Veterinary Surgery
38:811–817, 2009

The Effect of Laparoscopic Versus Open Ovariectomy on Postsurgical Activity in Small Dogs

WILLIAM T. N. CULP, VMD, Diplomate ACVS, PHILIPP D. MAYHEW, BVM&S, Diplomate ACVS, and DOROTHY C. BROWN, DVM, Diplomate ACVS

Objective—To describe a technique for laparoscopic ovariectomy (LapOVE) in small dogs, and compare the surgical time, complications, and postoperative activity of dogs undergoing LapOVE to those undergoing conventional traditional open ovariectomy (OOVE).
Study Design—A randomized, controlled clinical trial.
Animals—Intact small breed (<10 kg) female dogs (n = 20).
Methods—Ventral median celiotomy was performed for OOVE. A 2-midline portal technique using a 3.5 mm laparoscope port and a 6 mm instrument portal was used for LapOVE. An accelerometer was attached to the collar of each dog to record 24-hour preoperative and 48-hour postoperative activity. Total activity counts recorded before surgery were compared with total counts recorded after surgery. The percent change in counts after surgery was compared between OOVE- and LapOVE-treated dogs.
Results—No major complications occurred and surgical time for LapOVE was significantly longer than for OOVE cases ($P = .005$). Dogs in the LapOVE group had a 25% decrease in total activity counts after surgery (95% confidence interval [CI]: 11–38%), whereas dogs in the OOVE group had a 62% decrease in total activity counts after surgery (95% CI: 48–76%).
Conclusions—Both procedures were performed with reasonable surgical times and without major complication. Postoperative activity, as measured by accelerometry, was significantly different between the 2 groups.
Clinical Relevance—Laparoscopy is a safe method for ovariectomy in small dogs and results in increased postoperative activity counts when compared with an open technique.

INTRODUCTION

FEMALE STERILIZATION is common practice in veterinary medicine. Whereas ovariohysterectomy is often the procedure of choice for female sterilization in the United States, complications such as pyometra, urinary sphincter mechanism incontinence, and weight gain are not seen more commonly with ovariectomy (OVE) versus ovariohysterectomy (OVH).[1,2] Furthermore, some have promoted potential benefits of OVE over OVH including decreased surgical time, smaller celiotomy, and less manipulation of the female genital tract.[2–4] Laparoscopic techniques are still relatively new in veterinary medicine; however, laparoscopic sterilization is gaining popularity. Several studies have evaluated laparoscopic sterilization of female dogs and these techniques decrease postoperative pain[5–7] and surgical stress.[6] Surgical times, anesthetic times, and complications are also similar between laparoscopic-assisted OVH and open OVH in some reports.[6] Whereas studies have evaluated laparoscopy in smaller animals such as cats and birds,[8,9] studies are lacking that evaluate laparoscopic sterilization in small dogs (<10 kg).

From the Department of Clinical Studies—Philadelphia, School of Veterinary Medicine, University of Pennsylvania, Philadelphia, PA.
This work was performed at the Department of Clinical Studies, School of Veterinary Medicine, University of Pennsylvania.
Presented in part at the 2008 ACVS Veterinary Symposium, San Diego, CA.
Corresponding author: Dr. William Culp VMD, Diplomate ACVS, Animal Cancer Center, Veterinary Teaching Hospital, Colorado State University, 300 W. Drake Rd., Fort Collins, CO 80523. E-mail: william.culp@colostate.edu.
Submitted November 2008; Accepted January 2009

0161-3499/09
doi:10.1111/j.1532-950X.2009.00572.x

Many different modalities are available for achieving hemostasis during laparoscopic surgery. Electrocautery (monopolar and bipolar) and ultrasonic devices as well as steel sutures, hemoclips, laser, and extracorporeal sutures have been used successfully for laparoscopic sterilization techniques in dogs, cats, birds, and horses.[3,5,7–12] The LigaSure™ (Valleylab, Boulder, CO) device has been extensively evaluated in human laparoscopy studies[13,14] as well as in horses for the removal of both normal[10] and neoplastic ovaries.[11] The LigaSure™ device is an effective means of achieving hemostasis both in people and animals and is indicated for sealing arteries and veins up to a maximal diameter of 7 mm.[10,11,13,14]

Whereas postoperative pain scores have been measured in laparoscopic sterilization,[5–7] objective evaluations of postoperative recovery based on patient activity have not been described. The Actical Activity Monitor (AAM; Respironics Mini Mitter division, Bend, OR) is an accelerometer that can continuously record the intensity, frequency, and duration of movement for extended periods in a reliable manner.[15] Accelerometers are worn by the subject and the intensity of physical activity over a determined amount of time is recorded.[16] Accelerometers are used in human medicine regularly to assess pain and alterations in physical activity associated with chronic diseases such as cancer and cardiovascular disease.[16–19]

The AAM has been used to monitor the activity level of kenneled dogs in several investigations.[20–22] These studies have shown that under controlled handling and environmental conditions, the AAM gives a reliable assessment of the dogs' 24-hour day-to-day activity. In dogs, accelerometry has been compared with videography in the recording of physical activity.[19] Additionally accelerometry has been used to assess the effect of age and cognitive status on activity in dogs.[22]

Our purposes were (1) to describe a technique for laparoscopic ovariectomy (LapOVE) in small dogs (<10 kg); (2) to report surgical time and complications of this technique compared with open ovariectomy (OOVE); and (3) to compare postoperative activity counts measured by accelerometry in small dogs undergoing LapOVE versus dogs undergoing OOVE using the AAM. Our hypothesis was that LapOVE could be performed safely and efficiently in dogs <10 kg and that dogs undergoing OOVE would have a greater decrease in activity after surgery than dogs undergoing LapOVE.

MATERIALS AND METHODS

Study Design

This was a single-center, randomized, controlled trial.

Dogs

Intact female dogs weighing <10 kg were acquired from an animal welfare society at irregular intervals over 8 months. After admission, each dog had a complete physical examination and minimal database: hematocrit, total serum protein measured with a portable refractometer (Jorgensen Laboratories Inc., Loveland, CO), blood glucose assay (Accu-Chek, Roche Diagnostics Inc., Indianapolis, IN), and serum urea nitrogen assay (Azostix, Bayer Corp., Elkhart, IN).

Monitors

In all dogs, the AAM, an omnidirectional accelerometer-based device that measures continuously the intensity, frequency, and duration of movement, was used. The watch-sized monitor was attached to the collar of each dog and positioned ventrally on the neck. The accelerometer epoch was set at 15 seconds to allow maximum data collection.

Sample Size Estimation

It was determined that at least 9 dogs needed to be included in each group (OOVE and LapOVE) to have an 80% power of detecting differences of $\geq 30\%$ changes in activity counts between the groups (SD 20%, $P = .05$). To compensate for potential protocol deviations and losses to follow-up in the intention-to-treat analysis (ITT), 20 dogs would be randomized to the study (10 dogs/group).

Housing

Before and after surgery, all dogs were housed in standard hospital runs that measured 240 cm × 107 cm. Dogs were allowed free access to a 450 cm × 500 cm outside enclosure for 10 minutes twice daily.

Randomization

Dogs were randomized to 1 of 2 potential surgical interventions. A block randomization sequence with 2 potential treatment groups was generated with a block size of 4. Dogs were sequentially assigned to groups according to the randomization scheme and the scheme was concealed from animal welfare society employees who selected dogs to be delivered for OVE.

Anesthetic and Analgesic Protocol

All dogs were administered a standardized anesthesia and analgesia protocol. Dogs were premedicated with hydromorphone (0.2 mg/kg intramuscularly [IM]) and acepromazine (0.03 mg/kg IM). General anesthesia was induced with thiopentone administered to effect up to a maximum of 12 mg/kg IV before intubation. General anesthesia was maintained with isoflurane in oxygen to effect. All dogs were maintained on assisted ventilation throughout the procedures.

Once in recovery and 4 hours after the dogs were premedicated, buprenorphine (0.01 mg/kg intravenously [IV]) was administered. An additional 2 doses of buprenorphine (0.01 mg/kg IV) were administered to all dogs at 6-hour intervals thereafter.

Surgical Technique

The primary author performed all OOVE procedures as well as being the primary surgeon for all LapOVE cases. The second author assisted in all LapOVE procedures for the purpose of laparoscope handling.

OOVE. Each dog was positioned in dorsal recumbency, the ventral abdomen was liberally clipped and aseptically prepared for surgery in standard fashion. A ventral median incision was made extending caudally from 1 cm caudal to the umbilicus. The right ovary was exteriorized, and the suspensory ligament was ruptured by a combination of gentle traction and unipolar electrocautery. A hole was made in the mesovarium, and 2 encircling sutures of 2-0 polydioxanone were placed around the ovarian artery and vein. Two more encircling sutures of 2-0 polydioxanone were then placed around the proper ligament. The mesovarium and proper ligament were transected, and the ovary was removed. This was repeated on the left side in similar fashion. The external rectus fascia was closed in a simple continuous pattern using 2-0 polydioxanone. The subcutaneous tissue was closed in a simple continuous pattern using 3-0 polyglecaprone and the skin closed using 3-0 nylon in an interrupted cruciate suture pattern.

LapOVE. Each dog was positioned in dorsal recumbency, clipped, and aseptically prepared. The video monitor was placed at the caudal end of the dog. In each dog, a 2-midline portal technique was used. A sutureless modified Hasson technique was used for abdominal access.[12] An approximately 3–6 mm ventral median incision was made in the skin and subcutaneous tissue 1 cm caudal to the umbilicus. Blunt dissection to the linea alba was followed by a 2–3 mm stab incision through the linea alba into the abdominal cavity. Penetration of the abdominal cavity was confirmed by observation of intra-abdominal fat before trocar insertion. The linea alba incision was deliberately made slightly smaller than 3.5 mm trocar to be inserted, allowing a tight fit of the trocar through the incision and avoiding gas leakage during insufflation.

A 3.5 mm nonthreaded trocar and cannula assembly (Karl Storz Endoscopy, Goleta, CA) was placed into the abdomen through the linea alba stab incision. The abdomen was insufflated with CO_2 through this trocar using a pressure regulating mechanical insufflator (Endoflator, Karl Storz Endoscopy). The intra-abdominal pressure achieved in this group of dogs was between 9 and 12 mmHg. A 3 mm, 30°, 14-cm-long laparoscope (Hopkins II®, Karl Storz Endoscopy) was inserted into the trocar and oriented caudoventrally to view the ventral abdomen. A second skin incision (approximately 7–12 mm in length) was made 2–5 cm cranial to the pubis, and a 6 mm trocarless threaded cannula (Ternamian Endotip™ Cannula, Karl Storz Endoscopy) was inserted into the abdomen. Once trocar insertion was complete, the motorized float surgical table (C-Arms International Inc., San Diego, CA) was rotated ~ 25° to the right to allow the abdominal organs to move to the right side of the body.

The camera was then oriented to view the left ovary and proper ligament. A blunt probe was placed into the caudal portal and used to manipulate the spleen to the right side, away from the left ovary and proper ligament. The blunt probe was removed from the portal, and a laparoscopic Kelly hemostat (Karl Storz Endoscopy) was placed into the portal. The left proper ligament was grasped and elevated away from the kidney and body wall. At this point, a length of 2-0 polydioxanone suture on a 1/2 curved needle was passed percutaneously into the abdominal cavity at a location close to the site of the elevated ovary. This location was easily observed by locating the site of skin transillumination from the laparoscope which was held adjacent to the ovary during this part of the procedure. Under direct observation the needle was then directed through the mesovarium. The needle pass was continued through the body wall again (transabdominal suture placement) to suspend the ovary in a ventral position in close proximity to the ventral body wall. The 2 ends of the suture were pulled tightly together and clamped with a hemostat to keep the ovary in close contact with the ventral body wall. This transabdominal suture placement was similar to a previously described procedure.[6]

The proper ligament was released from the hemostat and the hemostat was withdrawn. The LigaSure™ vessel sealing device using the 5 mm LigasureV™ tip was then introduced into the caudal portal. The LigaSure™ was directed in a caudal to cranial direction, through the proper ligament and across the mesovarium, finally cauterizing the suspensory ligament and ovarian artery and vein. The LigaSure™ was removed and the hemostat was again introduced into the caudal portal. The ovary was grasped with the hemostat and pulled up to or partially into the caudal portal cannula after removing the suture that was holding it to the body wall. The caudal portal cannula was then removed from the abdomen in conjunction with the hemostat and ovary. The caudal portal cannula was then replaced into the same caudal portal incision as previously. The surgeons then moved to the left side of the dog and the table was tilted in the opposite direction.

The camera was then directed toward the right ovary and right proper ligament. The blunt probe was used to move the duodenum away from the right ovary and right proper ligament. The procedure was then performed on the right side as described previously. Before termination of the procedure, the ovariectomy sites were thoroughly examined for any evidence of hemorrhage. When both ovaries were removed, CO_2 was released from the portals, which were then removed. The external rectus fascia was closed with a single simple interrupted suture of 2-0 polydioxanone. The subcutaneous tissues were closed in a simple interrupted pattern using 3-0 polyglecaprone, and the skin incisions were closed using 3-0 nylon in an interrupted cruciate suture pattern.

Recovery Protocol

After extubation, all dogs were continuously monitored while they recovered in 70 cm × 75 cm cages. As soon as the dogs were normothermic and fully awake, they were returned to standard hospital runs. All dogs remained in the hospital for at least 48 hours and then were returned to the animal welfare center for adoption.

Outcome Measures

Surgical Variables. The time of surgery was recorded for each dog and was defined as the time from the start of the skin incision to the time of last suture placement. Surgical time was calculated and compared between techniques.

Other variables recorded during surgery included degree of hemorrhage (none, minor = bleeding requiring no hemostatic intervention, moderate = bleeding requiring laparoscopic hemostasis or placement of a single suture, severe = conversion from laparoscopy to an open procedure because of bleeding or necessity of multiple sutures to control bleeding) and incision length.

Activity Monitoring. A detailed description of the AAM has been reported.[15] In short, the AAM includes an omnidirectional accelerometer that is sensitive to movement in all directions. A piezoelectric sensor generates a voltage when the device is subjected to a change in velocity per unit time. The voltage is converted to a digital value which is used to adjust a running baseline value that permits filtering out constant accelerations such as those caused by gravity. The current digital value is compared with the baseline value and the difference from baseline is used to create a raw activity value for the measurement period (epoch). The epoch is determined by the investigator and can be set at 15-second increments up to a maximum of 1 minute. The raw activity value is converted by the associated computer software and reported as an activity count. For the present study, the accelerometer data epoch was set at 15 seconds. Therefore, an activity count was generated for every 15 seconds of activity monitoring.

Total presurgical activity was defined as the total activity count collected over the 24 hours just before the dog was taken from her housing run to the surgical preparation area. Postsurgical activity was defined in 24-hour intervals. Postsurgical Day 1 activity was defined as the total activity count collected over the 24 hours immediately after the dog was returned to her housing run from the recovery room. Postsurgical Day 2 was defined as the second 24-hour interval. To account for between dog variability in baseline activity, the outcome measure analyzed was the percent change in activity counts postoperatively, thus allowing each dog to be its own control. Percent change in counts was defined as (presurgical total activity—postsurgical total activity)/(presurgical total activity) $\times$ 100. To describe differences in activity level between the groups, the difference between the presurgical and postsurgical activity counts of the OOVE group was compared with the difference between the presurgical and postsurgical activity counts of the LapOVE group.

Statistical Analysis

An ITT analysis was used. That is, all dogs, once randomized, were followed through to the end of the study and were included in the analysis.[23] Descriptive statistics were calculated. Surgical time and total activity count data are not normally distributed. Continuous data were expressed as median values and ranges, and categorical data were expressed as frequencies for each group. The Mann–Whitney test was used to compare surgical times between the groups. The Wilcoxon signed test was used to compare activity counts before and after surgery. Two-tailed assessments were used for all analyses and values of $P < .05$ were considered significant.

Linear regression analyses were performed to evaluate the association of surgical procedure (OOVE and LapOVE) on the percentage change in total activity counts. Additional variables evaluated included dog age, dog weight, time in the recovery room, postsurgical day, baseline activity counts, and block. Two-way interactions among the main effects were investigated individually. An interaction term was retained based on a P value $< .05$ on the t-test for factors with a single degree of freedom or on an F-test for factors with multiple terms. If not effect modifiers, univariate analysis was performed and variables with a P-value $< .2$ were evaluated in the multivariable model. Variables were then retained in the model if the P-value for that variable was $< .05$ or if its addition to the model changed a coefficient for the surgical procedures by $> 15\%$.

Normality of residuals was checked with a kernel density plot. The constant variance of residuals was checked with the Cook-Weisberg test for heteroscedasticity. The variance inflation factor was calculated to test for multicollinearity. Residual scatter plots were used to check for nonlinearity. All analyses were performed in Stata version 8 (StataCorp, College Station, TX).

RESULTS

Twenty dogs were randomized, 10 to each group. There were no protocol deviations or losses to follow-up (Fig 1).

Surgical Bleeding and Incision Length

Six dogs in the OOVE group had minor bleeding, which was residual blood remaining in the ovarian or uterine horn pedicle after transection. Three dogs in the LapOVE group had minor bleeding from puncture of a tiny vessel in the mesovarium when the transabdominal suture was being placed.

Median incision length in OOVE dogs was 5.2 cm (range, 4.5–5.8 cm). The median length of the cranial incision in the LapOVE cases was 4.2 mm (range, 3.8–5.6 mm) and the median length of the caudal incision in the LapOVE cases was 9 mm (range, 7.2–11.3 mm).

Surgical Time

Median surgical time for OOVE (21 minutes; range, 20–37 minutes) was significantly less ($P = .005$) than for LapOVE (30 minutes; range, 24–48 minutes).

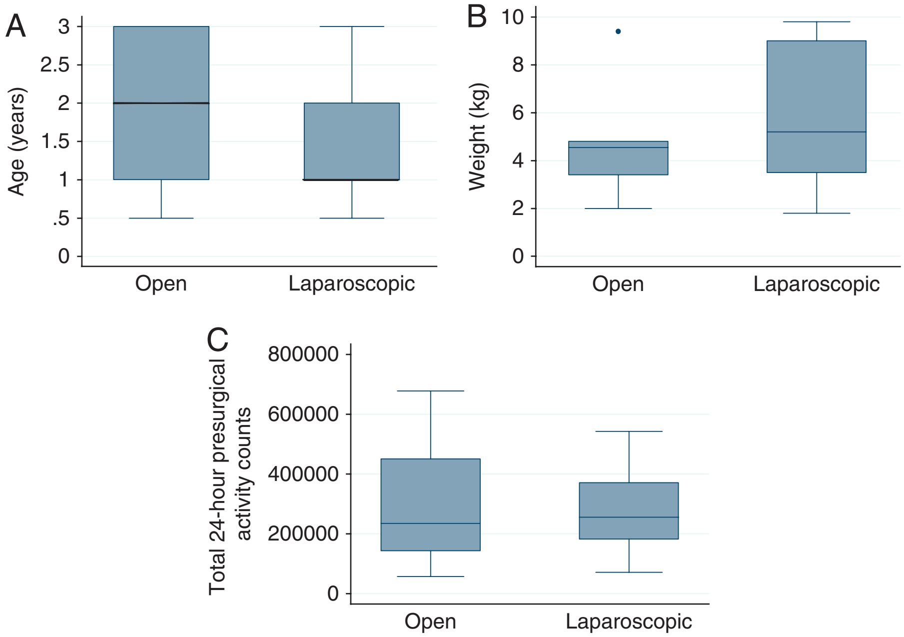

Fig 1. Baseline clinical characteristics (A. age; B. weight; C, presurgical activity counts) for dogs randomized to open ovariectomy (n = 10) and laparoscopic ovariectomy (n = 10).

- **The box itself contains the middle 50% of the data. The upper edge of the box indicates the 75th percentile of the data set, and the lower edge indicates the 25th percentile. The range of the middle two quartiles is known as the inter-quartile range.**
- **The line in the box indicates the median value of the data.**
- **The ends of the vertical line indicate the minimum and maximum data values, unless outliers are present in which case these extend to a maximum of 1.5 times the inter-quartile range.**
- **The points outside the ends of vertical lines are outliers (i.e. > 3 times the inter-quartile range).**
- **For plot A, the median and 25th percentile is the same in the laparoscopic group.**

Activity Evaluation

There was no significant change from the presurgical (median, 256,166; range 71,928–542,956) to the postsurgical Day 1 (median, 154,531; range, 51,296–312,370) and postsurgical Day 2 (median, 169,788; range, 66,107–644,357) total activity counts in the dogs undergoing LapOVE, whereas dogs undergoing OOVE had a significant decrease in activity counts from presurgical (median, 235,170; range, 57,322–677, 623; $P = .002$) to postsurgical Day 1 (median, 50,826; range, 16,280–207,704), as well as postsurgical Day 2 (median, 88,234; range, 23,192–444,871; $P = .002$) assessments (Table 1).

For linear regression analysis of the percent change in total activity counts, there were no interactions. On univariate analysis, 4 variables (surgical technique, dog weight, postsurgical day, and baseline activity counts) had a P-value $< .2$. When added individually to the model containing the surgical technique variable, no other variables were confounders or significantly associated with the change in total activity counts. Dogs in the LapOVE group had a 25% decrease in total activity counts after surgery (95% confidence interval [CI]: 11–38%), whereas dogs in the OOVE group had a 62% decrease in total activity counts after surgery (95% CI: 48–76%).

Table 1. Factors Significantly Affecting the Percent Change in Total Activity Counts (Presurgical to Postsurgical) in 20 Dogs Randomized to Open (n = 10) Versus Laparoscopic (n = 10) Ovariectomy

Variable	Coefficient	t	*P*-value	95% CI
Surgical Technique*	37.3	3.91	< .001	18.0–56.7
Constant	24.8	3.67	.001	11.1–38.5

*Baseline comparison is the laparoscopic procedure.

DISCUSSION

Previous studies have compared laparoscopic sterilization of female dogs with standard open techniques of sterilization.[5–7] In several of those studies, subjective postoperative pain scores were found to be significantly higher in cases of open OVH versus laparoscopic OVH.[5–7] For this study, an objective assessment of perioperative physical activity was used to compare the open versus laparoscopic procedure. This was accomplished by the use of accelerometry-based activity monitoring.

The anesthetic and analgesic protocol we used is commonly practiced in our clinic and allows for adequate sedation before induction of anesthesia. Each dog was fully awake before being returned to her run postoperatively. Additionally, administration of buprenorphine for these dogs was sufficient for pain control.

Dogs undergoing OOVE had significant decreases in activity postoperatively compared with dogs undergoing LapOVE. Whereas we cannot document exactly what kind of activities the dogs engaged in while housed in the runs (because they were not videotaped), we can comment that the baseline activity level of the dogs in this study were on par with the total 24-hour activity level of pet dogs in their routine environment at home with their owners. We have documented median 24-hour total activity counts of 180,000–250,000 in 80 pet dogs that wore the activity monitor for 2 continuous weeks (unpublished data) which is in line with the 235,000–257,000 median total activity counts documented at baseline in these 2 groups of dogs.

To our knowledge, the significant decrease in activity noted postoperatively in this current study has not been documented in animals previously; however, it has been appreciated in people undergoing surgery. In a study by Inoue et al,[24] the convalescence time as measured by accelerometry was significantly shorter in cases undergoing laparoscopic colorectal surgery when compared with the equivalent open surgery. A correlation was made in that study suggesting that the laparoscopic procedure is less invasive and those patients had an earlier recovery.[24] Because we controlled other perioperative variables, we hypothesize that the change in activity that was documented in the dogs in our study is related to the invasiveness of the surgery and thus the dogs' willingness to move around postoperatively.

Small dogs were selected in this study, as can be seen by the median weight of 5.1 kg, because previous studies have focused on laparoscopic sterilization procedures in dogs with a mean weight >10 kg.[3,5–7,25] Additionally, a 2 portal laparoscopic technique with the placement of a transabdominal suture was used. The transabdominal suture must be placed at a point to allow the ovary to be positioned away from vital structures or the body wall. An area of separation to allow the electrocoagulation device to properly attach to the mesovarium and suspensory ligament is essential. A 3.5 mm portal was successfully used for our laparoscope portal; however, a larger portal was used for the instrument portal. The abdominal incision for the 5 mm instrument portal was sufficient for the removal of the ovary and associated mesovarium, but this would not have been the case if a 3.5 mm portal had been used even in dogs of this size. The combination of small incisions and the use of only 2 portals likely contributed to the increased activity counts in the LapOVE group when compared with the OOVE group. Subjectively, the use of smaller portals did not increase the difficulty of the procedures, and the surgical technique we describe was quick and easy to perform in small dogs. The use of the 3.5 mm portal to perform laparoscopic procedures has been described previously with success in cats and birds.[8,9]

The LigaSure™ unit is an electrothermal feedback-controlled bipolar vessel sealing device. It has been shown to be useful in sealing vessels up to 7 mm in diameter and has been used for multiple human surgical procedures.[13,14,26] The use of the LigaSure device has not been evaluated in canine clinical sterilization cases; however, similar vessel sealing devices have been shown to decrease surgical time and result in sufficient hemostasis in dogs undergoing laparoscopic OVH.[12] The LigaSure™ device was found to be very easy to use and consistently resulted in excellent hemostasis.

Some veterinary studies have documented significantly longer surgical times associated with open OVH versus laparoscopic OVH.[5,7] Our median surgical time for OOVE was shorter than for LapOVE; however, the median surgical time of LapOVE was still only 30 minutes. The surgeons performing the LapOVE in this study had previous experience with laparoscopic procedures likely accounting for the similarity in surgical times and results may be different if the study was performed by different surgeons. Previous studies have documented the learning curve associated with laparoscopic-assisted OVH and the use of vessel-sealing devices for that procedure. Rapid improvements in surgical time were demonstrated within the first 10 cases operated in 1 study.[12]

Potential disadvantages directly related to laparoscopy include the cost of equipment, an associated learning curve, and added training time for surgeons and technical staff as well as potential perioperative complications such as subcutaneous emphysema, air embolism, and anesthetic death.[27] Complications directly associated with LapOVE and ovariohysterectomy in recent reports have included hemorrhage from the reproductive tract pedicles, organ laceration, and incisional problems such as swelling, redness, discharge, and dehiscence.[3,4,7,12] None of the dogs in the LapOVE group had surgically associated complications in the observed perioperative period (including 48 hours postoperatively). Minor bleeding encountered in the LapOVE dogs required no intervention to achieve hemostasis. It is recommended that the surgeon placing the transabdominal suture also be holding the laparoscopic Kelly hemostat that is grasping the proper ligament so that the mesovarium can be oriented in a position that allows for avoidance of large mesovarial vessels.

Several limitations in this study can be identified. First, the LigaSure™ device could have been used for hemostasis during the OOVE procedure. This would have eliminated a variable of comparison. Additionally, another control group of dogs undergoing simply abdominal insufflation could have allowed for a better assessment of the role of insufflation on a patient's postoperative activity. Lastly, the use of accelerometry in veterinary medicine is still in its infancy. Further studies need to be performed to evaluate the efficacy of this technique in the determination of canine activity.

OOVE is associated with a significant decrease in postoperative activity in small dogs compared with those undergoing LapOVE. LapOVE was not considered by the authors to be more technically demanding in small dogs. In veterinary practices where the equipment is available, laparoscopy should be considered a safe method of performing ovariectomy in small dogs, which may have less impact on postoperative recovery than open techniques.

REFERENCES

1. Okkens AC, Kooistra HS, Nickel RF: Comparison of long-term effects of ovariectomy versus ovariohysterectomy in bitches 51(Suppl): 227–231, 1997
2. Van Goethem B, Schaefers-Okkens A, Kirpensteijn J: Making a rational choice between ovariectomy and ovariohystectomy in the dog: a discussion of the benefits of either technique. Vet Surg 35:136–143, 2006
3. Van Goethem BE, Rosenveldt KW, Kirpensteijn J: Monopolar versus bipolar electrocoagulation in canine laparoscopic ovariectomy: a nonrandomized, prospective, clinical trial. Vet Surg 32:464–470, 2003
4. Van Nimwegen SA, Van Swol CFP, Kirpensteijn J: Neodymium: Yttrium aluminum garnet surgical laser versus bipolar electrocoagulation for laparoscopic ovariectomy in dogs. Vet Surg 34:353–357, 2005
5. Davidson EB, Moll HD, Payton ME: Comparison of laparoscopic ovariohysterectomy and ovariohysterectomy in dogs. Vet Surg 33:62–69, 2004
6. Devitt CM, Cox RE, Hailey JJ: Duration, complications, stress, and pain of open ovariohysterectomy versus a simple method of laparoscopic-assisted ovariohysterectomy in dogs. J Am Vet Med Assoc 227:921–927, 2005
7. Hancock RB, Lanz OI, Waldron DR, et al: Comparison of postoperative pain after ovariohysterectomy by harmonic scalpel-assisted laparoscopy compared with median celiotomy and ligation in dogs. Vet Surg 34:273–282, 2005
8. Van Nimwegen SA, Kirpensteijn J: Laparoscopic ovariectomy in cats: comparison of laser and bipolar electrocoagulation. J Feline Med Surg 9:397–403, 2007
9. Hernandez-Divers SJ, Stahl SJ, Wilson GH, et al: Endoscopic orchidectomy and salpingohysterectomy of pigeons (*Columba livia*): an avian model for minimally invasive endosurgery. J Avian Med Surg 21:22–37, 2007
10. Hand R, Rakestraw P, Taylor T: Evaluation of a vessel-sealing device for use in laparoscopic ovariectomy in mares. Vet Surg 31:240–244, 2002
11. Hubert JD, Burba DJ, Moore RM: Evaluation of a vessel-sealing device for laparoscopic granulosa cell tumor removal in standing mares. Vet Surg 35:324–329, 2006
12. Mayhew PD, Brown DC: Comparison of three techniques for ovarian pedicle hemostasis during laparoscopic-assisted ovariohysterectomy. Vet Surg 36:541–547, 2007
13. Soon PSH, Yeh MW, Sywak MS, et al: Use of the LigaSure vessel sealing system in laparoscopic adrenalectomy. ANZ J Surg 76:850–852, 2006
14. Hubner M, Hahnloser D, Hetzer F, et al: A prospective randomized comparison of two instruments for dissection and vessel sealing in laparoscopic colorectal surgery. Surg Endosc 21:592–594, 2007
15. Hansen BD, Lascelles BDX, Keene BW, et al: Evaluation of an accelerometer for at-home monitoring of spontaneous activity in dogs. Am J Vet Res 68:468–475, 2007
16. Chen KY, Bassett DR: The technology of accelerometry-based activity monitors: current and future. Med Sci Sports Exerc 37:S490–S500, 2005
17. Liszka-Hackzell JJ, Martin DP: An analysis of the relationship between activity and pain in chronic and acute low back pain. Anesth Analg 99:477–481, 2004
18. Van den Berg-Emons RJ, Schasfoort FC, de Vos LA, et al: Impact of chronic pain on everyday physical activity. Eur J Pain 11:587–593, 2007
19. Yamada M, Tokuriki M: Spontaneous activities measured continuously by an accelerometer in beagle dogs housed in a cage. J Vet Med Sci 62:443–447, 2000
20. Siwak C, Tapp P, Milgram N: Effect of age and level of cognitive function on spontaneous and exploratory behaviors in the beagle dog. Learn Mem 8:317–325, 2001
21. Siwak C, Murphey H, Muggenburg B, et al: Age-dependent decline in locomotor activity in dogs is environment specific. Physiol Behav 75:65–70, 2002
22. Siwak C, Tapp PD, Zicker SC, et al: Locomotor activity rhythms in dogs vary with age and cognitive status. Behav Neurosci 117:813–824, 2003
23. Brown DC: Sources and handling of losses to follow-up in parallel-group randomized clinical trials in dogs and cats: 63 trials (2000–2005). Am J Vet Res 68:694–698, 2007
24. Inoue Y, Kimura T, Noro H, et al: Is laparoscopic colorectal surgery less invasive than classical open surgery? Quantitation of physical activity using an accelerometer to assess postoperative convalescence. Surg Endosc 17:1269–1273, 2003
25. Van Nimwegen SA, Kirpensteijn J: Comparison of Nd: YAG surgical laser and Remorgida bipolar electrosurgery forceps for canine laparoscopic ovariectomy. Vet Surg 36:533–540, 2007
26. Kennedy JS, Stranahan PL, Taylor KD, et al: High-burst-strength, feedback-controlled bipolar vessel sealing. Surg Endosc 12:876–878, 1998
27. Monnet E, Twedt DC: Laparoscopy. Vet Clin Small Anim 33:1147–1163, 2003