Outcome of laparoscopic ovariectomy and laparoscopic-assisted ovariohysterectomy in dogs: 278 cases (2003–2013)

Kayla M. Corriveau DVM

Michelle A. Giuffrida VMD

Philipp D. Mayhew BVM&S

Jeffrey J. Runge DVM

From the Department of Small Animal Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University, College Station, TX 77843 (Corriveau); the Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California-Davis, Davis, CA 95616 (Giuffrida, Mayhew); and the Section of Surgery, Department of Clinical Studies–Philadelphia, School of Veterinary Medicine, University of Pennsylvania, Philadelphia, PA 19104 (Runge).

Address correspondence to Dr. Runge (jrunge@vet.upenn.edu).

OBJECTIVE
To compare outcomes for laparoscopic ovariectomy (LapOVE) and laparoscopic-assisted ovariohysterectomy (LapOVH) in dogs.

DESIGN
Retrospective case series.

ANIMALS
278 female dogs.

PROCEDURES
Medical records of female dogs that underwent laparoscopic sterilization between 2003 and 2013 were reviewed. History, signalment, results of physical examination, results of preoperative diagnostic testing, details of the surgical procedure, durations of anesthesia and surgery, intraoperative and immediate postoperative (ie, during hospitalization) complications, and short- (≤ 14 days after surgery) and long-term (> 14 days after surgery) outcomes were recorded. Data for patients undergoing LapOVE versus LapOVH were compared.

RESULTS
Intraoperative and immediate postoperative complications were infrequent, and incidence did not differ between groups. Duration of surgery for LapOVE was significantly less than that for LapOVH; however, potential confounders were not assessed. Surgical site infection was identified in 3 of 224 (1.3%) dogs. At the time of long-term follow-up, postoperative urinary incontinence was reported in 7 of 125 (5.6%) dogs that underwent LapOVE and 12 of 82 (14.6%) dogs that underwent LapOVH. None of the dogs had reportedly developed estrus or pyometra by the time of final follow-up. Overall, 205 of 207 (99%) owners were satisfied with the surgery, and 196 of 207 (95%) would consider laparoscopic sterilization for their dogs in the future.

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested that short- and long-term outcomes were similar for female dogs undergoing sterilization by means of LapOVE or LapOVH; however, surgery time may have been shorter for dogs that underwent LapOVE. Most owners were satisfied with the outcome of laparoscopic sterilization. (*J Am Vet Med Assoc* 2017;251:443–450)

Surgical sterilization of dogs is one of the most commonly performed operative procedures in veterinary practice.[1] Surgical sterilization of female dogs can be accomplished by means of OVH or OVE, with the former being the preferred approached in the United States.[1] Applicable surgical approaches include laparoscopy with a single[2-5] or multiple access

ports,[5] open midline laparotomy, and lateral flank laparotomy.[6] Studies documenting advantages for patients undergoing laparoscopic versus open surgery have been published for both human and veterinary patients undergoing a variety of procedures. In female dogs, laparoscopic sterilization provides a greatly improved view of the surgical field because of the enhanced illumination and magnification afforded by the instrumentation, which may decrease the risk of intraoperative complications such as hemorrhage or incomplete removal of ovarian tissue. Studies have shown that LapOVH is associated with less pain and surgical stress, compared with open OVH,[7-9] and that LapOVE is associated with a shorter recovery time than open OVE when postoperative activity levels are compared.[10] Results of a 2012 study[11] suggested

ABBREVIATIONS

ACVS	American College of Veterinary Surgeons
CI	Confidence interval
LapOVE	Laparoscopic ovariectomy
LapOVH	Laparoscopic-assisted ovariohysterectomy
OVE	Ovariectomy
OVH	Ovariohysterectomy
SSI	Surgical site infection

that dogs and cats undergoing clean or clean-contaminated procedures by means of minimally invasive approaches to the pleural and peritoneal cavities could also have lower rates of SSIs, compared with rates for patients undergoing open approaches, although it is not clear whether this finding was associated with the surgical approach or other confounding factors.

Whereas previous studies[2-5,7,8,10] have reported short-term (ie, ≤ 15 days after surgery) outcomes and complications associated with laparoscopic sterilization of small animals, we are not aware of any studies evaluating outcome for female dogs undergoing LapOVH versus LapOVE or the long-term outcomes for these procedures. As such, the objective of the study reported here was to examine and compare patient variables and short- and long-term outcomes for dogs that underwent LapOVH versus LapOVE. We hypothesized that LapOVE and LapOVH would both be found to be safe and effective techniques for sterilization of female dogs, but that surgery times for LapOVH would exceed those for LapOVE. Further, we hypothesized that there would be no difference in patient characteristics or the incidence of perioperative complications between techniques.

Materials and Methods

The medical record database of the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania was reviewed to identify eligible cases. Shelter-owned and client-owned female dogs were eligible for inclusion if a LapOVH or LapOVE had been performed for sterilization during the 10-year period from October 2003 through October 2013 and if a complete medical record was available for review. Cases were excluded if records were incomplete, sterilization was performed because of a neoplastic process, or the dog was found to have previously been sterilized during the initial laparoscopic exploration of the abdomen.

Data collected from the medical records of dogs included in the study consisted of breed, age, body weight, body condition score (on a scale of 1 to 9), history of urinary tract abnormalities (eg, urinary tract infections, incontinence, or calculi), preoperative systemic disease status (none, mild, or severe), type of sterilization procedure (LapOVH or LapOVE), number of laparoscopic ports used (single or multiple), surgeon experience (ACVS diplomate vs non–board-certified surgeon), total duration of anesthesia (defined as the period between starting and stopping administration of an inhalant anesthetic), OVE or OVH procedure time (defined as the period from first incision to completed closure), additional procedures performed, intraoperative surgical complications (eg, splenic laceration, pedicle hemorrhage, dropped ovary, other technical issues, or conversion to laparotomy), immediate postoperative complications (defined as the period during which the dog was hospitalized following surgery and including complications such as diarrhea or hematochezia, vomiting or regurgita-

tion, corneal ulceration, and hemoperitoneum), duration of hospitalization, and short-term postoperative incisional complications (defined as complications occurring ≤ 14 days after surgery and including erythema, seroma, and suspected SSIs). Cases were classified as occurring from the years 2003 through 2008 versus 2009 through 2013 because a change in hospital personnel resulted in differences in laparoscopic case populations, preferred surgical techniques, and follow-up procedures between the 2 time periods.

Laparoscopic-assisted ovariohysterectomy and LapOVE were performed via one of the previously described multiport[5,7,12] or single-port[3,4,13] techniques. Initial access to the peritoneal cavity was achieved by means of the Hasson or modified Hasson technique in all cases. In all dogs undergoing LapOVE, the ovarian pedicles and uterine horns were ligated intracorporeally with a vessel-sealing device. In dogs undergoing LapOVH, the ovarian pedicles were ligated intracorporeally with a vessel-sealing device, and uterine ligation was performed extracorporeally by means of a double suture ligation; the specific ligation technique varied according to surgeon preference.

Long-term follow-up (> 14 days after surgery) to assess postoperative complications and overall owner satisfaction was conducted by means of a questionnaire administered by telephone or email. Four follow-up attempts were made for each owner via 2 emails and 2 telephone calls or 4 telephone calls if an email address was not available. Patients were considered lost to follow-up if all contact information was invalid or contact was not successful after 4 attempts. Questions on the telephone or email questionnaire were phrased to allow for initial yes-or-no responses by the owner regarding postoperative development of urinary incontinence, signs of estrus, or pyometra as diagnosed by a veterinarian; owner satisfaction with the procedure; and owner willingness to have the same procedure performed for another female dog. If a complication was noted, additional information was requested, including time of onset of clinical signs or diagnosis, any diagnostic testing performed, and any treatment.

Statistical analysis

Baseline patient and procedural characteristics were examined, and summary statistics were reported for all measured variables according to procedure (LapOVH or LapOVE). The distribution of continuous variables was evaluated with histograms and tests of skewness and kurtosis, and data were expressed as median and range. Categorical variables were expressed as numbers and percentages. Between-group comparisons were performed with Fisher exact tests for categorical variables. All tests were 2 sided, and results were considered significant if $P \leq 0.05$.

Logistic regression modeling was used to explore whether patient or procedural variables were associated with the development of short-term postoperative incisional complications or postoperative

urinary incontinence. In the first model, a report of an incisional complication within ≤ 14 days after surgery was the dependent variable, and body weight, age, procedure (LapOVH or Lap OVE), number of ports (single or multiple), surgeon experience (ACVS diplomate vs non–board-certified surgeon), time period of surgery (2003 through 2008 vs 2009 through 2013), anesthesia time, and report of an immediate postoperative complication were the independent variables. In the second model, a report of postoperative urinary incontinence during the follow-up period was the dependent variable, and body weight, body condition score, age, procedure, number of ports, surgeon experience, a history of urinary tract abnormalities, number of days of follow-up, and time period of surgery were the independent variables. Variables with a *P* value ≤ 0.20 on univariate analysis were tested for inclusion in the multivariable models. Two-way interactions among the main effects were investigated. A variable was retained if the Wald *P* value for that variable was ≤ 0.05 or if it was considered a confounder (ie, addition of the variable changed the coefficient for the independent variable by > 15%). Linearity of continuous variables was assessed with graphic plots and fractional polynomials; variables were transformed when appropriate to meet assumptions of linearity. Model fit was assessed with the Hosmer-Lemeshow goodness-of-fit statistic. Results of the final multivariate model were expressed as ORs and corresponding 95% CIs. Analyses were performed with computer software.[a]

Results

Initially, 279 dogs were evaluated for study eligibility. One dog was excluded, because it was found during the initial laparoscopic exploration to have already undergone sterilization. The remaining 278 dogs met the study inclusion criteria, of which 131 (47%) had undergone LapOVH and 147 (53%) had undergone LapOVE. Patient and procedural data were summarized **(Table 1)**. There were 66 (219/278 [79%]) breeds represented and 59 (59/278 [21%]) mixed-breed dogs. Most common breeds included Great Dane (24/219[11%]), Labrador Retriever (22/219 [10%]), and Golden Retriever (13/219 [6%]). From 2003 through 2008, 115 of 128 (90%) dogs underwent LapOVH and 13 (10%) underwent LapOVE. From 2009 through 2013, 16 of 150 (11%) dogs underwent LapOVH and 134 (89%) underwent LapOVE. The distribution of procedures performed differed significantly (*P* < 0.001) between the 2 time periods. The surgical population also changed from 34% (44/128 cases; 34 LapOVH and 10 LapOVE) shelter-owned dogs during 2003 through 2008 to 0.7% (1/150

Table 1—Patient characteristics for 278 female dogs that underwent surgical sterilization by means of LapOVH (n = 131) or LapOVE (147) from October 2003 through October 2013.

Variable	LapOVH	LapOVE	*P* value
Age (mo)*	9.8 (2.2–133.3)	9.2 (3.1–111.2)	0.837
Weight (kg)*	20.1 (2.2–74)	20.0 (1.4–63)	0.317
Preoperative urinary tract abnormality	22 (16.8)	6 (4.1)	< 0.001
Preoperative anesthesia status			0.060
No systemic disease	103 (79.8)	129 (87.8)	
Mild systemic disease	20 (15.5)	17 (11.6)	
Severe systemic disease	6 (4.7)	1 (0.7)	
ACVS diplomate as surgeon	64 (48.9)	79 (53.7)	0.416
Multiport technique	130 (99.3)	48 (32.7)	< 0.001
Additional surgical procedure	53 (40.1)	52 (35.6)	0.379
Surgery time (min)*	67 (25–130)	50 (22–150)	< 0.001
Total anesthesia time (min)*	150 (70–375)	125 (70–375)	< 0.001
Intraoperative complication	3 (2.3)	7 (4.8)	0.269
Immediate postoperative complication	9 (6.9)	10 (6.8)	0.982
Duration of hospitalization			< 0.001
Outpatient	25 (19.1)	85 (57.8)	
1 night	96 (73.3)	52 (35.4)	
≥ 2 nights	10 (7.6)	10 (6.8)	
Short-term (≤ 14 d) incisional complication†	8 (8.8)	7 (5.3)	0.640
Follow-up time (d)*‡	2,143 (570–3,650)	636 (111–2,806)	< 0.001
Postoperative urinary incontinence‡	12 (14.6)	7 (5.6)	0.028
Postoperative pyometra‡	0 (0.0)	0 (0.0)	NA
Postoperative signs of estrus‡	0 (0.0)	0 (0.0)	NA

Data are reported as number (%) except where indicated.

*Median (range). †Short-term follow-up information was available for 224 dogs (91 that underwent LapOVH and 133 that underwent LapOVE). ‡Long-term follow-up information was available for 207 dogs (82 that underwent LapOVH and 125 that underwent LapOVE).

NA = Not applicable.

cases; 1 LapOVE) shelter-owned dogs during 2009 through 2013. Shelter cases were all lost to short- and long-term follow-up.

All LapOVH cases except 1 were performed with a multiport laparoscopic technique, whereas 99 of 147 (67.3%) LapOVE cases were performed with a single-port technique. Among single-port cases, a commercially available multitrocar port[b] was used in 91 of 99 (91.9%) cases, and the single-port access technique[4] was used in 8 (8.1%). Laparoscopic sterilization procedures were performed by 6 ACVS diplomates and 34 non board-certified surgeons (ie, surgery residents, interns, and American College of Veterinary Internal Medicine diplomates). Combing LapOVH and LapOVE cases, 105 of 278 (37.8%) dogs had 1 or more additional procedures performed, for a total of 122 additional procedures, during the same anesthetic episode. Laparoscopic-assisted gastropexy was the most common additional procedure (57/122 [46.7%]). Other additional procedures included mass removal (13/122 [10.7%]), urinary tract surgery or cystoscopy (12/122 [9.8%]), hernia repair (10/122 [8.2%]), digestive tract surgery or endoscopy (10/122 [8.2%]), dental procedures (8/122 [6.6%]), episioplasty (6/122 [4.9%]), orthopedic surgery or radiography (6/122 [4.9%]), CT angiography (4/122 [3.3%]), and ocular surgery (4/122 [3.3%]).

Incidence of intraoperative complication did not differ significantly between surgery groups. Of the 131 cases in the LapOVH group, 3 (2.3%) had intraoperative complications (1 bleeding ovarian pedicle, 1 splenic laceration, and 1 conversion to laparotomy because of the presence of soft tissue masses in the omentum). Of the 147 cases in the LapOVE group, 7 (4.8%) had intraoperative complications (3 iatrogenic splenic lacerations, 1 of which required introduction of additional laparoscopic ports to suture the splenic capsule and 1 of which required conversion to celiotomy; 1 bleeding ovarian pedicle; 1 extended abdominal incision to retrieve a dropped ovary; and 1 conversion to celiotomy because of ascites and splenomegaly). Additionally, 1 patient undergoing LapOVE experienced 2 intraoperative complications: additional laparoscopic ports were required to facilitate identification of the ovaries, and a swaged needle broke intracorporeally, necessitating conversion to laparotomy for retrieval.

Incidence of immediate postoperative complication also did not differ significantly between surgery groups. At least 1 immediate postoperative complication occurred in 19 of the 278 cases. The most common complications were diarrhea or hematochezia (12/278 [4.3%]), vomiting (2/278 [0.7%]), corneal ulceration (3/278 [1.1%]), and regurgitation (2/278 [0.7%]). One dog had a soft tissue swelling at the gastropexy site, and 1 dog had ocular and nasal discharge consistent with an upper respiratory tract infection. All these complications were mild and self-limiting or resolved with supportive care. One patient in the LapOVH group developed hemoperitoneum that was

diagnosed 1 day after surgery. A celiotomy was performed, and hemorrhage associated with the uterine body, right ovarian pedicle, and left broad ligament was identified.

Dogs undergoing LapOVE were more likely to be discharged from the hospital on the same day as surgery (85/147 [57.8%]) than were dogs in the LapOVH group (25/131 [19.1%]; Table 1). With both surgery groups combined, 168 dogs were treated as inpatients, with 148 of the 168 (88.1%) staying only 1 night in hospital. The reasons cases were treated on an outpatient versus inpatient basis could not be determined from retrospective review of the medical records. Hospitalization of ≥ 2 nights was related to development of postoperative complications (7/20 cases), care associated with nonspay surgical procedures (6/20 cases), care for medical problems unrelated to surgery (4/20 cases), and unknown reasons (3/20 cases).

Short-term (≤ 14 days after surgery) follow-up information was available for 91 of 131 (69.4%) patients in the LapOVH group and 133 of 147 (90.5%) patients in the LapOVE group. Collectively, short-term follow-up information was significantly ($P < 0.001$) more likely to be available for dogs treated from 2009 through 2013 (143/150 [95.3%]) versus 2003 through 2008 (81/128 [63.3%]). Short-term postoperative incisional complications including erythema, seroma, or infection were reported in 15 of 224 (6.7%) dogs and were not significantly associated with procedure (Table 1). On multivariable analysis, duration of anesthesia and development of an immediate postoperative complication (eg, hematochezia, vomiting or regurgitation, corneal ulceration, or hemoperitoneum) were significantly associated with development of a postoperative incisional complication, after adjusting for body weight. For the 224 patients for which short-term follow-up information was available, for every additional 30 minutes of anesthetic time, the odds of developing an incisional complication increased by 24% (OR, 1.24; 95% CI, 1.00 to 1.54; $P = 0.050$), adjusting for body weight and immediate postoperative complications. Dogs that developed an immediate postoperative complication were 6.67 times as likely (95% CI, 1.70 to 26.1; $P = 0.006$) to develop an incisional complication, as were dogs with no immediate postoperative complications **(Table 2).** Although 15 dogs developed incisional complications, only 3 of 224 (1.3%) met the criteria for an SSI (ie, purulent discharge at the site of an incision within 14 days after the procedure).

Long-term follow-up information was available for 82 of 131 (62.6%) patients in the LapOVH group and 125 of 147 (85.0%) patients in the LapOVE group. Collectively, long-term follow-up information was significantly ($P < 0.001$) more likely to be available for dogs treated from 2009 through 2013 (135/150 [90.0%]) versus 2003 through 2008 (72/128 [56.3%]). Urinary incontinence occurred in 19 of 207 (9.2%) dogs and was associated with the LapOVH group on

unadjusted analysis (Table 1). However, on multivariable analysis, procedure was not independently associated with urinary incontinence following surgery, but was a confounding factor in the association between preoperative urinary tract abnormalities and postoperative incontinence **(Table 3)**. After adjusting for body weight, duration of follow-up, and procedure (LapOVH vs LapOVE), dogs with preoperative urinary tract abnormalities, including incontinence, urinary tract infection, or calculi, were 3.27 times as likely (95% CI, 1.03 to 10.33; $P = 0.044$) to have postoperative urinary incontinence as were dogs without a history of preoperative urinary tract abnormalities. Of the 25 dogs with preoperative urinary tract abnormalities for which long-term follow-up information was available, 6 (24.0%) were reported to have postoperative urinary incontinence. Of the 182 dogs with no preoperative urinary tract abnormalities for which long-term follow-up information was available, 13 (7.1%) were reported to have postoperative urinary incontinence. No dogs were reported to have exhibited signs of estrus, pyometra, or a persistent ovarian remnant following laparoscopic sterilization.

Overall, owners of 205 of 207 (99%) dogs for which long-term follow-up information was available reported that they were satisfied with the surgery. The owner of 1 dog that underwent LapOVH reported that the dog's combined incision lengths were longer than would have been expected with open OVH, that the dog experienced more discomfort than expected, and that the procedure and anesthetic times were excessive. The owner of 1 dog that underwent LapOVE was dissatisfied because the dog sustained a splenic laceration that resulted in conversion to laparotomy. Owners of 196 of 207 (95%) dogs reported that they would consider laparoscopic sterilization for female dogs in the future. Complications, higher cost, and a lack of perceived benefit, compared with open surgery in small dogs, were cited as reasons why owners would not necessarily choose laparoscopic sterilization in the future.

Table 2—Factors associated with the development of an incisional complication ≤ 14 days after laparoscopic spay surgery in 224 female dogs that underwent surgical sterilization by means of LapOVH (n = 91) or LapOVE (133) and for which adequate short-term follow-up information was available.

	Univariate analysis		Multivariable analysis	
Independent variable	OR (95%CI)	P value	OR (95%CI)	P value
Age (1 mo)	0.99 (0.97–1.02)	0.593	NA	NA
Weight (5 kg)	1.21 (1.03–1.43)	0.018	1.19 (0.99–1.42)	0.063
ACVS diplomate as surgeon	0.50 (0.17–1.51)	0.222	NA	NA
LapOVH	1.28 (0.45–3.64)	0.640	NA	NA
Single-port technique	0.89 (0.29–2.68)	0.833	NA	NA
Total anesthesia time (30 min)	1.32 (1.09–1.59)	0.004	1.24 (1.00–1.54)	0.050
Immediate postoperative complication	5.96 (1.70–21.0)	0.005	6.67 (1.70–26.1)	0.006
Surgery during 2003 through 2008	1.79 (0.62–5.17)	0.282	NA	NA

Odds ratios for continuous variables indicate the difference in odds for each additional increment (1 month of age, 5 kg of body weight, or 30 minutes of anesthesia time). Odds ratios for categorical variables indicate the difference in odds relative to the alternative (non–board-certified surgeon, LapOVE, multiport technique, absence of immediate postoperative complications, or surgery from 2009 through 2013).
NA = Not applicable.

Table 3—Factors associated with postoperative urinary incontinence in 207 female dogs that underwent surgical sterilization by means of LapOVH (n = 82) or LapOVE (125) and for which adequate long-term follow-up information was available.

	Univariate analysis		Multivariable analysis	
Independent variable	OR (95%CI)	P value	OR (95%CI)	P value
Age (1 mo)	0.99 (0.97–1.02)	0.605	NA	NA
Weight (5 kg)	1.14 (0.99–1.32)	0.074	1.14 (0.98–1.33)	0.083
Body condition score	1.87 (0.94–3.69)	0.073	NA	NA
Preoperative urinary tract abnormality	4.11 (1.38–12.06)	0.010	3.27 (1.03–10.33)	0.044
ACVS diplomate as surgeon	0.90 (0.35–2.34)	0.830	NA	NA
LapOVH	2.89 (1.09–7.68)	0.033	1.59 (0.30–8.44)	0.584
Single-port technique	0.42 (0.15–1.22)	0.112	NA	NA
Duration of follow-up (1 mo)	1.02 (1.00–1.03)	0.043	1.01 (0.98–1.04)	0.653
Surgery during 2003 through 2008	2.26 (0.87–5.84)	0.093	NA	NA

Odds ratios for continuous variables indicate the difference in odds for each additional increment (1 month of age, 5 kg of body weight, 1 U of body condition score, or 1 month of follow-up time). Odds ratios for categorical variables indicate the difference in odds relative to the alternative (absence of preoperative urinary tract abnormality, non–board-certified surgeon, LapOVE, multiport technique, or surgery from 2009 through 2013).
NA = Not applicable.

Discussion

Results of the present 10-year (2003 through 2013) retrospective study suggested that short- and long-term outcomes were similar for female dogs undergoing sterilization by means of LapOVH or LapOVE. Most owners were satisfied with the procedure and indicated that they would consider laparoscopic sterilization for future dogs. No complications novel to LapOVE were noted in comparison with LapOVH, thus adding support for the proposition that OVE is an equally acceptable sterilization practice versus OVH. In the present study, LapOVE was associated with shorter surgical times, but the validity of this finding must be confirmed under experimental conditions less susceptible to bias and confounding. The only long-term complication in the present study was urinary incontinence, with a higher odds of postoperative urinary incontinence in dogs with a history of preoperative urinary tract abnormalities. However, postoperative urinary incontinence was not significantly associated with surgical procedure (LapOVE vs LapOVH) or body weight.

The combined incidence of intraoperative and postoperative complications associated with traditional open OVH in healthy dogs has been reported to be as high as 20.6%.[14] Described complications associated with OVH include hemorrhage, incisional complications, ovarian remnant syndrome, stump pyometra, abscess or granuloma formation, obstipation, ureteral trauma, vaginoperitoneal fistula formation, and urinary incontinence.[15] To date, we are aware of few published reports describing complications and outcomes associated with OVE in a large group of dogs. One study[16] of 20 dogs reported no significant differences in surgery time, pain scores, or wound scores when open OVE and OVH were compared. Similarly, when final-year veterinary students performed surgical sterilization on 106 dogs (52 OVH and 54 OVE), surgical variables did not differ between groups.[17] Three studies[18-20] evaluating the incidence of long-term (ie, 3 to 11 years) postoperative urogenital complications following open OVH and OVE in dogs indicated no significant difference between procedures.

To our knowledge, the present case series is the first large study documenting and evaluating the outcomes of laparoscopic sterilization in dogs. As for previously published data on traditional open sterilization, the present study did not identify any differences in patient characteristics or outcomes between laparoscopic sterilization techniques. Both LapOVH and LapOVE appeared to be safe and effective methods of surgical sterilization when performed with a multiport or single-port technique. The median surgery times of 67 minutes (range, 25 to 130 minutes) for LapOVH and 50 minutes (range, 22 to 150 minutes) for LapOVE were consistent with previously published results for LapOVH (mean, 20.8 to 120 minutes[7,9]; median, 36.5 to 60 minutes[12,21]) and LapOVE (mean, 18.2 to 52.5 minutes[2,4,5,22]; me-

dian, 35 minutes[3]). The additional time required for uterine body exteriorization and ligation and for reestablishment of the pneumoperitoneum likely accounted for the significantly ($P < 0.001$) longer median surgery time for LapOVH versus LapOVE in the present study. Furthermore, LapOVE was typically performed with fewer ports, which could reduce surgical time independent of viscera excised. However, these surgical times must be interpreted cautiously, as factors beyond surgical technique could also influence procedure times in these groups. Our study spanned a 10-year period during which operating room personnel, laparoscopic equipment, caseload, and institutional policies changed and patients were not assigned to procedures at random. The overall wide range in surgery times in the present study was likely related to the variety of techniques (single-port vs multiport) and laparoscopic skill levels among the surgeons, which included 6 ACVS diplomates and 34 non–board-certified surgeons. Additionally, as this was a retrospective study, the influence of intraoperative training and a learning curve effect could not be determined but likely resulted in longer procedural times, at least initially, for both ACVS diplomates and non–board-certified surgeons, compared with what might be expected for a single experienced laparoscopic surgeon performing all the surgeries in a standardized fashion with a trained operating-room team. A well-designed prospective study comparing LapOVE with LapOVH under standardized conditions would be necessary to determine whether a meaningful difference in operative time can be expected for one of these procedures versus the other.

Intraoperative complications noted in the present study were infrequent and consistent with the types of complications reported in previous studies of open and laparoscopic sterilization in dogs. Specifically, access-related lesions such as splenic laceration are well-documented complications of laparoscopic surgery.[2,12,22,23] The incidence of access-related lesions in a large cohort of dogs has yet to be reported. Iatrogenic splenic lacerations were reported in 4 of 278 (1.4%) patients in the present study during laparoscopic OVH (1 dog) and OVE (3 dogs). Because the specific abdominal access technique (ie, Hasson or modified Hasson) was not consistently noted in surgery reports in the medical records, we were unable to comment further on whether the access technique chosen may have influenced the incidence of access-related complications. The overall occurrence of combined intraoperative and postoperative pedicle hemorrhage was quite low in the present study (3/278 [1%]) and much lower than that reported in previous studies of open sterilization. In 377 dogs undergoing OVH, Berzon et al[24] reported intraoperative hemorrhage in 20% of dogs, 2% in dogs weighing < 22.7 kg (50 lb), and 79% in dogs ≥ 22.7 kg. In a prospective study[17] of 106 dogs, minor intraoperative hemorrhage and suture difficulties requiring additional ligation was reported for 23% (12/52) of dogs undergoing OVH and 39% (21/54) of dogs undergo-

ing OVE, with only 1 (1.9%) instance of major ovarian pedicle hemorrhage in the OVH group. Burrow et al[14] reported a lower intraoperative hemorrhage rate of 6.3% (9/142) for dogs undergoing elective OVH, with an additional postoperative self-resolving hemorrhage rate of 2.8% (4/142). In the present study, the low rate of hemorrhage could support the theory that laparoscopic sterilization reduces the risk for pedicle hemorrhage; however, a valid comparison cannot be made with previously published reports[14,17,24] of open sterilization when the procedures were performed by veterinary students. A lower rate of hemorrhage would be expected when experienced surgeons perform the procedures. Additionally, the use of a vessel-sealing device in the present study likely contributed to the low intraoperative hemorrhage rates, compared with rates in studies involving traditional pedicle ligation. Whereas there are currently no data comparing intraoperative blood loss between vessel-sealing devices and traditional suture ligation in the veterinary literature, use of an electrosurgical bipolar vessel-sealing device versus suture resulted in significantly decreased mean estimated blood loss in human patients undergoing hysterectomy.[25]

The overall postoperative incisional complication rate for patients in the present study, inclusive of erythema, seroma, and suspected SSI, was 6.7% (15/224). However, only 3 of 224 (1.3%) dogs were found to have signs consistent with a diagnosis of SSI (ie, purulent discharge at the site of the incision ≤ 14 days after the procedure).[11] This rate was slightly lower than previously published rates of SSIs in dogs undergoing clean open procedures, which range from 2% to 4.8%.[26-29] In the present study, incisional complications increased by 24% for every additional 30 minutes of anesthetic time. Similarly, in a study evaluating postoperative SSIs in dogs and cats, Eugster et al[29] reported a 1% increase in the risk of infection for each additional minute of surgery. In a prospective study, Brown et al[27] reported that the incidence of postoperative wound infections doubled in dogs and cats when procedure times were longer 90 minutes versus 60 minutes. Lastly, Beal et al[28] reported a 30% higher risk of postoperative wound infection for each additional hour of anesthesia. In the present study, incisional complications were 6.7 times as likely to occur in dogs that experienced an immediate postoperative complication such as vomiting, regurgitation, diarrhea, or hematochezia. However, further prospective evaluation is needed to explore this association.

The only long-term complication in the present study at final follow-up (range, 111 to 3,650 days) was postoperative urinary incontinence, which was reported in 19 of 207 (9.2%) dogs. Development of urinary incontinence was not significantly associated with procedure type or body weight, and the incidence of urinary incontinence was similar to that previously reported for dogs undergoing open OVH or OVE, ranging from 5.1% to 20.1%.[18–20,30,31] Our finding that dogs with a preoperative urinary tract abnormality were 3.27 times as likely to experience postoperative urinary incontinence as were dogs that did not have a preoperative urinary tract abnormality has not been previously reported. However, the lack of complete historical information about preoperative urinary dysfunction affected our ability to interpret the importance of postoperative urinary incontinence. Owners of 5 of the 6 patients with preoperative urinary tract abnormalities and postoperative urinary incontinence reported urinary incontinence as a preoperative problem. This may have suggested that the overall urinary incontinence rate of 9% was in part the result of other congenital diseases such as ectopic ureters. Urinary incontinence because of other acquired conditions unrelated to the sterilization procedure must also be considered, as was likely in 2 cases: 1 dog developed protein-losing nephropathy a few years after the LapOVH, and 1 dog was examined for extensive pelvic fractures in the weeks prior to LapOVH. None of the patients in the present study with long-term follow-up available were reported to have postoperative signs of estrus or a diagnosis of pyometra. This supports the results of prior reports[1,6,20,32] that the risk of long-term uterine pathology is not increased in dogs undergoing OVE, when complete ovarian excision is performed.

It is our opinion that the shift toward predominantly outpatient LapOVE with a higher 2-week follow-up rate over the years in the present study was the result of a variety of factors. An increased preference for LapOVE (vs LapOVH) was made on the basis of increasing published evidence[1,6,16,32] advising against uterine removal, with no difference in surgical outcomes for OVE versus OVE. Changes in surgical staff resulting in different patient management philosophies could also have affected the duration of hospitalization and 2-week follow-up rate. Furthermore, for earlier years, discharge notes frequently advised recheck examination with the primary care veterinarian, whereas newer discharge notes tended to advise recheck examination with the surgeon. Additionally, the surgical population changed during the 10-year study period; cases in earlier years included a higher proportion of shelter animals, compared with those later years. Shelter animals were all lost to short- and long-term follow-up and sometimes stayed overnight after surgery for shelter convenience only. Therefore, because the rationale for duration of hospitalization and 2-week follow-up rates could not be clearly identified in the retrospective record review, and results relating to these outcomes must be interpreted with caution.

Limitations of the present study included the lack of standardization of surgeon or technique, loss of follow-up for shelter animals, and a lack of historical details for patients with preoperative urinary tract abnormalities. Further limitations included the retrospective design with the attendant possibility of medical record omissions, variations in follow-up protocol, and lack of other historical patient details. For example, historical information was not available for the number of estrous cycles prior to surgery, and this information has been previously reported to be associated with postoperative

urinary incontinence rate.[19,30,33] Use of a client questionnaire to obtain long-term follow-up information was also a limitation of this study because it was greatly reliant on owner observation and interpretation of long-term outcomes and was thus subject to recall bias. This reliance on owners could also have introduced response bias because the owners of dogs with concerns may have had a greater incentive to respond to the questionnaire. The long-term follow-up time was also significantly different between the procedural groups, and a median follow-up time of 1.7 years (range, 0.3 to 7.7 years) for the LapOVE group may have been inadequate to accurately document the incidence of urinary incontinence, as previous reports have stated that acquired urethral sphincter incontinence can manifest several years after sterilization, with a median onset of 2.9 years after surgery.[15] Lastly, the study may have lacked a sufficient number of patients to detect significant differences in the incidence of complications between patients undergoing LapOVE versus LapOVH, because complications associated with surgical sterilization in dogs are uncommon.

Acknowledgments

Footnotes

a. Stata, release 12, StataCorp LLC, College Station, Tex.
b. SILS Port, Covidien, Mansfield, Mass.

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