarian visiting the shelter (ie, neither an SEV nor a student).

Surgical procedures and supervision

The University of Pennsylvania STS (required) and SAM (elective) rotations at the animal shelter typically accommodated 3 to 4 students/surgical day. A sole faculty member proctored the SAM rotation, whereas an STS intern primarily proctored the STS rotation. The STS rotation also had a rotating intern, a dedicated technician, and 1 or 2 veterinary technician students present on most days for support. The ratio of proctoring veterinarians to rotation students actively engaged in surgery was a minimum of 1:4, mean of 1:2, and maximum of 2:3. The exact surgical methods varied with proctoring surgeon preference. Students who performed surgeries included senior students taking the required STS or elective SAM rotations as well as participants in a structured extracurricular program involving students of all years.

Generally, a dedicated proctoring veterinarian was not present during surgical procedures involving extracurricular students, given that these students were required to have a substantial amount of prior experience (ie, ≥ 3 days of volunteering at the extracurricular program's main teaching location and neutering of ≥ 8 male cats). No students involved in the extracurricular program evaluated in the study per-

formed cat ovariohysterectomy or dog gonadectomy surgeries alone without first having received formal certification by a program veterinarian of their ability to spay a cat without immediate assistance. Student experience with ovariohysterectomy procedures prior to certification was gained by scrubbing in with a program veterinarian and performing 1 portion of each surgery as the primary surgeon (ie, performing the initial incision into the abdomen, finding the uterus, ligating the ovarian pedicles, ligating the uterine body, or closing the body wall, subcutaneous tissues, and skin). The ratio of supervising veterinarians to extracurricular students was a minimum of 1:5 (for large-scale TNR events), mean of 1:2, and maximum of 1:1.

Dogs and cats were allocated to students on the basis of suitability, as determined by the proctoring veterinarian, SEV, or shelter management. The criteria for suitability varied but included body weight (for dogs), age, foster parent preference, perceived student capability, and health status.

For each gonadectomy procedure, dogs and cats were anesthetized with an IM injection of a mixture of tiletamine hydrochloride-zolazepam hydrochloride,^a butorphanol tartrate,^b and dexmedetomidine hydrochloride^c (0.03 mL/kg).^{9,10} Dogs were endotracheally intubated with clean but not sterile endotracheal tubes (with the exception of pediatric male dogs, which were generally not intubated), and a face mask was used for female cats to maintain isoflurane anesthesia during surgery. Intubation could have been performed by students, shelter-employed veterinary assistants, proctoring veterinarians, STS or rotating interns, veterinary technician students, or veterinary technicians. Castration of male cats by both student and SEV surgeons was generally performed without intubation, as was castration of pediatric male dogs by SEV surgeons.

Dogs were monitored with pulse oximetry and direct observation, whereas cats were monitored with direct observation alone or direct observation in conjunction with pulse oximetry or portable inline capnometry. Intravenous fluid and perioperative antimicrobial administration was not routinely performed, except for cats that were part of the TNR program, which received 1 perioperative injection of procaine penicillin G (75,000 U if ≤ 2.3 kg [5.1 lb] and 150,000 U if > 2.3 kg). Those cats were typically released within 48 hours after surgery.

All gonadectomy procedures were performed with sterile surgical approaches and techniques. All surgeons used the suture material available at the shelter (size-0, 2-0, or 3-0 glycolide co-caprolactone^d), and the shelter's autoclave was used for sterilization of all instruments. No gowns were worn by SEV or student surgeons for any procedure other than ovariohysterectomy in dogs. The shelter's procedures were consistent with the Association of Shelter Veterinarians guidelines for spay-neuter programs.¹¹ Animals were tattooed after gonadectomy, and cats for

TNR were vaccinated and 1 cm of their left ear was clipped for identification at the time of surgery. Only occasionally, additional procedures such as minor mass removal were performed after gonadectomy. All male cats were neutered via closed castration, with the testicular pedicles autoligated and the incisions left to heal by second intention.

The SEVs and SAM students used high-quality, high-volume gonadectomy techniques consistent with Humane Alliance protocols.¹² For female patients, this included small, precisely located incisions, use of a spay hook to locate the uterus, autoligation of the ovarian pedicles of cats, single Miller knots on the ovarian pedicles of dogs and the uterine bodies of both species, and simple continuous closures of body walls (when incisions exceeded the size appropriate for a single cruciate). For male dogs, closed castration was performed via a prescrotal incision, with a single Miller knot and closure using the modified Colorado technique. Shelter-employed veterinarians and students typically used a single pack of suture (2-0 for dogs and 3-0 for cats) for the ligatures, body wall closure, subcutaneous tissue and skin.

For STS students, procedural details varied with proctoring veterinarian. Some students used techniques similar to those of SEVs and SAM students, whereas others used techniques more typical of traditional academic instruction in ovariectomy. For female dogs, this included large incisions, double ligation of ovarian and uterine pedicles with encircling or transfixing ligatures, simple interrupted body wall closures, simple continuous subcutaneous tissue closures, and intradermal skin closures with buried knots at both ends. The STS surgeons typically used one pack of suture material for ligatures and another 1-size smaller pack for closures in dogs.

Data collection

Electronic medical record data for the study period were exported from the shelter's software into a customized database. Age (as estimated on the basis of dentition) and body weight at the time of gonadectomy were determined for each patient. Additional information regarding the procedures (ie, surgeon and complicating factors) was obtained from paper surgical logs. To identify patients with major and minor complications, clinical examination records dated after the surgery were electronically searched for various terms, all surgical examination records for animals with a previous gonadectomy surgery were individually reviewed to identify any surgical revisions, and all entries for euthanasias or deaths that occurred at any time after surgery were evaluated. Examples of terms used to search clinical examination records included red, infect*, swelling, hematoma, bruise*, irritat*, letharg*, vomit*, and suture. These terms had been selected through manual review of data from several hundred randomly selected clinical examinations that occurred after the date of surgery, which identified common words and misspellings.

All data coding was performed by 1 investigator (REK), who was blinded to surgeon identity. All complications were considered during the period from anesthetic induction through to 30 days after gonadectomy, which represented a period when treatment of complications was generally undertaken by animal shelter staff. Intraoperative surgical complications other than death were not evaluated because such complications were not well documented for SEV procedures.

Major complications were defined as those requiring intense supportive care or surgical correction, whereas minor complications were defined as self-limiting or responsive to basic supportive care. Minor complications included skin dehiscence, scrotal or skin hematomas, transient vomiting or inappetence, or mild incisional infection or inflammation. Major complications included body wall dehiscence, death or euthanasia, or incisional abnormalities requiring surgical revision. Animals were coded as having died or been euthanized for reasons related to the procedure if the event occurred between anesthetic induction and 72 hours after surgery and a procedure-related cause of death could not be ruled out.

Statistical analysis

Median body weight and age of patients were compared between SEV and student surgeons with the 2-sample Wilcoxon rank sum (Mann-Whitney 2-sample) test. Proportions of each procedure (dog spay, cat spay, dog neuter, and cat neuter) distributions and ASA status were compared between these 2 surgeon groups with the 2-sample test of proportions. For these comparisons, values of $P < 0.05$ were considered significant.

Because underreporting of complications was expected and observed complication rates were therefore viewed as minimum rates only, the PRR, a measure of disproportionality commonly used in situations in which underreporting is a concern (eg, adverse drug reactions),¹³ was calculated to compare rates of overall complications, major complications, and minor complications between SEV and student surgeons as follows:

$$\text{PRR} = (a/[a+c]) / (b/[b+d])$$

where a is the number of student surgeries with a complication, b is the number of SEV surgeries with a complication, c is the number of student surgeries without a complication, and d is the number of SEV surgeries without a complication. The 95% CIs on these values were also computed,¹³ and intervals that excluded 1 were used to determine whether the PRR was significant. The number of subjects used to calculate the PRR was adjusted for proportions of each procedure type by use of statistical software^e to yield a weighted mean of the stratum-specific rates given the marked difference in risk among procedures.

Results

Overall, 10,073 of 10,599 (95.0%) surgeries performed in the shelter during the study period quali-

fied for inclusion in the study. Veterinary students performed 3,048 (30.3%) of the included gonadectomy procedures, and SEVs performed 7,025 (69.7%). The rate of additional procedures performed (such as small mass removals) was 0.8% for student surgeons and 1.6% for SEV surgeons.

Characteristics of dogs and cats in each surgeon group were summarized (**Table 1**). Differences were identified between groups with respect to distributions of male and female dogs and cats ($P < 0.001$). However, these differences were accounted for via weighting in the calculation of the PRR. Median age of cats ($P < 0.001$) and dogs ($P < 0.001$) differed significantly between surgeon groups. Median body weight of cats ($P < 0.001$), but not dogs ($P = 0.42$), differed significantly between groups.

Data regarding overall, minor, and major complication rates for each surgeon group were summarized (**Table 2**), as were details regarding these complications (**Supplementary Tables 1 and 2**, available at avmajournals.avma.org/doi/suppl/10.2460/javma.253.10.1294). Minor complications for students ($n = 3,048$ surgeries) and SEVs (7,025 surgeries) included incisional inflammation or infection (27 [0.89%] and 30 [0.43%], respectively), scrotal hematoma (5 [0.16%] and 3 [0.04%], respectively), skin dehiscence (2 [0.07%] and 3 [0.04%], respectively), vomiting or inappetence (1 [0.03%] and 11 [0.16%], respectively), and other types (1 [0.03%] and 11 [0.16%], respectively). Major complications included death or euthanasia (4 [0.13%] and 20 [0.28%], respectively), incisional problems requiring revision surgery (4 [0.13%] and 4 [0.06%], respectively), body wall dehiscence (3 [0.10%] and 0 [0%], respectively), and other types (3 [0.10%] and 4 [0.06%], respectively).

Confidence intervals for the PRRs of comparisons of complication rates included 1, indicating no significant difference between student and SEV surgeons in overall complications for both species combined (PRR, 1.22; 95% CI, 0.86 to 1.74), minor complications for both species combined (PRR, 1.15; 95% CI, 0.77 to 1.72), major complications for both species combined (PRR, 1.33; 95% CI 0.84 to 1.93), overall complications for dogs (PRR, 1.23; 95% CI, 0.78 to 1.94), and overall complications for cats (PRR, 0.98; 95% CI, 0.56 to 1.73). Adjusted for proportions of various procedures performed, the overall complication rate for student surgeons was 1.63% (95% CI, 1.22% to 2.16%), compared with 1.26% (95% CI, 1.02% to 1.56%) for SEV surgeons.

Of the 24 deaths or euthanasias for which a procedure-related cause could not be ruled out, 14 occurred between anesthetic induction and recovery, whereas 10 occurred between anesthetic recovery

Table 1—Characteristics of dogs and cats for which gonadectomy was performed by veterinary students ($n = 3,048$ procedures) or SEVs (7,025 procedures) at an urban animal shelter over a 16-month period.

Characteristic	Students	SEVs	P value
Male cat	1,334 (43.8)	2,299 (32.7)	< 0.001
Female cat	817 (26.8)	3,249 (46.2)	< 0.001
Male dog	495 (16.2)	760 (10.8)	< 0.001
Female dog	402 (13.2)	717 (10.2)	< 0.001
Cat body weight (kg)	2.6 (0.7–9.1)	1.8 (0.7–8.6)	< 0.001
Dog body weight (kg)	17.5 (2.0–52.2)	17.6 (1.1–64.0)	0.42
Cat age (mo)	5.4 (1.5–83.9)	3.4 (1.5–155.1)	< 0.001
Dog age (mo)	12.0 (1.7–119.8)	12.0 (1.7–215.6)	0.02
ASA status 1	2,920 (95.8%)	6,737 (95.9%)	0.82
ASA status 2	128 (4.2%)	288 (4.1%)	0.82

Data for sex and ASA status are reported as number (%) of animals in each group. To convert kilograms to pounds, multiply by 2.2.

Table 2—Numbers and rates of complications recorded for gonadectomy procedures performed by veterinary students and SEVs on the cats and dogs characterized in Table 1.

Patient type	Overall complications		Minor complications				Major complications					
	Students		SEVs		Students		SEVs		Students		SEVs	
	No.	Rate (95% CI)	No.	Rate (95% CI)	No.	Rate (95% CI)	No.	Rate (95% CI)	No.	Rate (95% CI)	No.	Rate (95% CI)
Male cat	3	0.23 (0.05–0.66)	7	0.30 (0.12–0.63)	0	0.00 (0.00–0.28)	2	0.09 (0.01–0.31)	3	0.23 (0.05–0.66)	5	0.22 (0.07–0.51)
Female cat	11	1.35 (0.67–2.40)	42	1.29 (0.93–1.74)	5	0.61 (0.20–1.42)	22	0.68 (0.42–1.02)	6	0.73 (0.27–1.59)	20	0.62 (0.38–0.95)
Male dog	19	3.83 (2.32–5.92)	20	2.63 (1.61–4.04)	18	3.63 (2.16–5.67)	18	2.37 (1.41–3.72)	1	0.20 (0.01–1.12)	2	0.26 (0.03–0.95)
Female dog	17	4.23 (2.48–6.68)	18	2.51 (1.49–3.94)	13	3.23 (1.73–5.47)	16	2.23 (1.28–3.60)	4	1.00 (0.27–2.53)	2	0.28 (0.03–1.00)

and 72 hours after surgery. Overall mortality rate was 0.29% (22/7,698; 95% CI, 0.18% to 0.43%) for cats and 0.08% (2/2,375; 95% CI, 0.01% to 0.30%) for dogs. Mortality rates for student surgeons were 0.19% (4/2,150; 95% CI, 0.05% to 0.48%) for cats and 0% (0/898; 95% CI, 0.00% to 0.41%) for dogs and for SEV surgeons were 0.32% (18/5,548; 95% CI, 0.19% to 0.51%) and 0.14% (2/1,477; 0.02% to 0.49%), respectively. No PRRs were calculated for mortality rate comparisons between the 2 surgeon groups owing to small numbers of nonsurviving animals; however, these rates appeared similar between groups.

Three of the euthanized cats with an SEV-performed surgery would likely have recovered with minimal to moderate supportive care standard for private practice but were euthanized largely for population management purposes. Elimination of these cats from mortality rate calculations yielded an adjusted overall mortality rate for cats of 0.25% (95% CI, 0.15% to 0.39%).

Discussion

No significant differences were identified between veterinary students and SEVs in complication rates associated with gonadectomy procedures performed for cats and dogs in the present study. Rates for which comparisons could be meaningfully calculated included those of overall complications for both cats and dogs, minor complications for both species, and overall complications for dogs only. Although neither major complication rate for both species combined nor overall complication rate for cats only differed significantly between surgeon groups, these outcomes were too uncommon to allow meaningful comparisons in this regard.

In human medicine, research has shown no difference between trainees and more-experienced surgeons in postoperative complication rates when careful patient selection and close supervision of trainees is applied.¹⁴⁻¹⁶ A study¹⁴ of the impact of resident participation in surgical procedures revealed that patient mortality rates were similar between surgeries performed with versus without resident participation, but that the mild surgical complication rate, chiefly that of superficial surgical site infection, was higher with resident participation (3.0% vs 2.2%). Duration of surgery was also higher with versus without resident participation.¹⁴ Intriguingly, another study¹⁷ showed slightly higher morbidity rates (OR, 1.14) and longer procedure durations but lower mortality rates (OR, 0.4) for common elective general surgical procedures performed with surgical residents.

In private veterinary practice, the reported anesthesia-related mortality rate for healthy cats (ASA status 1 or 2) is 0.11% (95% CI, 0.09% to 0.14%) and for healthy dogs is lower at 0.05% (95% CI, 0.04% to 0.07%).¹⁸ The 95% CI for the mortality rate for dogs in the present study overlapped the corresponding previously reported 95% CI; however, the 95% CI for the cat mortality rate in the present study did not and

was higher. Beyond the fact that mortality rates in the present study pertained to both anesthesia- and surgery-related deaths (and not just anesthesia-related deaths), this difference in cat mortality rates between studies could also have been attributable in part to the stressful shelter environment, in which cats might hide an illness, therefore resulting in inadvertent inclusion of a few unhealthy cats. The reported anesthesia-related mortality rate for unhealthy cats in private practice is 1.4% (95% CI, 1.12% to 1.68%),¹⁸ and the mortality rate for cats in TNR programs is between 0.30% (95% CI, 0.21% to 0.42%) and 0.35% (95% CI, 0.23% to 0.51%).^{19,20} As expected in a shelter with a mixed-animal population, the adjusted cat mortality rate in the present study of 0.25% was less than that reported for unhealthy cats and between the reported rates for healthy owned cats and cats in a TNR program.

Nine cats in the present study (7 SEV surgeries and 2 student surgeries; Supplementary Table 1) died or were euthanized in the postoperative period. Eight of these cats were female (6 SEV surgeries and 2 student surgeries), and 6 were pregnant at the time of surgery (5 SEV surgeries and 1 student surgery). The same veterinarian performed the SEV surgeries for all 6 female cats and supervised the student who had performed surgery on the pregnant female cat. Results of necropsy were available for 2 of the pregnant female cats, revealing a large blood clot at the uterine body of one cat and hemoabdomen in the other, despite 2 ligatures having been placed in the uterine body of both cats. The distal ligature of the cat with the large blood clot was transfixed. Pregnancy in both cats had been near term, and we hypothesized that in both situations the uterus had involuted after ligature placement, resulting in a loss of complete occlusion of the uterine arteries. These findings emphasized the importance of keeping and reviewing data regarding surgical complication to identify areas for improvement such as stick tying each uterine artery or closer monitoring of pregnant cats.

The present retrospective study had several limitations. Reporting of complications in the shelter environment, except for in-shelter death, was incomplete because of animal transfers and adoptions, despite a shelter policy to provide free postoperative care for complications related to surgery. Incomplete medical records and nonstandard characterization of patient examinations and outcomes may also have led to inconsistent identification of complications. In addition, complications not identified through an in-person appointment and not assigned an in-shelter treatment may have gone unrecorded by shelter staff. For these reasons, the PRR was deemed a more useful measure of student performance than complication rates. However, anticipated rates of reported complications, as estimated in the present study, may be useful for shelters or academic programs when allocating resources for postoperative clinical support.

An additional study limitation involved the lack of prospective, random allocation of dogs and cats to

surgeon groups. Although statistical comparisons indicated that several patient characteristics (eg, ASA status and dogs body weight) were similar between student and SEV surgeons, not all indicators of increased anesthetic or surgical risk, such as obesity, were assessed. Additionally, age for both dogs and cats and body weight for cats were significantly different between student and SEV surgeons. However, the difference in age, particularly for dogs, was unlikely to have been clinically relevant. In general, students were preferentially assigned animals deemed less risky by proctoring veterinarians, SEVs, or shelter management staff. In addition, proctoring veterinarians typically assigned animals they perceived as more challenging to students they deemed more capable. These biases likely contributed to a lower complication rate for student surgeons than if students and SEVs had an equivalent surgical caseload. Despite any biases, we believe our findings likely represented a common scenario for student programs operating in a shelter framework and therefore were likely better generalizable to that setting than findings obtained through a more controlled study. Evidence-based determination of the types of surgical cases that pose a low risk for student surgeons is an avenue for future research.

Overall, the present study showed that the risk of complications associated with gonadectomy procedures for cats and dogs in a shelter setting was no different between veterinary students and SEVs. We believe such information regarding patient outcomes for students participating in a structured training program, particularly as compared with SEVs, will allow shelter staff to make informed decisions and help them in discussions with stakeholders who may have concerns about student participation.

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Footnotes

- a. Telazol, Zoetis Inc, New York, NY.
- b. Torbugesic, Zoetis Inc, New York, NY.
- c. Dexdomitor, Zoetis Inc, New York, NY.
- d. Monoswift, CP Medical, Norcross, Ga.
- e. DSTDIZE, Stata, version 14.2, StataCorp LLC, College Station, Tex.

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