Comparison of Surgical Variables and Pain in Cats Undergoing Ovariohysterectomy, Laparoscopic-Assisted Ovariohysterectomy, and Laparoscopic Ovariectomy

J. Brad Case, MS, DVM, DACVS, Pedro L. Boscan, PhD, DVM, DACVA, Eric L. Monnet, PhD, DVM, DACVS, DECVS, Sirirat R. Niyom, DVM, Darren J. Imhoff, DVM, MS*, Mandy L. Wallace, DVM†, Dan D. Smeak, DVM, DACVS

ABSTRACT

Laparoscopy is an established modality in veterinary medicine. To date, laparoscopy in feline surgery is rarely reported. The objectives of this study were to compare surgical time, complications, and postoperative pain in a group of cats undergoing laparoscopic ovariectomy (LOVE), laparoscopic-assisted ovariohysterectomy (LAOVH), and ovariohysterectomy via celiotomy (COVH). Eighteen healthy cats were randomly assigned to undergo LOVE, LAOVH, or COVH. Severity of pain was monitored 1, 2, 3, and 4 hr after surgery. Surgical time was significantly longer for LAOVH (mean ± standard deviation [SD], 51.6 ± 7.7 min) compared to COVH (mean ± SD, 21.0 ± 7.1 min) and LOVE (mean ± SD, 34.2 ± 11.2 min). There were no major intraoperative complications, although minor complications were more common in both laparoscopic groups. Cats sterilized via laparoscopy (LOVE and LAOVH) were statistically less painful than cats spayed via celiotomy (COVH) 4 hr following surgery. Results suggested that LOVE in cats is safe, can be performed in a comparable amount of time as COVH, and may result in less postoperative discomfort. (*J Am Anim Hosp Assoc* 2015; 51:1–7. DOI 10.5326/JAAHA-MS-5886)

Introduction

Laparoscopy is an established surgical modality in feline veterinary medicine.[1–4] Elective ovariohysterectomy and ovariectomy are common surgical procedures performed in general veterinary practice. Laparoscopic ovariectomy (LOVE) and laparoscopic-assisted ovariohysterectomy (LAOVH) are routinely performed for the sterilization of dogs in veterinary medicine.[1,5–9] The major advantages of laparoscopic surgery are magnification and illumination during the procedure, reduction of pain in the postoperative period, and faster recovery compared to laparotomy.[5,6,8–14]

The reduction in pain after laparoscopy has been well established in dogs undergoing a variety of laparoscopic procedures.[6,8,9,13] The severity of pain is likely related to the degree of soft-tissue trauma, pH of the peritoneal fluid, duration of the surgical procedure, and phrenic nerve irritation.[5,6,8,9,15–18] In veterinary medicine, there has been increasing interest in performing minimally invasive surgery in cats. The proposed benefits are similar to those reported in dogs; however, the small size of the patient may make laparoscopic surgery more difficult and time consuming, which could be detrimental to the patient and increase morbidity. Further, laparoscopic equipment is expensive and requires dedicated technical assistance for routine use.

At the time of this study (2010), comparison of postoperative pain in cats undergoing laparoscopic and traditional open

From the Department of Small Animal Surgery, University of Florida, Gainesville, FL (J.C.); and Department of Clinical Sciences, Veterinary Medical Center, Colorado State University, Fort Collins, CO (P.B., E.M., S.N., D.I., M.W., D.S.).

Correspondence: caseb@ufl.edu (J.C.)

COVH, ovariohysterectomy by celiotomy; LAOVH, laparoscopic-assisted ovariohysterectomy; LOVE, laparoscopic ovariectomy; SD, standard deviation; SDS, simple descriptive scale; VAS, visual analogue scale; vFF, von Frey filament

*Darren Imhoff's present affiliation is VCA Alameda East Veterinary Hospital, Denver, CO.

†Mandy Wallace's present affiliation is Department of Small Animal Clinical Sciences, University of Florida, Gainesville, FL.

sterilization has not been performed in a controlled study.[19,20] The purpose of this study was to prospectively compare surgical time, complications, and postoperative pain in a group of cats undergoing LOVE, LAOVH, and ovariohysterectomy via celiotomy (COVH). The study authors hypothesized that LOVE and LAOVH would result in less postoperative pain compared to COVH. Secondary hypotheses were that operative time would be longer with LAOVH compared to LOVE and that both LAOVH and LOVE would take significantly longer than COVH. To test the above hypotheses, the authors prospectively evaluated surgical time and postoperative pain in 18 cats undergoing LOVE, LAOVH, or COVH.

Materials and Methods

Animals

This study was approved by the Institute of Animal Care and Use Committee of the Colorado State University. Eighteen female client-owned cats were initially enrolled. Age and body weight were documented in the medical record. All cats received a complete physical examination and were deemed healthy prior to admittance. A packed cell volume and total solids were performed for each cat at the time of induction. Procedural order was determined randomly at the beginning of the study by drawing numbers from an opaque bag. Cats were removed from the study if they had any gross abnormalities of the reproductive tract or if they were found to be pregnant during surgery.

Anesthetic Period

All cats were induced and anesthetized with sevoflurane[a] in O_2 using an anesthesia induction box. Anesthesia was maintained using sevoflurane in O_2. An IV catheter was placed after anesthesia induction for IV fluid support[b] (5 mL/kg/hr) and venous access. No other medications were administered during anesthesia. Standard anesthetic monitoring included electrocardiography, heart rate, respiratory rate, systolic blood pressure, and end tidal partial pressure of CO_2. In the event of a systolic blood pressure $<$75 mm Hg, the inhalant was decreased and a 10 mL/kg IV fluid bolus was administered. At the conclusion of surgery, all cats were administered ketoprofen[c] (1 mg/kg subcutaneously) and buprenorphine[d] (0.02 mg/kg subcutaneously).

Surgical Procedures

Operations were performed individually by a third-year surgery resident (J.C.) or faculty surgeon (D.S.), each with at least 2 yr experience performing laparoscopic procedures. In addition, each of those individuals had performed at least three laparoscopic sterilization procedures in a previous study evaluating intraoperative anesthetic requirements in cats (unpublished data). Surgeries were performed individually instead of in pairs to maintain relevance to veterinary practice where routine ovariohysterectomy is typically performed by one person. Anesthesia was performed by one author for all surgeries (P.B.).

All cats were prepared with a wide clip extending cranially to the xyphoid, caudally to the inguinal region, and laterally to the epaxial area using standard aseptic technique. Urinary bladders were manually expressed prior to surgery, and all cats were initially positioned in dorsal recumbency.

Cats in the laparoscopic groups (LOVE, LAOVH) were rotated into right and left dorso-oblique recumbency by a technician during the procedure to facilitate manipulation of each ovary and pedicle. LOVE and LAOVH were performed using two 5 mm smooth steel cannulas[e]. The initial trocars were placed using the Hasson technique at the level of the umbilicus. The peritoneal cavity was insufflated using CO_2 to an intra-abdominal pressure of 6 cm H_2O. Following insufflation, the abdomen was explored for evidence of iatrogenic trauma. The second trocars were then placed under laparoscopic[f] visualization approximately 3–4 cm caudal to the umbilicus. Each cannula incision was 4 mm in length. That was done in an attempt to maintain radial tension on the cannulas to help minimize slipping in and out of the abdomen during the procedure and to maintain the pneumoperitoneum. Both LOVE and LAOVH cats were rotated first into left dorso-oblique recumbency for right ovariectomy then into right dorso-oblique recumbency for left ovariectomy. Finally, in the LAOVH group, the cats were positioned back in dorsal recumbency to complete the hysterectomy.

For LOVE, the laparoscope was placed in the caudal cannula and the 5 mm vessel-sealing device[g] inserted in the cranial cannula. The bipolar instrument was used to grasp the proper ligament near the ovary and to bring the ovary to the lateral body wall, exposing the ovarian pedicle. A 3-0 monofilament suture material[h] was then placed percutaneously through the body wall and proper ovarian ligament and tied extracorporeally to stabilize the ovarian pedicle prior to transection. The bipolar device was then used to ligate and divide the ovarian pedicle and uterine horn at the junction with the proper ovarian ligament. The bipolar device was removed from the cannula and a pair of endoscopic Babcock forceps inserted to grasp the ovary. The transabdominal-stabilizing suture was cut and the ovary was then brought to the cannula tip. The cannula and ovary were brought to the body wall together for removal of the ovary from the abdomen. The laparoscope and instruments were then removed from the abdomen and the cat rotated into right dorso-oblique recumbency for removal of the left ovary. The left ovary was excised in the same manner as the right.

The abdomen was evacuated of CO_2 and simple interrupted sutures using the 3-0 monofilament suture material were placed in the abdominal wall to close both trocar incisions. Skin glue[i] was used to close the skin defects. A thin opaque bandage[j] was placed over the trocar sites. A black indelible marker[k] was used to mark two 10 mm × 5 mm marks on the bandage, one at the umbilicus and the other 4 cm caudal to the umbilicus.

For LAOVH, both ovarian pedicles were sealed as described for LOVE with the exception of ligation of the uterine horn. Following transection of the ovarian pedicles, the bipolar device was removed from the cannula and the cat was positioned in dorsal recumbency. A pair of endoscopic Babcock forceps was inserted in the caudal cannula to grasp the left proper ovarian ligament. Both ovarian pedicle-stabilizing sutures were then transected and removed. The left ovary and uterine horn was then brought to the cannula tip and, together with the cannula, brought to the body wall for exteriorization from the abdomen. The abdomen was evacuated of CO_2. The caudal incision was enlarged to a length of about 1 cm to facilitate exteriorization of the uterine horns and body. Once both uterine horns and associated ovaries were exteriorized, a double clamp ligation technique was used to ligate the uterine body just proximal to the cervix using a 3-0 monofilament suture material. The uterine stump was placed back into the abdomen and the incisions closed using a 3-0 monofilament suture material in a simple interrupted pattern. The skin was closed using skin glue, an opaque bandage was placed over the trochar sites, and an indelible marker was used to mark two 10 mm × 5 mm marks on the bandage, one at the umbilicus and the other 4 cm caudal to the umbilicus.

For COVH, a 4–5 cm midline celiotomy was performed starting just caudal to the umbilicus. A spay hook was used to identify and exteriorize the right uterine horn. The suspensory ligament was broken down digitally to facilitate exposure of the ovarian pedicle. The ovarian pedicle was ligated using a 3-0 monofilament suture material. The broad ligament was broken down digitally to the level of the uterine body. The left uterine horn was identified at the uterine body and traced cranially to the ovarian pedicle. The left ovarian pedicle and uterine horn were treated similar to the right. The uterine body was ligated just proximal to the cervix with a 3-0 monofilament suture material. The incision was closed in two layers in a simple continuous fashion using a 3-0 monofilament suture material. The skin was closed with skin glue, and a bandage with indelible marks was applied as described for LOVE.

The operative time for LOVE, LAOVH, and COVH was defined as the period between the start of the first skin incision and placement of the last suture.

Pain Assessment

Pain scores were assigned by one of two observers (D.I. and M.W.) who were blinded to the surgical treatment group. Pain scores were determined prior to anesthesia and at 1, 2, 3, and 4 hr after extubation using (in the following order) a visual analogue scale (VAS), simple descriptive Scale (SDS), and via mechanical stimulation of the incision site with variably sized von Frey filaments (vFF), starting with the smallest filament and progressing to stiffer filaments until a response was noted (**Appendix 1**). Stiffness of the filament was recorded when a response was noted. If no response was noted, the highest stiffness (6.65) or the stiffness of the highest negative control was recorded. The negative control site (right lateral abdomen) was the same for all cats, and the two sites were palpated in the same order (cranial then caudal) at each observation point.

Statistical Analysis

Data were summarized as mean ± standard deviation (SD) or as median and range. The Shapiro-Wilk test was used to assess normality prior to evaluation. One-way analysis of variance was used to test for differences in age, body weight, surgical time, and intraoperative complications among groups. A Tukey-Kramer test was used for post hoc analysis. Complications were considered mild if they either required no treatment or were treated at the time of surgery without conversion to celiotomy. Minor complications included inadvertent loss of pneumoperitoneum or minor hemorrhage. Complications were considered major if they required conversion to laparotomy (e.g., severe hemorrhage). A Wilcoxon signed rank/Kruskal-Wallis test was used to test for the effect of treatment group on pain score over the 4 hr period that they were monitored postsurgically. Sample size (n = 6/group) was determined by power analysis (80%) for surgical time and pain comparisons. For surgical time comparisons, a difference of 7 ± 2 min was used. For pain comparisons, a difference in pain score of 0.25 ± 0.08 was used. All analyses were performed with standard software[l]. Values of $P < .05$ were considered significant.

Results

Sixteen of 18 healthy female cats with no gross reproductive abnormalities were ultimately included in this study. Two cats were in early pregnancy and were eliminated from the study, leaving five cats in the LOVE group, five cats in the LAOVH group, and six cats in the COVH group. Mean age was 13.2 ± 5.6, 16.4 ± 13.4, and 12 ± 7.8 mo for the LOVE, LAOVH, and COVH groups, respectively. Body weight was 4 ± 0.75, 3.1 ± 0.38, 3.1 ± 0.42 kg for the LOVE, LAOVH, and COVH groups, respectively. Neither age ($P = .82$) nor body weight ($P = .18$) of the included cats was different between groups.

Anesthesia

Anesthesia was managed identically between groups and no major complications were observed. Anesthesia induction was performed with sevoflurane in O_2 and the induction was uneventful in all cats. After anesthesia induction, airway access was obtained with a size 4 endotracheal tube. The average systolic blood pressure through the surgery in the LOVE and LAOVH groups was 73 ± 12 and 72 ± 6 mm Hg, respectively. The average systolic blood pressure in the LOVE and LAOVH groups was significantly lower compared to the COVH group, which had an average systolic blood pressure through surgery of 91 ± 12 mm Hg (both $P < .05$). In contrast, heart rate throughout surgery was similar between the three groups, with LOVE, LAOVH and COVH groups having a heart rate of 128 ± 4, 129 ± 6 and 128 ± 11 beats/min respectively ($P = .9$). Respiratory rate was not documented consistently in the anesthesia record and was therefore not analyzed.

All cats were extubated within 5 min after turning the sevoflurane vaporizer off. No complications were observed during the recovery period.

Surgery Time

There were significant differences in operative time between groups ($P = .006$). Operative time for LAOVH (51.6 ± 7.7 min) was significantly longer compared to LOVE (34.2 ± 11.2 min; $P = .02$) and COVH (21.0 ± 7.1 min; $P = .0004$). However, there was not a statistically significant difference in operative time between LOVE and COVH ($P = .09$).

Surgical Complications

Significant differences in mild intraoperative complications were identified between groups ($P = .001$). No major complications occurred in any cats. Intraoperative complications encountered included loss of pneumoperitoneum due to slipping of the cannulas out of the peritoneal cavity (five cats in each of the LOVE and LAOVH groups), mild ovarian pedicle hemorrhage (two cats in the LAOVH and no cats in the LOVE and COVH groups), and omentum entrapped in an instrument cannula (one cat in the LOVE group). Intraoperative complications were significantly more common for both LOVE and LAOVH compared to COVH ($P = .0003$ and $P = .0001$, respectively). However, complications were not different between LOVE and LAOVH ($P = .13$).

Postoperative Pain

VAS

No significant difference in preoperative pain scores existed between groups using the VAS ($P = .58$); however, a significant difference ($P = .0024$) in postoperative pain was determined between groups (**Table 1**). Pain scores in the first 4 hr after surgery were significantly lower for LOVE and LAOVH cats compared to COVH cats ($P = .0008$ and $P = .006$, respectively). In contrast, no significant difference was seen between LOVE and LAOVH cats ($P = .83$).

TABLE 1

Pain Scores Determined by Each of the Three Pain Scales

	COVH	LAOVH	LOVE	*P* value
SDS	0.6 ± 0.72	0 ± 0	0 ± 0	.0001*
VAS	0.4 ± 0.34	0.17 ± 0.23	0.12 ± 0.17	.0024*
VFF	0.2 ± 0.4	0.04 ± 0.2	0 ± 0	.02*

*Statistically significant difference.
COVH, ovariohysterectomy via celiotomy; LAOVH, laparoscopic-assisted ovariohysterectomy; LOVE, laparoscopic ovariectomy; SDS, simple descriptive scale; VAS, visual analogue scale; vFF, von Frey filament.

SDS

No significant difference in preoperative pain scores existed between groups using the SDS ($P = .99$); however, a significant difference ($P = .001$) in postoperative pain was determined between groups (Table 1). Pain scores in the first 4 hr after surgery were significantly lower for LOVE and LAOVH cats compared to COVH cats ($P = .0001$ and $P = .0001$, respectively). In contrast, no significant difference was seen between LOVE and LAOVH cats ($P = .99$).

vFF

No significant differences in preoperative response to filament palpation existed between groups ($P = .96$); however, a significant difference ($P = .02$) in postoperative pain was determined between groups (Table 1). Palpation pain scores in the first 4 hr after surgery were significantly lower for LOVE cats compared to COVH cats ($P = .02$). In contrast, no significant differences were seen between LOVE and LAOVH cats or LAOVH and COVH cats ($P = .08$ and $P = .86$, respectively).

Discussion

The study authors found that cats undergoing LOVE were neutered safely, in reasonable time, and with apparently less postoperative pain than cats neutered via celiotomy.

The study authors included young, healthy, female cats in this study to mimic the typical clinical setting where elective sterilization procedures are commonly performed. In addition, surgeries were performed without an assistant to mimic a typical clinical scenario. Cats were of similar age and body weight in each group, limiting the potential for confounding factors.

The anesthesia protocol used was consistent between cats, limiting the effects of nonsurgical variables on operative time and pain scores. The difference observed in systolic blood pressure is of interest. A possibility is that pneumoperitoneum even as low as 6 cm H_2O may impair venous return in cats. However, the study was neither designed nor carried out to compare the effect of intra-abdominal pressure with either cardiac output or blood pressure. Future prospective studies evaluating the effects of peritoneal insufflation on cardiopulmonary function in cats would be useful.

The laparoscopic surgical techniques used in this study were similar to those previously described in dogs with the exception of cannula placement.[7,8] The cannulas were placed in the described sites to keep the relative location of the incisions similar between groups. For LOVE, it would be anatomically preferable to place both cannulas centered around the umbilicus as previously described.[7] The study authors do not feel that the altered location of the cannulas in this study had a significant effect on surgical difficulty given the relatively small size of cats compared to dogs. LOVE in dogs and cats has also been described using three midline cannulas.[1,20] The study authors elected to use the two-cannula technique because each surgery was performed alone and because incision size and the associated tissue trauma may be contributing factors in postoperative pain.[5,6,8,9,17,18]

Ovariectomy is the standard for dogs and cats in many European countries such as the Netherlands.[1,22] This in contrast to the United States where ovariohysterectomy is considered the standard of care, despite a body of evidence to suggest that a hysterectomy is unnecessary.[22] Some of the benefits of canine ovariectomy/ovariohysterectomy include prevention of ovarian tumors and decreased risk for development of other reproductive tumors such as mammary carcinoma.[22,23] A similar relationship has been demonstrated in cats spayed prior to 6 mo of age.[24] The risk for developing a malignant uterine neoplasm in dogs is about 0.003%.[22] Likewise, the risk of feline uterine neoplasia is small.[25,26] There is inconsistency in the literature as to whether or not uterine leiomyomas or adenocarcinomas are more frequent in cats.[25] It is suspected that uterine adenocarcinomas may be influenced by estrogen because many uterine adenocarcinoma samples were found to have estrogen receptors in a recent study.[25] In light of those findings, one might expect that ovariohysterectomy would eliminate the possibility of uterine adenocarcinoma in cats. That does not seem to be the case because multiple reports have documented uterine stump adenocarcinoma in previously spayed cats.[25,27] In some of those cats, retained ovarian tissue was present at necropsy.

Ovarian remnant syndrome is also reported in cats and dogs.[12] Concurrent reproductive neoplasms are seen in up to 30% of ovarian remnant syndrome cases.[12] A major advantage of laparoscopy is the additional magnification and illumination compared to traditional surgery. The additional magnification and illumination may be helpful for ensuring complete removal of ovarian tissue. There does not seem to be sufficient evidence to support either ovariectomy or ovariohysterectomy as the elective sterilization treatment of choice in cats.

Operative times were similar to previous reports, and all complications were considered minor, including ovarian pedicle bleeding, which was easily controlled with the ligation device.[1,28–30] It may be that the minor bleeding was only seen because of the magnification and illumination provided by the laparoscope. Previous studies have demonstrated efficacy in the ligation of the ovarian pedicle in dogs using bipolar devices.[10,11] COVH and LOVE were associated with shorter operative times compared to LAOVH. That is not an unexpected finding and likely represents the added time required for dissection and excision of the uterus in LAOVH cats compared to LOVE cats. Conversely, the shorter surgical time for COVH was likely due to the absence of complications and handling of the laparoscopic instrumentation. The most significant complication contributing to the longer surgical time was loss of pneumoperitoneum, which resulted from slipping of the cannulas out of the peritoneal cavity. Following loss of pneumoperitoneum, the trocar had to be reinserted and the peritoneal cavity insufflated prior to continuation of the procedure. Loss of pneumoperitoneum was a frequent event during both LOVE and LAOVH. That is one of the main difficulties in performing LOVE and LAOVH by a single surgeon. It is interesting that this complication was not reported in a recent study looking at LOVE in cats performed with two surgeons.[1] In that study, it was suggested that more effort was required to prevent cannula slippage, but that seemed to be accomplished by the addition of the surgical assistant.[1] Given those findings, the study authors recommend that either LOVE or LAOVH in cats be performed by a surgeon with the aid of an assistant, if available. However, the addition of extra personnel may limit the utility of laparoscopy in feline surgery due to the added cost. One could also consider using a threaded or balloon-tipped cannula to minimize cannula slippage. To the authors' knowledge, that has not been reported in cats. That may reduce surgery time and complications to a level equivalent to that of COVH, which might make LOVE and LAOVH more desirable.

The study authors did not find a statistically significant difference in surgical time between LOVE and COVH. Average operative time for LOVE was about 34 min, which is similar to a previous report.[1] In that study, average operative time was 30 min, which is slightly shorter than the operative time reported here. That difference was most easily explained by loss of pneumoperitoneum and the single-surgeon approach reported here. Previously reported operative times for COVH range from 12 to 24 min, which is consistent with the current study that found average operative times of about 20 min.[28–30] Given those findings, as well as a small sample size and a trend towards a significant difference ($P = .09$), it is likely that type 2 statistical error precluded determining a difference in operative time between LOVE and COVH. Power calculations were performed prior to beginning this study, which indicated that six cats would be adequate for detecting a difference of 7 min with 80% power. It is regrettable that two cats were eliminated from the analysis. While an operative time difference of 10 min is likely significant in routine practice, the study authors believe it to be marginal and should not preclude surgeons from performing LOVE in some cats. Additionally, in specialty practice where a surgical assistant is usually available, LOVE could likely be performed in a shorter time period. As with any surgical procedure, all aspects, including cost, complications, outcome, and postoperative pain should be considered when deciding the appropriate technique for a patient.

Cats undergoing LOVE and LAOVH were significantly less painful than cats in the COVH group in the first 4 hr following extubation. The study authors elected to monitor pain scores for only 4 hr as a matter of practicality and because it has been shown that pain scores return to baseline in cats undergoing ovariohysterectomy who have been treated with similar postoperative analgesic medications after 4 hr.[28]

The VAS, SDS, and vFF have been validated and used to assess pain in cats in previous studies.[28–32] Additionally, those scales are easily used to assess postoperative pain in cats in the clinical setting making the current study results relevant to practitioners that perform ovariectomy and ovariohysterectomy.

All pain scores were assigned by one of two blinded observers in the current study, thus eliminating the possibility of treatment-based observer bias. The study authors feel that was an important aspect of this study, which lends validity to the results.

Although postoperative pain in cats following LOVE and LAOVH was statistically less than cats undergoing COVH, it is possible that difference was not clinically significant. Subjectively, all cats were relatively comfortable and did not seem to require additional analgesic medication. However, the pain scales used in this study are a more accurate and reliable method of assessing pain than a simple subjective opinion. The study authors, like most veterinarians, agree that sterilization causes pain and that cats tend to mask signs of pain.[33,34] Therefore, veterinarians should strive to minimize postoperative discomfort as much as possible in cats, and laparoscopic sterilization may be useful to that end.

Nonsteroidal anti-inflammatory medications either alone or in conjunction with opioids have also been demonstrated to be effective in managing postoperative pain in cats.[28,29,31] However, due to the potential adverse effects of nonsteroidal anti-inflammatory medications, some veterinarians may be reluctant to use them in routine practice.[35] The study authors did not examine the effect of nonsteroidal anti-inflammatory drugs specifically in this study, and all cats received a single dose of ketoprofen. However, in cats where nonsteroidal anti-inflammatory drugs are not an option (e.g., aged cats or cats with renal, liver, or gastrointestinal disease) LOVE may be a reasonable surgical option to limit postoperative pain.

It is well accepted in human surgery that the most significant method of minimizing postoperative pain is by performing minimally invasive surgery in place of traditional open surgery.[17,18] A significant body of knowledge supports that conclusion in dogs as well.[5,6,8,9,36,37] Although there is little hard evidence to directly support that conclusion in cats, it is worth noting that all owners in a previous study of LOVE in cats reported that they would choose LOVE over ovariectomy via celiotomy in the future.[1] Existing knowledge and the results reported herein offer some support for the idea that minimally invasive surgery will help reduce postoperative pain in cats.

Conclusion

LOVE in cats can be performed safely and in a reasonable amount of time compared to COVH. Additionally, LOVE appears to be associated with less postoperative pain compared to COVH. LAOVE takes significantly longer than LOVE and COVH. LOVE is an effective method for elective sterilization in cats.

FOOTNOTES

[a] Petrem; Minrad, Bethlehem, PA

[b] Lactated Ringer's solution; Abbott Laboratories, Chicago, IL

[c] Ketofen; Fort Dodge, Fort Dodge, IA

[d] Buprenex; Reckitt Benckiser Pharmaceuticals Inc., Richmond, VA

[e] 5 mm smooth steel cannulas; Karl Storz GMBH & Co. KG, Tuttlingen, Germany

[f] 5 mm diameter 0° laparoscope HOPKINS II; Karl Storz GMBH & Co KG, Tuttlingen, Germany

[g] Ligasure; Valleylab/Tyco Healthcare, Boulder, CO

[h] Biosyn; Covidien, Mansfield, MA

[i] Vetbond; 3M Co., St. Paul, MN.

[j] Hypafix; Smith & Nephew, Largo, FL

[k] Sharpie; Sanford Corp., Oak Brook, IL

[l] JMP 8; SAS Institute Inc., Cary, NC

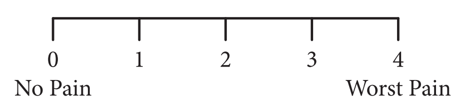
REFERENCES

1. van Nimwegen SA, Kirpensteijn J. Laparoscopic ovariectomy in cats: comparison of laser and bipolar electrocoagulation. *J Feline Med Surg* 2007;9:397–403.
2. Miller NA, Van Lue SJ, Rawlings CA. Use of laparoscopic-assisted cryptorchidectomy in dogs and cats. *J Am Vet Med Assoc* 2004;224:875–8, 865.

3. Buote NJ, Kovak-McClaran JR, Schold JD. Conversion from diagnostic laparoscopy to laparotomy: risk factors and occurrence. *Vet Surg* 2011;40:106–14.
4. Webb CB, Trott C. Laparoscopic diagnosis of pancreatic disease in dogs and cats. *J Vet Intern Med* 2008;22:1263–6.
5. Case JB, Boscan P, Monnet E, et al. Surgical time and severity of post-operative pain in dogs undergoing laparoscopic ovariectomy with one, two, or three instrument cannulas. *J AmVet Med Assoc* 2011;15;239:203–8.
6. Culp WT, Mayhew PD, Brown DC. The effect of laparoscopic versus open ovariectomy on postsurgical activity in small dogs. *Vet Surg* 2009;38:811–7.
7. Dupre G, Fiorbianco V, Skalicky M, et al. Laparoscopic ovariectomy in dogs: comparison between single portal and two-portal access. *Vet Surg* 2009;38:818–24.
8. 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* 2005;227:921–7.
9. 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* 2005;34:273–82.
10. Mayhew PD, Brown DC. Comparison of three techniques for ovarian pedicle hemostasis during laparoscopic-assisted ovariohysterectomy. *Vet Surg* 2007;36:541–7.
11. Van Goethem BE, Rosenveldt KW, Kirpensteijn J. Monopolar versus bipolar electrocoagulation in canine laparoscopic ovariectomy: a nonrandomized, prospective, clinical trial. *Vet Surg* 2003;32:464–70.
12. Ball RL, Birchard SJ, May LR, et al. Ovarian remnant syndrome in dogs and cats: 21 cases (2000–2007). *J Am Vet Med Assoc* 2010;236:548–53.
13. Davidson EB, Moll HD, Payton ME. Comparison of laparoscopic ovariohysterectomy and ovariohysterectomy in dogs. *Vet Surg* 2004;33:62–9.
14. Bohm B, Milsom JW, Fazio VW. Postoperative intestinal motility following conventional and laparoscopic intestinal surgery. *Arch Surg* 1995;130:415–9.
15. Alves AE, Ribeiro AP, Filippo PA, et al. Evaluation of creatine kinase (CK) and aspartate aminotransferase (AST) activities after laparoscopic or conventional ovariectomy in queens. *Schweiz Arch Tierheilkd* 2009;151:223–7.
16. Duerr FM, Twedt DC, Monnet E. Changes in pH of peritoneal fluid associated with carbon dioxide insufflation during laparoscopic surgery in dogs. *Am J Vet Res* 2008;69:298–301.
17. Fredman B. Residual pneumoperitoneum; a cause of postoperative pain after laparoscopic cholecystectomy. *Anesth Analg* 1994;79:152–4.
18. Alexander JI. Abdominal pain after laparoscopy; the value of a gas drain. *Br J Obstet Gynaecol* 1987:267–9.
19. Sakals S, Rawlings CA, Laity J, et al. Laparoscopic-assisted ovariectomy using a bipolar vessel sealing device. In: Proceedings from the American College of Veterinary Surgeons; Nov 3–5, 2011; Chicago, IL.
20. Coisman GJ, Case BJ, Shih A, et al. Comparison of surgical variables in cats undergoing single-incision laparoscopic ovariectomy using a Ligasure or extracorporeal suture versus open ovariectomy. *Vet Surg* 2014;43:38–44.
21. Van Nimwegen SA, Van Swol CF, Kirpensteijn J. Neodymium:yttrium aluminum garnet surgical laser versus bipolar electrocoagulation for laparoscopic ovariectomy in dogs. *Vet Surg* 2005;34:353–7.
22. van Goethem B, Schaefers-Okkens A, Kirpensteijn J. Making a rational choice between ovariectomy and ovariohysterectomy in the dog: a discussion of the benefits of either technique. *Vet Surg* 2006;35:136–43.
23. Sonnenschein EG, Glickman LT, Goldschmidt MH, et al. Body conformation, diet, and risk of breast cancer in pet dogs: a case-control study. *Am J Epidemiol* 1991;133:694–703.
24. Overley B, Shofer FS, Goldschmidt MH, et al. Association between ovarihysterectomy and feline mammary carcinoma. *J Vet Intern Med* 2005;19:560–3.
25. Miller MA, Ramos-Vara JA, Dickerson MF, et al. Uterine neoplasia in 13 cats. *J Vet Diagn Invest* 2003;15:515–22.
26. Dorn CR, Taylor DO, Schneider R, et al. Survey of animal neoplasms in Alameda and Contra Costa Counties, California. II. Cancer morbidity in dogs and cats from Alameda County. *J Natl Cancer Inst* 1968;40:307–18.
27. Anderson C, Pratschke K. Uterine adenocarcinoma with abdominal metastases in an ovariohysterectomised cat. *J Feline Med Surg* 2011;13:44–7.
28. Tobias KM, Harvey RC, Byarlay JM. A comparison of four methods of analgesia in cats following ovariohysterectomy. *Vet Anaesth Analg* 2006;33:390–8.
29. Steagall PV, Taylor PM, Rodrigues LC, et al. Analgesia for cats after ovariohysterectomy with either buprenorphine or carprofen alone or in combination. *Vet Rec* 2009;164:359–63.
30. Taylor PM, Kirby JJ, Robinson C, et al. A prospective multi-centre clinical trial to compare buprenorphine and butorphanol for postoperative analgesia in cats. *J Feline Med Surg* 2010;12:247–55.
31. Benito-de-la-Vibora J, Lascelles BD, Garcia-Fernandez P, et al. Efficacy of tolfenamic acid and meloxicam in the control of postoperative pain following ovariohysterectomy in the cat. *Vet Anaesth Analg* 2008;35:501–10.
32. Castro DS, Silva MF, Shih AC, et al. Comparison between the analgesic effects of morphine and tramadol delivered epidurally in cats receiving a standardized noxious stimulation. *J Feline Med Surg* 2009;11:948–53.
33. Capner CA, Lascelles BD, Waterman-Pearson AE. Current British veterinary attitudes to perioperative analgesia for dogs. *Vet Rec* 1999;145:95–9.
34. Robertson SA, Lascelles BD. Long-term pain in cats: how much do we know about this important welfare issue? *J Feline Med Surg* 2010;12:188–99.
35. Sparkes AH, Heiene R, Lascelles BD, et al. ISFM and AAFP consensus guidelines: long-term use of NSAIDs in cats. *J Feline Med Surg* 2010;12:521–38.
36. Walsh PJ, Remedios AM, Ferguson JF, et al. Thoracoscopic versus open partial pericardectomy in dogs: comparison of postoperative pain and morbidity. *Vet Surg* 1999;28:472–9.
37. Freeman LJ, Rahmani EY, Al-Haddad M, et al. Comparison of pain and postoperative stress in dogs undergoing natural orifice transluminal endoscopic surgery, laparoscopic, and open oophorectomy. *Gastrointest Endosc* 2010;72:373–80.

APPENDIX 1

Description of the Visual Analog Scale (VAS) and Simple Descriptive Scale (SDS) Used to Assess Pain



0 = No sedation, no pain.

1 = Can stand but is wobbly. Happy cat, purring and friendly. Flinches with pressure on wound but not when wound is stroked.

2 = In sternal recumbency. Happy cat but flinches when wound is stroked.

3 = Can lift its head. Looks uncomfortable but wound can be touched.

4 = Fast asleep/no response to hand clap. Looks uncomfortable and wound cannot be touched. Growls and hisses.