Surgical time and severity of postoperative pain in dogs undergoing laparoscopic ovariectomy with one, two, or three instrument cannulas

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Objective—To determine whether number of instrument cannulas is associated with surgical time or severity of postoperative pain in dogs undergoing laparoscopic ovariectomy.

Design—Randomized clinical trial.

Animals—18 healthy dogs.

Procedures—Dogs were randomly assigned to undergo laparoscopic ovariectomy with 1, 2, or 3 instrument cannulas. Surgical time and intraoperative and postoperative complications were recorded. Severity of pain was monitored 2, 4, 8, 12, and 24 hours after surgery by means of pain scoring with a modified Melbourne Pain Scale and palpation of surgical sites with variably sized von Frey filaments. Owner-assessed postoperative comfort was also evaluated.

Results—Surgical time was significantly longer with 1 cannula (mean ± SD, 29.7 ± 5.6 minutes) than with 2 cannulas (18.2 ± 4.4 minutes) or 3 cannulas (19.3 ± 3.4 minutes). Intraoperative complications included splenic puncture (2 dogs), pedicle hemorrhage (1 dog), and SC emphysema (1 dog); complication rates were not significantly different among groups. Total pain score was significantly lower for dogs with 2 cannulas than for dogs with 3 cannulas; total pain score for dogs with 1 cannula did not differ significantly from scores for dogs with 2 cannulas or 3 cannulas. Owner assessments of postoperative comfort and number of days pain medications were administered did not differ among groups.

Conclusions and Clinical Relevance—Results suggested that laparoscopic ovariectomy with 2 instrument cannulas, rather than with 1, resulted in shorter surgical times without increasing severity of postoperative pain. (*J Am Vet Med Assoc* 2011;239:203–208)

The major reported advantages of laparoscopy, compared with laparotomy, include better visualization of important structures during the procedure, reduced severity of pain during the postoperative period, and faster patient recovery.[1–6]

Pain after laparoscopy is related to neurapraxia of the phrenic nerves secondary to abdominal distention, and severity of postoperative pain depends to some extent on the amount, temperature, and humidity of residual intra-abdominal gas.[7] Pain is also associated with the type of gas (eg, carbon dioxide) used to insufflate the abdominal cavity, which is likely related to resultant changes in pH.[7] In addition, severity of postoperative pain can be related to the number of cannulas placed to gain access to the abdominal cavity during the procedure, the nature of the surgery performed, and the experience of the surgeon.[1,8] In human and veterinary surgery, there has been interest in reducing the number and size of portals used in minimally invasive procedures to minimize pain after surgery.[1,8] However, reducing the number of cannulas may make the surgical procedure more difficult, which could prolong the surgical time and increase the morbidity rate.[1,8]

To our knowledge, severity of pain after laparoscopy has not previously been shown in a controlled study to be associated with the number of instrument cannulas used. We hypothesized that the number of instrument cannulas would be associated with severity of postoperative pain in dogs undergoing laparoscopy. Specifically, the purpose of the study reported here was to determine whether use of 1, 2, or 3 instrument cannulas was associated with surgical time or severity of postoperative pain in healthy dogs undergoing laparoscopic OVE.

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Abbreviation

OVE	Ovariectomy

Materials and Methods

The study protocol was approved by the Institutional Animal Care and Use Committee of Colorado State University prior to enrollment of any dogs in the study. Dogs brought to the Colorado State University for routine neutering were considered for inclusion in the study. Dogs were eligible for enrollment in the study only if they were overtly healthy and weighed at least 9 kg (19.8 lb) and if the owner signed a client consent form describing the risks of laparoscopic OVE and the differences between laparoscopic OVE and traditional laparoscopic ovariohysterectomy.

Dogs enrolled in the study were randomly assigned to 1 of 3 groups by drawing a number out of a hat. For dogs in the first group, laparoscopic OVE was performed with a single 10-mm cannula and operating telescope.[a] For dogs in the second group, laparoscopic OVE was performed with a 5-mm cannula, 10-mm cannula, and a 5-mm telescope.[b] For dogs in the third group, laparoscopic OVE was performed with two 5-mm cannulas, a single 10-mm cannula, and a 5-mm telescope.[b]

Acclimation—All dogs were admitted to a section of the hospital separate from the anesthesia induction area and were allowed to acclimate to the kennel for at least 60 minutes prior to acquisition of baseline physiologic parameters. Each dog was ausculted 3 times, and the lowest respiratory and heart rates were documented and used for comparisons.

Anesthesia protocol—Packed cell volume and total solids concentration were measured for each dog prior to anesthesia and surgery. All dogs were premedicated with fentanyl (3 μg/kg [1.36 μg/lb], IV) and glycopyrrolate (0.01 mg/kg [0.0045 mg/lb], IM), and anesthesia was induced with propofol (4 mg/kg [1.8 mg/lb], IV). Dogs were intubated, and anesthesia was maintained with isoflurane in oxygen. Standard anesthetic monitoring included electrocardiography and measurement of heart rate, respiratory rate, blood pressure, and end-tidal partial pressure of CO_2. All dogs received a single dose of fentanyl (1 μg/kg [0.45 μg/lb], IV) at the time of extubation.

Surgical procedures—In all dogs, laparoscopic OVE was performed by the same 2 surgeons (ELM and JBC). Dogs were placed in dorsal recumbency in a positioner table[c] that was designed to allow lateral rotation of the patient to facilitate identification and manipulation of ovarian tissue. Standard aseptic technique was used to prepare each dog prior to surgery. Depending on group assignment, 1, 2, or 3 instrument cannulas were inserted. Prior to placement of each instrument cannula, a skin incision the same length as the diameter of the cannula to be used was made and a Veress needle was used to gain entrance to the peritoneal cavity. The abdomen was insufflated with CO_2 to a pressure of 13 mm Hg; this pressure was maintained throughout the surgical procedure.

For dogs in which only 1 cannula was used, a single 10-mm cannula was placed 1 cm caudal to the umbilicus. For dogs in which 2 cannulas were used, a 5-mm cannula was placed 1 cm caudal to the umbilicus and a 10-mm cannula was placed 1 cm cranial to the umbilicus. For dogs in which 3 cannulas were used, a 5-mm cannula was placed 1 cm caudal to the umbilicus, a 10-mm cannula was placed 1 cm cranial to the umbilicus, and a second 5-mm cannula was placed approximately 2 cm caudal to the first cannula. A vessel-sealing device[d] was used to achieve hemostasis of the ovarian pedicle and to transect the suspensory ligament and uterine horn at the level of the proper ovarian ligament. For the dogs in which only a single cannula was used, a 5-mm vessel-sealing device[d] was used; for dogs in which 2 or 3 cannulas were used, a 10-mm vessel-sealing device[d] was used.

Once the first instrument cannula was placed, the telescope[a,b] was inserted and the abdomen was evaluated for signs of iatrogenic trauma. Additional cannulas were then placed, according to group assignment. The patient was rotated into right lateral oblique recumbency for removal of the left ovary and then into left lateral oblique recumbency for removal of the right ovary. Ovaries were removed through the cranial 10-mm cannula. A weighted hook[e] was used during each procedure to transabdominally stabilize the ovary against the abdominal wall.

Following removal of both ovaries, a single absorbable cruciate suture[f] was placed in the linea to close the abdominal wall at each cannula site. A single interrupted, buried cruciate suture consisting of nonabsorbable monofilament suture[f] was then placed in the SC tissue. Tissue glue[g] was then used to seal the skin. Surgical time was defined as the time between the start of the first skin incision and the time of removal of the last cannula.

Following completion of the surgical procedure, a thin, opaque bandage[h] was placed over the surgical site in each dog. A black indelible marker[i] was then used to create 3 symmetric 15 × 5-mm black rectangles over the 3 possible cannula sites in each dog.

Pain assessment—All postoperative observations were made by a single observer (SJM) blinded to treatment group assignment. Severity of pain was monitored 2, 4, 8, 12, and 24 hours after surgery on the basis of pain scores obtained with a modified University of Melbourne Pain Scale (**Appendix**) and on the basis of results of mechanical stimulation of the 3 potential surgical sites with variably sized von Frey filaments, starting with the smallest filament and progressing to stiffer filaments until a response was noted. 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 filament that elicited a response at a negative control site was recorded. The negative control site (right lateral aspect of the abdomen) was the same for all dogs, and all cannula sites were palpated in the same order at each observation point. A pain score ≥ 6 was considered justification for rescue analgesia, and morphine (0.2 mg/kg [0.09 mg/lb], SC) was administered. Information regarding owner-assessed comfort level 24 and 48 hours after surgery and number of days pain medications were administered after surgery was obtained through recheck examinations or telephone calls. For owner assessments of pain severity, owners were asked to indicate their pet's comfort level on a scale from 1 to 10, with 1 equaling the worst pain and 10 equaling normal comfort. Tramadol (3 mg/kg [1.36 mg/lb], PO, q 8 to 12 h, as needed) was prescribed for at-home postoperative analgesia. General guidelines for pain evaluation (lethargy, decreased appetite, inability to get comfortable, and guarding of the abdomen) were discussed with each owner at the time of discharge.

Statistical analysis—Data were summarized as mean ± SD or as median and range. One-way ANOVA was used to test for differences in age, body weight, surgical time, and number of days tramadol was administered postoperatively among groups. The Kolmogorov-Smirnov test was used to assess for normality prior to evaluation. A Tukey-Kramer test was used for post hoc analysis. Analysis of variance for repeated measurements was used to test for an effect of location on the von Frey filament response within each group. A sphericity test with Mauchly criterion was used, and a Greenhouse-Geisser adjusted *F* test was used if required. A Kruskal-Wallis test was used to test for the effects of treatment group and time on pain score. The Fisher exact test was used to compare requirement for rescue pain medication and comfort level 24 and 48 hours after surgery. All analyses were performed with standard software.[j] Values of $P < 0.05$ were considered significant.

Results

Eighteen dogs (6/group) were enrolled in the study. There were 4 mixed-breed dogs, 3 American Pitbull Terriers, 2 Labrador Retrievers, and 1 each of the following breeds: Irish Setter, Australian Cattle Dog, Australian Shepherd, Welsh Corgi, Great Dane, Standard Poodle, Golden Retriever, Boxer, and Border Collie. Mean ± SD age was 9.8 ± 4.4 months for dogs in which a single cannula was used, 5.3 ± 1.2 months for dogs in which 2 cannulas were used, and 11.2 ± 3.5 months for dogs in which 3 cannulas were used. Dogs in which 2 cannulas were used were significantly ($P = 0.021$) younger than dogs in which 3 cannulas were used. Mean body weight was 21.3 ± 5.9 kg (46.9 ± 13.0 lb), 13.9 ± 7.1 kg (30.6 ± 15.6 lb), and 19.9 ± 5.5 kg (43.8 ± 12.1 lb), respectively, for dogs in which 1, 2, and 3 cannulas were used; body weight did not differ significantly ($P = 0.13$) among groups.

Mean surgical time was 29.7 ± 5.6 minutes, 18.2 ± 4.4 minutes, and 19.3 ± 3.4 minutes, respectively, for dogs in which 1, 2, and 3 cannulas were used. Surgical time was significantly longer for dogs in which a single cannula was used than for dogs in which 2 ($P < 0.001$) or 3 ($P < 0.001$) cannulas were used.

Intraoperative complications included puncture of the spleen with the 10-mm cannula in 2 dogs in which a single cannula was used, SC emphysema in 1 dog in which 3 cannulas were used, and ovarian pedicle hemorrhage in another dog in which 3 cannulas were used. Hemorrhage was controlled with a vessel-sealing device.[c] No other complications were identified. The complication rate did not differ significantly ($P = 0.28$) among groups.

Overall median pain score for all observation times differed significantly ($P = 0.020$; **Figure 1**) among groups. Overall median pain score for dogs in which 2 cannulas were used was significantly ($P = 0.006$) lower than the overall median pain score for dogs in which 3 cannulas were used. Overall median pain score for dogs in which a single cannula was used did not differ significantly from the overall median pain score for dogs in which 2 cannulas were used ($P = 0.151$; power = 0.451) or for dogs in which 3 cannulas were used ($P = 0.143$; power = 0.522). A significant effect of observation time (2, 4, 8, 12, and 24 hours after surgery) on median pain score was not detected ($P = 0.371$; power = 0.752; **Figure 2**).

Four dogs (2 dogs in which a single cannula was used and 2 dogs in which 3 cannulas were used) required rescue pain medication. Percentage of dogs requiring rescue pain medication did not differ significantly ($P = 0.20$) among groups. For dogs in which a single cannula was used, overall mean ± SD sizes of the von Frey filament for all observation times were 6.59 ± 0.15, 6.63 ± 0.10, and 6.65 ± 0.0, respectively, for the cranial, middle, and caudal cannula sites; filament sizes did not differ significantly ($P = 0.290$; power = 0.390) among sites. For dogs in which 2 cannulas were used, overall mean sizes of the von Frey filament for all observation times were 6.63 ± 0.10, 6.65 ± 0.0, and 6.65 ± 0.0, respectively, for the cranial, middle, and caudal cannula sites; filament sizes did not differ significantly ($P = 0.322$; power = 0.420) among sites. For dogs in which 3 cannulas were used, overall mean sizes of the von Frey filament for all observation times were 6.59 ± 0.23, 6.62 ± 0.10, and 6.63 ± 0.1, respectively, for the cranial, middle, and caudal cannula sites; filament sizes did not differ significantly ($P = 0.16$; power = 0.180)

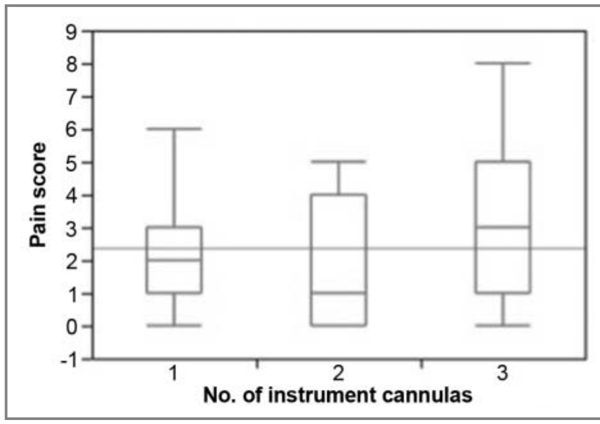

Figure 1—Box-and-whisker plots of pain scores for dogs (n = 6/group) that underwent laparoscopic OVE with 1, 2, or 3 instrument cannulas. Dogs were assessed for severity of postoperative pain 2, 4, 8, 12, and 24 hours after surgery with a modified University of Melbourne Pain Scale, and pain scores represent the median value for all observation times. Possible pain scores ranged from 0 to 18. For each plot, the box represents the interquartile range (25th to 75th percentile), the horizontal line within the box represents the median, and the whiskers represent the first quartile (0% to 25%) and the fourth quartile (75% to 100%) of the data distribution.

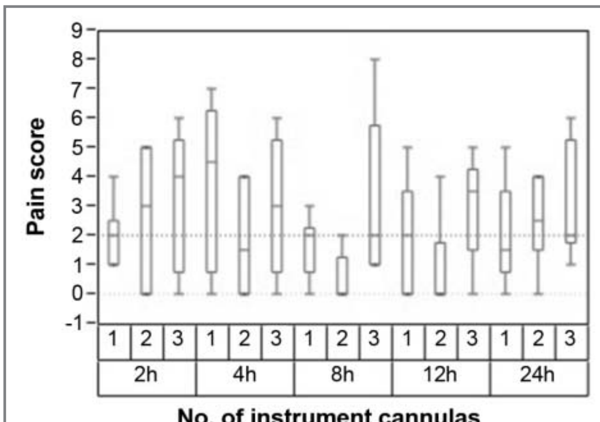

Figure 2—Box-and-whisker plots of pain scores 2, 4, 8, 12, and 24 hours after surgery in dogs (n = 6/group) that underwent laparoscopic OVE with 1, 2, or 3 instrument cannulas. *See* Figure 1 for key.

among sites. When all 3 sites were considered together, size of the von Frey filament at which a response was noted was not significantly associated with group (*P* = 0.831; power = 0.90) or observation time (*P* = 0.531; power = 0.90).

One dog in which 3 cannulas were used was eliminated from owner assessment analyses because of an injury to the digital pad that occurred at the time of discharge. Of the remaining 17 owners, 7 (41.2%) and 12 (70.1%) reported no signs of discomfort (ie, a comfort score of 10) 24 and 48 hours after surgery, respectively. Median owner-assigned comfort scores were 8.5 (range, 5 to 10), 10.0 (range, 8 to 10), and 8.0 (range, 7 to 10), respectively, 24 hours after surgery for dogs in which 1, 2, and 3 cannulas were used; scores did not differ significantly (*P* = 0.33) among groups. Median owner-assigned comfort scores were 10.0 (range, 7 to 10), 10.0 (range, 9 to 10), and 9.0 (range, 8 to 10), respectively, 48 hours after surgery for dogs in which 1, 2, and 3 cannulas were used; scores did not differ significantly (*P* = 0.30) among groups. Median number of days tramadol was administered postoperatively was 3 days (range, 0 to 4 days), 2 days (range, 0 to 3 days), and 3 days (range, 0 to 3 days), respectively, for dogs in which 1, 2, and 3 cannulas were used; number of days tramadol was administered did not differ significantly (*P* = 0.40) among groups.

Discussion

Results of the present study suggested that number of instrument cannulas significantly affected postoperative pain severity, as assessed with the modified Melbourne Pain Scale, in dogs undergoing laparoscopic OVE. Specifically, median pain score for dogs in which 2 cannulas were used was significantly lower than median pain score for dogs in which 3 cannulas were used. However, median pain score for dogs in which a single cannula was used did not differ significantly from scores for dogs in which 2 or 3 cannulas were used. Dogs in the present study were representative of young, healthy dogs typically admitted to veterinary hospitals for elective neutering. Although dogs in which 2 cannulas were used were significantly younger than dogs in which 3 cannulas were used, we do not believe that this had a substantial effect on our results because body weight did not differ significantly among groups and the pain scale that was used is not known to have any age-based limitations.

Dogs in the present study in which 3 instrument cannulas were used had a significantly higher median pain score than did dogs in which only 2 cannulas were used, and the median pain score for dogs in which 3 cannulas were used was higher than the median value for all groups combined across all observation times. Subjectively, the distribution of pain scores for dogs in which 3 cannulas were used appeared to be wider at most observation times, although this was not analyzed. Importantly, we did not detect a significant difference in median pain score between dogs in which 2 instrument cannulas were used and dogs in which a single cannula was used. Dogs in which a single cannula was used had a significantly longer surgical time than did dogs in which 2 or 3 cannulas were used, and the longer surgical time in this group may have increased the severity of pain. Insufflation of the abdominal cavity with CO_2 induces mechanical pain as a result of stretching of the abdominal cavity and dehydration of the serosal surfaces and induces chemical pain as a result of formation of carbonic acids.[9] Because we maintained a constant intra-abdominal pressure in all dogs, the degree of mechanical pain associated with stretching should have been equivalent among groups. However, the degree of mechanical pain associated with serosal dehydration was most likely greater in the dogs in which a single cannula was used, which may have resulted in more pain in the postoperative period for this group. Production of carbonic acid reduces peritoneal pH,[10,11] and peritoneal pH decreases during the first 25 minutes of an abdominal laparoscopic procedure before it plateaus.[11] We did not measure the pH of the abdominal cavity in the present study; however, because surgical time was significantly longer for dogs in which only a single cannula was used, compared with times for dogs in which 2 or 3 cannulas were used, and mean surgical time was longer than 25 minutes, the peritoneal pH was likely lower among dogs in this group, compared with dogs in the other groups. Additionally, it has been shown that the amount of CO_2 left in the abdominal cavity at the end of a laparoscopic procedure is an ongoing source of pain because the CO_2 continues to produce carbonic acid.[12,13] To help with this problem as well as to reduce intra-abdominal pressure, it is recommended to evacuate the peritoneal cavity as much as possible at the end of the procedure.

Severity of incisional pain, as determined by use of von Frey filaments, was not found to be associated with number of instrument cannulas in the present study. The von Frey filaments were used in an effort to characterize the degree of somatic pain related to the surgical incision, in that they provide a reproducible mechanical stimulation to the surgical incision. Their use has been validated as an objective measure of incisional pain in a variety of species in both clinical and laboratory settings.[14] Both an area near the incision and an area remote to the incision have to be tested to allow for differentiation between incisional pain, hyperalgesia, and the natural response of the animal to the filaments,[14] as was done in the present study. The lack of significant differences among groups in regard to size of the von Frey filament at which a response was noted suggests that pain following laparoscopy is associated more with visceral stimulation than with the incision itself.

In our opinion, mild discomfort 2 to 3 days after laparoscopic OVE would be a reasonable expectation, but to our knowledge, there are few studies in veterinary medicine evaluating this with a validated pain scale. Culp et al[6] performed laparoscopic or open OVE in a series of dogs and monitored activity level 1 and 2 days after surgery. They found that activity levels did not decrease significantly in dogs that underwent laparoscopic OVE but did in dogs that underwent open OVE. Hancock et al[15] found that 72 hours after ovariohysterectomy in dogs by means of laparoscopy or laparotomy, differences in pain scores between groups were no longer apparent. In the present study, we elected to evaluate owner impressions of comfort level 24 and 48 hours after surgery and the number of days tramadol was administered because the Melbourne Pain Scale has been shown to be of limited value when discriminating severity of pain 18 hours after ovariohysterectomy.[16] For owner-assessed comfort level, we used a simple numeric scale and did not identify any differences among groups in owner-assigned comfort scores 24 and 48 hours after surgery. Additionally, number of days tramadol was administered did not differ significantly among groups.

We believe that the significantly longer surgical time for dogs in the present study in which a single cannula was used, compared with times for dogs in which 2 or 3 cannulas were used, was a result of smaller instruments and a lack of independent maneuverability of the instrument and laparoscope. Subjectively, both of these factors appeared to limit the speed of ligation and made the procedure technically more difficult. Dupre et al[8] in a study of laparoscopic OVE in dogs reported surgical times of 21 and 19 minutes, respectively, when 1 and 2 instrument cannulas were used. However, they used a 5-mm ligation device for both surgical procedures, whereas in the present study, we used a 10-mm vessel-sealing device when 2 or 3 cannulas were inserted and a 5-mm vessel-sealing device when only a single cannula was inserted. The 10-mm device allows the same amount of tissue to be ligated and transected in half the time, and we decided to use 2 different-sized devices because this is one of the advantages of a multiple-cannula procedure. With the 1-cannula procedure, the surgeon is limited by the 5-mm working channel of the operating telescope. The second advantage of a multiple-cannula procedure is the ability to maintain the triangulation technique and orient the instruments appropriately to the ovarian pedicle. The 2-cannula technique allows for complete independence of the scope from the instrument, whereas the 1-cannula technique limits independent maneuverability of the instrument to depth only.

We did not identify a significant difference in complication rates among groups in the present study, and the complications that were identified were those typically associated with laparoscopic OVE.[2–5,8] Ovarian pedicle hemorrhage was identified in 1 dog in the present study in which 3 cannulas had been used and was easily controlled with the 10-mm vessel-sealing device. The amount of blood loss was considered to be minimal, and hemorrhage was noticed because of the magnification associated with the endoscope. This bleeding may not have been noticed during a laparotomy. A previous study[8] reported a 43% rate of ovarian pedicle hemorrhage. A possible explanation for this difference might be the attention paid to ensuring minimal tension on the ovarian pedicle during ligation in the present study. Excessive tissue tension will cause an inadequate seal and lead to bleeding after the ligation cycle is completed. It is also possible that use of the 10-mm vessel-sealing device limits the number of ligations and increases contact area, thus reducing the risk of ovarian pedicle hemorrhage. Puncture of the spleen resulting in limited splenic hemorrhage was seen in 2 dogs in the present report. The hemorrhage was self-limiting in both dogs and did not require any specific treatment. Both of these dogs had only a single cannula inserted, and splenic puncture occurred during insertion of the 10-mm cannula without direct visualization. The 10-mm cannulas used in the dogs with 2 or 3 cannulas were introduced during visualization with the endoscope. Given this finding, the Hasson technique for cannula insertion may be more prudent than use of a Veress needle when a single cannula is used. Subcutaneous emphysema was seen at the end of the laparoscopic procedure in 1 dog in the present study. In this dog, multiple attempts had been made to place the Veress needle because appropriate gas flow for abdominal insufflation was not established initially as a result of a large falciform ligament occluding the tip of the Veress needle. The emphysema likely resulted from tissue plane disruption and subsequent leakage of CO_2 from within the peritoneum during the procedure. The emphysema resolved within 30 minutes after surgery.

The Melbourne Pain Scale has previously been established as a valid method of evaluating postoperative pain in dogs.[16] We used a modification of this scale in which rectal temperature, salivation, and pupil size were not included. We also standardized the palpation component of the scale by using von Frey filaments instead of hand palpation. The reason for eliminating rectal temperature was to limit patient disturbance and therefore limit potential confounding of other pain parameters. Salivation was not present in any of the dogs in this study, and its exclusion would therefore have had no effect on our pain scores. Finally, because we wanted to assess the cannula sites separately, palpation by hand was replaced by palpation with von Frey filaments. This was done because we did not believe that palpation by hand could be done consistently between dogs and observation times. Potential limitations of this scale that were encountered in the present study included the presence of non-nociceptive stressors, such as noise and unfamiliar personnel, who may not have been accounted for at every observation time. Although attempts were made to keep the recovery area quiet and separate, it was impossible to exclude all hospital personnel from the recovery area. On a number of occasions, hospital personnel were found in and around the recovery area and were asked to leave for at least 5 minutes before any further pain assessments were made.

Sample size in the present study was limited to 6 dogs/group, and this might have limited our ability to detect differences in pain score among groups. Power calculations were performed when appropriate, and power was relatively low when pain scores were compared between groups.

a. 10-mm-diameter 0° operating laparoscope with working channel, HOPKINS Optik, Karl Storz GMBH & Co KG, Tuttlingen, Germany.
b. 5-mm-diameter 0° laparoscope, HOPKINS II, Karl Storz GMBH & Co KG, Tuttlingen, Germany.
c. TT endoscopic positioner, Apexx Veterinary Equipment Inc, Englewood, Colo.
d. Ligasure, Valleylab/Tyco Healthcare, Boulder, Colo.
e. Tankersly Ovariectomy Hook, Karl Storz Veterinary Endoscopy, Goleta, Calif.
f. Biosyn, Covidien, Mansfield, Mass.
g. Vetbond, 3M Co, Saint Paul, Minn.
h. Tegaderm, 3M Co, Saint Paul, Minn.

i. Sharpie, Sanford Corp, Oak Brook, Ill.
j. JMP, version 8.0, SAS Institute Inc, Cary, NC.

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Appendix

Modified University of Melbourne Pain Scale for assessing severity of postoperative pain in dogs.

Variable	Criteria	Score
Percentage change in heart rate, compared with baseline rate		
	< 20% increase	0
	> 20% to ≤ 50% increase	1
	> 50% to ≤ 100% increase	2
	> 100% increase	3
Percentage change in respiratory rate, compared with baseline rate		
	< 20% increase	0
	> 20% to ≤ 50% increase	1
	> 50% to ≤ 100% increase	2
	> 100% increase	3
Activity level		
	Resting or asleep	0
	Awake	1
	Restless	2
	Rolling or thrashing	3
Posture		
	Sleeping or calm	0
	Sternal or sitting up	1
	Standing up with head down	2
	Guarded posture	3
Vocalization		
	None	0
	During palpation of the surgical site	1
	Intermittent	2
	Continuous	3
Palpation of the surgical site with a size 6.65 von Frey filament		
	No response	0
	Turns head or guards	2
	Cries out	3

Pain score was calculated as the sum of scores for the 6 individual categories; possible scores ranged from 0 to 18.