The Journal of Veterinary Medical Science

FULL PAPER

Surgery

Comparison of postoperative pain and inflammation reaction in dogs undergoing preventive laparoscopic-assisted and incisional gastropexy

Tomoya HARAGUCHI[1)], Shiho KIMURA[1)], Harumichi ITOH[1)], Shimpei NISHIKAWA[1)], Masato HIYAMA[2)], Kenji TANI[2)], Toshie ISERI[3)], Yoshiki ITOH[3)], Munekazu NAKAICHI[3)], Yasuho TAURA[2)] and Kazuhito ITAMOTO[1)]*

[1)]Laboratory of Veterinary Medical Center, Joint Faculty of Veterinary Medicine, Yamaguchi University, 1677-1 Yoshida, Yamaguchi 753-8515, Japan

[2)]Laboratory of Veterinary Surgery, Joint Faculty of Veterinary Medicine, Yamaguchi University, 1677-1 Yoshida, Yamaguchi 753-8515, Japan

[3)]Laboratory of Veterinary Radiology, Joint Faculty of Veterinary Medicine, Yamaguchi University, 1677-1 Yoshida, Yamaguchi 753-8515, Japan

J. Vet. Med. Sci.
79(9): 1524–1531, 2017
doi: 10.1292/jvms.17-0103

Received: 1 March 2017
Accepted: 4 July 2017
Published online in J-STAGE: 17 July 2017

ABSTRACT. This study compared the effects of postoperative pain and inflammation reaction after preventive laparoscopic-assisted gastropexy (LAG) and incisional gastropexy (IG) in 10 clinically normal Beagles. Surgical time, incision length, visual analog scale (VAS) score, University of Melbourne Pain Scale (UMPS) score, and plasma C-reactive protein (CRP), plasma cortisol (COR), and serum interleukin-6 (IL-6) levels were evaluated. The VAS and UMPS scores and COR and IL-6 levels were recorded at 0.5, 1, 2, 4, 8, 12, 18 and 24 hr after surgery. CRP level was recorded at 12, 24 and 48 hr after surgery. The VAS and UMPS scores showed no significant intergroup differences. Compared to IG, LAG had significantly lower surgical time (45 ± 9.91 min vs 64 ± 5.30 min; $P<0.05$), incision length (46 ± 8.21 mm vs 129 ± 19.49 mm; $P<0.05$), CRP level (12 hr after surgery; 4.58 ± 1.58 mg/*dl* vs 12.4 ± 1.34 mg/*dl*; $P<0.01$), and COR level (1 hr after surgery; 10.79 ± 3.07 μg/*dl* vs 15.9 ± 3.77 μg/*dl*; $P<0.05$). IL-6 levels showed no significant intergroup differences at any time point. However, LAG resulted in lower IL-6 levels than did IG at all postoperative time points. Neither procedure resulted in significant surgical complications. LAG produced lower surgical stress than did IG, suggesting that LAG is a safe, minimally invasive, and highly useful technique for preventing canine gastric dilatation-volvulus. Nevertheless, since this study used experimental models, its usefulness should be evaluated in future cases.

KEY WORDS: gastric dilatation-volvulus (GDV), incision gastropexy (IG), inflammation reaction, laparoscopic-assisted gastropexy (LAG), postoperative pain

Gastric dilatation-volvulus (GDV) most often affects large- and giant-breed dogs with deep and narrow chests, such as Great Danes, Standard Poodles, and Doberman Pinschers [15], and often affects medium- and small-breed dogs, such as Basset Hounds and Miniature Dachshunds [13]. These reports suggest that GDV is a disease affecting all dog breeds. Other risk factors associated with the development of GDV are age, ingestion of large amounts of food or water, eating rapidly or from an elevated food dish, fearful temperament, and exercise after eating [13, 28]. Mortality rates in dogs with GDV are 15–68% even with prompt and aggressive treatment [2, 8, 14, 23]. Hence, prevention of GDV is important because treating the disease is difficult.

Gastropexy is the most useful method for preventing GDV. Many gastropexy techniques have been described for dogs, and their objective is to create a permanent and strong adhesion of the stomach to the abdominal wall in order to prevent the stomach from rotating on its axis when it dilates [12, 34]. Incisional gastropexy (IG) is a fast and simple procedure that results in the long-term adhesion of the stomach to the body wall [1]. In recent years, minimally invasive surgery has gained popularity in veterinary medicine, and it offers advantages such as reduced postoperative pain, shorter hospital stay, and possible reduction in surgical site infections [3, 10, 18, 20, 24–26, 31, 33]. Laparoscopic-assisted gastropexy (LAG) has been shown to create a permanent and strong adhesion between the stomach and body wall. LAG induces less morbidity than does gastropexy via celiotomy [7, 30, 32].

*Correspondence to: Itamoto K.: kaz2356@yamaguchi-u.ac.jp

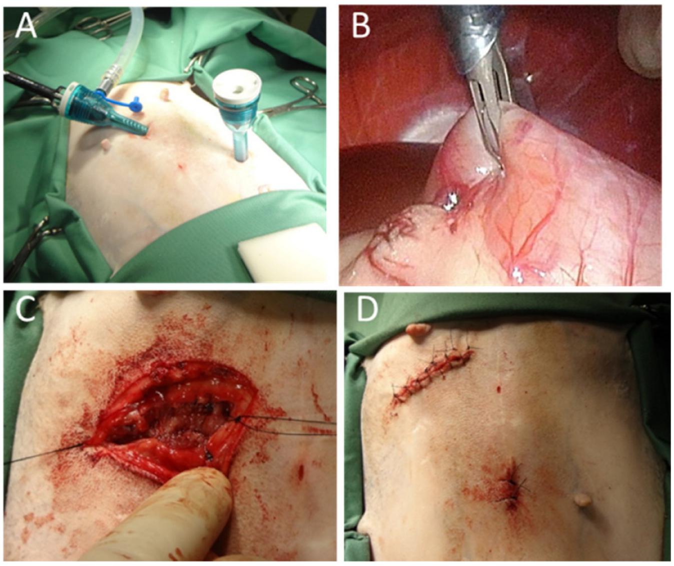

Fig. 1. Laparoscopic-assisted gastropexy (LAG). A: Port positions for LAG. B: The pyloric antrum is grasped between the lesser and greater curvatures of the stomach. C: The seromuscular layers of the stomach are incised, and the cranial edges of the transversus abdominis muscle and stomach are sutured together followed by the caudal edges in a simple continuous pattern by using 4-0 PDS*II®. D: Postoperative view following wound closure after LAG.

However, to our knowledge, no study has objectively evaluated and compared the postoperative pain and inflammation reaction between LAG and open IG. This study aimed to compare the effects of postoperative pain and inflammation reaction after LAG and IG. We used the visual analog scale (VAS) score, University of Melbourne Pain Scale (UMPS) score, surgical time, and incision length for arriving at an index of postoperative pain. The plasma C-reactive protein (CRP), serum cortisol (COR), and serum interleukin-6 (IL-6) levels were used for arriving at an index of inflammation reaction.

MATERIALS AND METHODS

Animals

This study was performed under the guidance of the Yamaguchi University Animal Care and Use Committee (No. 317). Ten healthy adult Beagles (4 males and 6 females) ranging in weight from 8.5 to 13.2 kg (mean ± SD: 11.4 ± 1.06 kg) and aged between 5 and 7 years (mean ± SD: 6.0 ± 0.97 years) were used in this study. The dogs were randomly assigned to the LAG group (n=5) and IG group (n=5). Physical examination and clinical laboratory analyses, including complete blood count, serum biochemical analysis, and abdominal computed tomography, were used to assess their health status.

Anesthesia

All dogs were administered a standardized anesthesia and analgesia protocol. Food was withheld from all dogs 12 hr before surgery. A catheter (SUPER CATH® 22G; Medikit Co., Ltd., Tokyo, Japan) was inserted into a cephalic vein before anesthesia. Piperacillin sodium (30 mg/kg, intravascular [iv]; PIPERACILLIN NA® injection 1 g; Sawai Pharmaceutical Co., Ltd., Osaka, Japan), carbazochrome sodium sulfonate (0.5 mg/kg, intramuscular [im]; ADONA® injection 10 mg; Tanabe Pharmaceutical Co., Ltd., Osaka, Japan), and tranexamic acid (25 mg/kg im; TRANSAMIN® injection 5%; Daiichi-Sankyo Co., Ltd, Tokyo, Japan) were administered as preoperative prophylaxis at the time of inducing anesthesia. General anesthesia was induced using propofol (PROPOFOL® 1% injection 20 m*l*; Pfizer Co., Ltd., Tokyo, Japan) administered at 7 mg/kg iv before intubation. General anesthesia was maintained using isoflurane (ISOFLU®; DS Pharma Animal Health Co., Ltd., Osaka, Japan) in oxygen. Pressure-controlled mechanical ventilation (Apollo®; Dragel Medical Japan, Tokyo, Japan) was carried out in order to maintain normocapnia (end tidal CO_2 from 30 to 40 mm Hg). Ringer's lactate (RINGER'S LACTATE®; FUSO Pharmaceutical Industries, Ltd., Osaka, Japan) was administered as intravenous fluidotherapy and maintained at 5 m*l*/kg/hr. A CV catheter (CV Legaforce SX; Terumo Co., Tokyo, Japan) was inserted into a jugular vein before surgery. After extubation, buprenorphine (0.02 mg/kg im; LEPETAN® injection 0.2 mg; Otsuka Pharmaceutical Co., Ltd., Tokyo, Japan) was administered to all dogs.

Surgical technique

LAG (Fig. 1. Laparoscopic-assisted gastropexy): The surgical technique was performed as previously described by Rawlings *et al* [29]. Briefly, the dogs were placed in dorsal recumbency, and the ventral abdomen was aseptically prepared for surgery. Abdominal access was obtained using a Veress needle. The Veress needle was inserted into the abdomen after a small skin incision

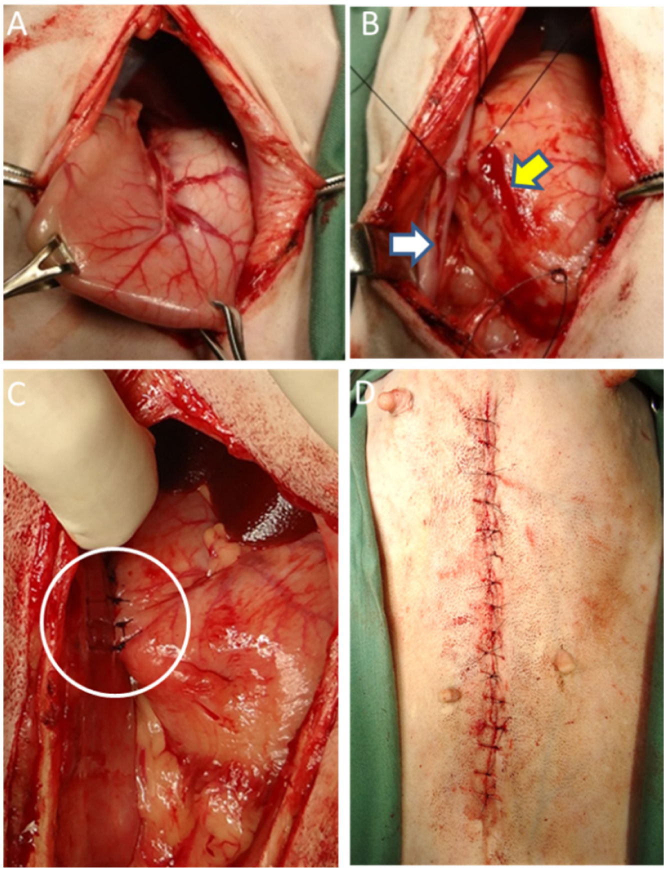

Fig. 2. Incision gastropexy (IG). A: Ventral midline abdominal incision is made, beginning at the xiphoid cartilage and extending caudal to the umbilicus. B: Gastric and abdominal wall incisions are apposed using 4-0 PDS*II® (white arrow: fascial incision in the transverse abdominis muscle; yellow arrow: seromuscular incision in the gastric antrum). C: A simple suture pattern beginning with the craniodorsal edges of the incision. D: Postoperative view following wound closure after IG.

about 5 cm cranial to the umbilicus and the abdomen was insufflated to a maximum pressure of 10 mm Hg with CO_2 gas and a mechanical insufflator (UHI-4®; Olympus, Co., Ltd., Tokyo, Japan). The Veress needle was retrieved and a 5-mm port (first port; Kii® Access Systems with Separator Technology 5 mm × 55 mm; Olympus, Co., Ltd.) was inserted in the subumbilical area. After superficial exploration of the abdomen, another 5-mm port (second port) was created 2–4 cm caudal to the last rib and 2–4 cm lateral to the rectus abdominis muscle under direct laparoscopic guidance (Fig. 1A). Laparoscopic grasping forceps (HiQ Plus WS1802/1®; Olympus, Co., Ltd.) were then inserted into the abdomen, and an avascular region of the pyloric antrum was grasped between the lesser and greater curvatures of the stomach (Fig. 1B). The abdomen was deflated and the second port was removed while traction was gently maintained on the stomach by using the grasping forceps. The skin and subcutaneous tissue incisions were enlarged on either side of the instrument port incision to create an access incision of 2–3 cm. The approach was continued through the external oblique, internal oblique, and transversus abdominis muscles. Allis tissue forceps were used to grasp the cranial and caudal edges of the transversus abdominis muscle to maintain clear identification of these muscles for gastropexy. The stomach was then carefully exteriorized through the access incision by using the grasping forceps, and stay sutures were placed at the orad and aborad extents of the proposed gastropexy to maintain appropriate gastric orientation. The seromuscular layers of the stomach were incised, and the cranial edges of the transversus abdominis muscle and stomach were sutured together followed by the caudal edges in a simple continuous pattern by using 4–0 polydioxanone sutures (ETHICON PDS*II®; Johnson & Johnson, Co., Ltd., Tokyo, Japan). Typically, the suture line began laterally and progressed medially on either the cranial or caudal aspect. When the suture line reached the medial aspect, 5–6 throws were performed and the line continued to the other side (Fig. 1C). After the completion of gastropexy, the internal and external abdominal oblique musculature, subcutaneous tissues, and skin were closed in three layers by using a simple continuous pattern. Pneumoperitoneum was re-established through the first port, and the gastropexy was inspected to ensure appropriate gastric function (Fig. 1D).

IG (Fig. 2 Incision gastropexy): The surgical technique was performed according to a fixed method [12, 34]. Briefly, dogs were placed in dorsal recumbency, and the ventral abdomen was aseptically prepared for surgery. A ventral midline abdominal incision was made, beginning at the xiphoid cartilage and extending caudal to the umbilicus (Fig. 2A). The first incision was a 3- to 4-cm seromuscular incision in the gastric antrum, either parallel or perpendicular to the long axis of the stomach. A second incision was made through the peritoneum and the transversus abdominis muscle on the lateral or ventrolateral right abdominal wall approximately 2–3 cm caudal to the last rib (Fig. 2B). The gastric and abdominal wall incisions were apposed using 4–0 PDS*II® in a simple suture pattern, beginning with the craniodorsal edges of the incision (Fig. 2C). After washing the abdominal cavity, a routine three-layer closure of the abdominal wall was performed (Fig. 2D).

Postoperative care

After awakening from anesthesia, the dogs were transported to the ward for recovery. All dogs were monitored for postoperative pain by using a video monitor for 48 hr after surgery.

After surgery, antibiotics were changed from Piperacillin sodium to Amoxicillin (23 mg/kg bid per oral; SAWACILLIN® tablets 250 mg; Astellas Pharmaceutical Co., Ltd., Tokyo, Japan). Antibiotics were discontinued after suture removal. The sutures were removed after 10 days (LAG) or 14 days (IG). The dogs were managed in isolation rooms until suture removal after surgery. They underwent daily physical checkups and diet monitoring.

Perioperative assessment

Surgical time and incision length: The surgical variables compared between the LAG and IG groups included incision length and surgical time from initial skin incision to the placement of the last closing suture.

VAS and UMPS scores: Throughout the study, preoperative and postoperative pain was assessed at baseline (before the induction of anesthesia) and then at 0.5, 1, 2, 4, 8, 12, 18 and 24 hr after endotracheal extubation. For a given 100-mm VAS line, 0 mm represented “the absence of pain” and 100 mm indicated “the worst pain possible”. The evaluation of VAS scores was carried out by two observers on the basis of images we recorded later. The UMPS included multiple descriptors in five categories of data or behaviors associated with response to pain. The categories included physiological data, response to palpation, activity, mental status, posture, and vocalization. More painful behaviors were weighted with increasingly higher scores. Maximal pain was given a score of 27, and no pain was scored as 0. The same observer, blinded to the experimental design, performed all scoring throughout the experiment.

Blood samples and analysis

Venous blood samples (4 m*l*) were collected at baseline (before surgery) and then at 0.5, 1, 2, 4, 8, 12, 18 and 24 hr after endotracheal extubation from the central venous catheter. Blood samples were separated into serum, ethylenediaminetetraacetic acid (EDTA) plasma, and heparin plasma. Serum was separated by centrifugation within 0.5 hr and stored at −20°C. EDTA plasma was separated immediately and stored at −20°C. Heparin plasma was separated immediately and used for analysis. Heparin plasma sample (1 m*l*) was obtained at 48 hr after endotracheal extubation.

CRP level

CRP level was measured using a canine CRP measurement kit (Laser CRP-2; Arrows Co., Ltd., Osaka, Japan) according to the manufacturer’s instructions. The reference range for CRP was considered as less than 0.95 mg/d*l* based on the manufacturer’s data sheet.

COR level

COR level was measured using the chemiluminescence method (IMMULITE 1000; Mitsubishi Chemical Medience Corporation, Tokyo, Japan) according to the manufacturer’s instructions.

IL-6 level

The analysis for IL-6 level was performed using a commercially available canine-specific IL-6 ELISA (Quantikine Canine IL-6; R&D systems, Minneapolis, MN, U.S.A.). All serum samples were analyzed in duplicate according to the manufacturer’s instructions. The assay functions as a controlled direct-sandwich ELISA with calibration material and controls consisting of recombinant canine IL-6. The reference range for IL-6 was considered as less than 31.3 *pg*/*l* based on the manufacturer’s data sheet.

Statistical analysis

GraphPad Prism 6 (GraphPad Software, La Jolla, CA, U.S.A.) was used for statistical analyses. Results are reported as mean ± SD. The VAS and UMPS scores were used in a distribution-free test. When we conducted the Kruskal–Wallis test for comparing time-related changes, and a significant difference was found, we performed Dunn’s multiple comparison as a post-hoc test. We conducted the Mann–Whitney U test for intergroup comparisons. When a comparison between time-related changes of other items revealed a significant difference in dispersion on Bartlett’s test, we performed Dunn’s multiple comparison as a *post-hoc* test. When the dispersion was nonequivalent, we performed Kruskal–Wallis authorization, and if a significant difference was found, we performed Dunn’s multiple comparison as a *post-hoc* test. Intergroup comparisons of dispersion were examined using the F test. When the dispersion was equal, we performed a t test without correspondence, and when the dispersion was nonequivalent, we performed a Welch t-test. Values of P<0.05 were considered significant for all analyses.

RESULTS

Postoperative assessment

Perioperative and postoperative complications (such as bleeding, vomiting, anorexia, and peritonitis) were not observed in any of the dogs.

Surgical time and incision length

Surgical times were 45 ± 9.91 min and 64 ± 5.30 min for LAG and IG, respectively (P<0.05) (Table 1). The total incision length was longer in IG (129 ± 19.49 mm) than in LAG (46 ± 8.21 mm; P<0.05) (Table 2).

VAS and UMPS scores

The VAS scores tended to increase in both groups for up to 0.5 hr after extubation, and then decreased over time. Both groups had scores that were higher at 0.5, 1, 2 and 4 hr after extubation than before surgery (P<0.05). Time-related changes were not significantly different between the groups at any of the time points (Fig. 3). The UMPS scores tended to increase in both groups for up to 0.5 hr after extubation, and then decreased over time. However, no significant differences were observed between the groups at any of the time points (Fig. 4).

CRP level

CRP levels tended to increase in both groups for up to 24 hr after extubation, and then decreased over time. In the LAG group, CRP levels were 4.58 ± 1.58 mg/d*l* (12 hr after extubation), 5.81 ± 2.52 mg/d*l* (24 hr after extubation) and 4.58 ± 1.58 mg/d*l* (48 hr after extubation). In the IG group, CRP levels were 12.4 ± 1.34 mg/d*l* (12 hr after extubation), 15 ± 1.87 mg/d*l* (24 hr after extubation) and 10.3 ± 4.99 mg/d*l* (48 hr after extubation). CRP levels were higher in the IG group than in the LAG group at all time points (P<0.05). Moreover, CRP levels in both groups were higher at 12 and 24 hr after extubation than before surgery (P<0.05) (Fig. 5).

COR level

COR levels tended to increase in both groups for up to 1 hr after extubation, and then decreased over time. COR levels were

Table 1. Surgical time

	Surgical time (min)
LAG	45 ± 9.11
IG	64 ± 5.30 a)

a) P<0.05 v.s. LAG.

Table 2. Incision length

	Incision length (mm)
LAG	46 ± 8.21
IG	129 ± 19.49 a)

a) P<0.05 v.s. LAG.

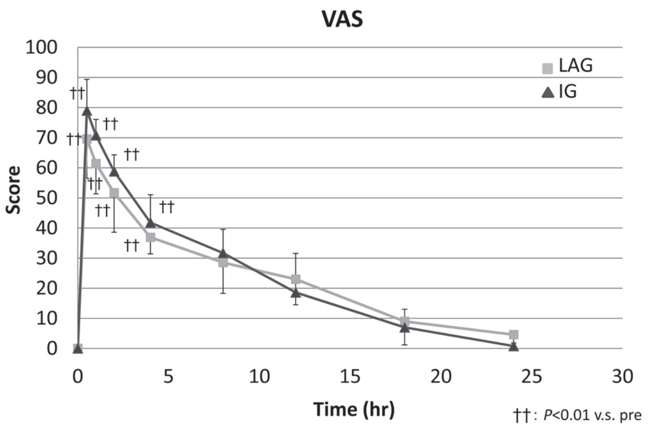

Fig. 3. Visual analog scale (VAS) score. For a given 100-mm VAS line, 0 mm represents "the absence of pain" and 100 mm indicates "the worst pain possible." Results are reported as mean ± SD. Values of P<0.05 are considered significant.

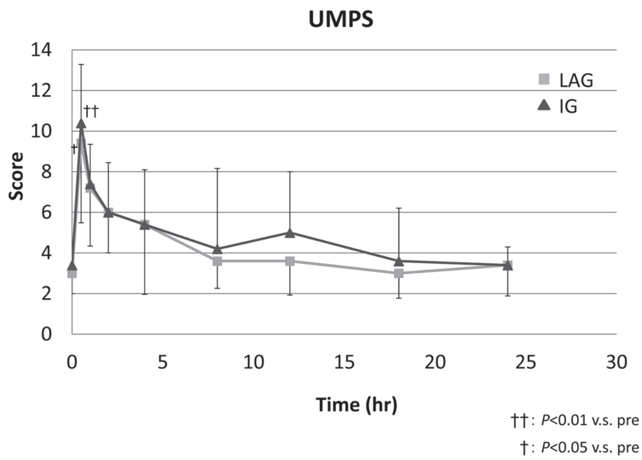

Fig. 4. University of Melbourne Pain Scale (UMPS) score. The categories included are physiological data, response to palpation, activity, mental status, posture, and vocalization. More painful behaviors are weighted with increasingly higher scores. Maximal pain is given a score of 27, and no pain is scored as 0. Results are reported as mean ± SD. Values of P<0.05 are considered significant.

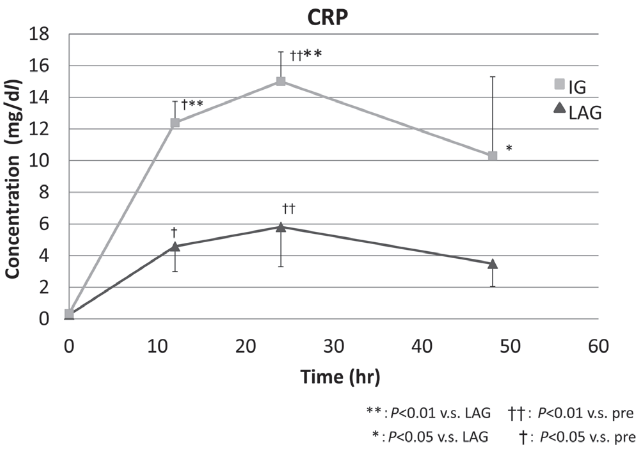

Fig. 5. C-reactive protein (CRP) level. CRP level is measured at baseline (before surgery) and then at 12, 24 and 48 hr after endotracheal extubation. Results are reported as mean ± SD. Values of P<0.05 are considered significant.

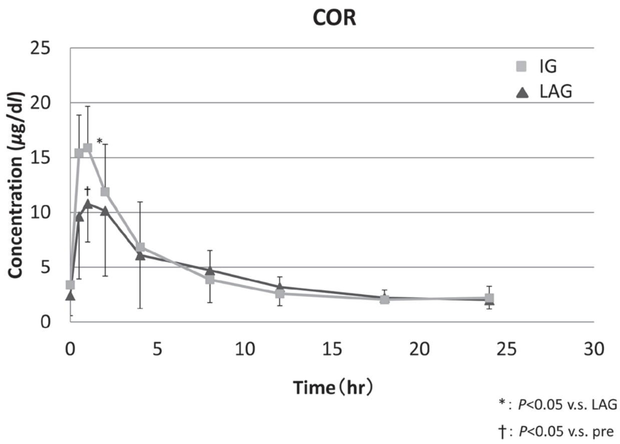

Fig. 6. Cortisol (COR) level. COR level is measured at baseline (before surgery) and then at 0.5, 1, 2, 4, 8, 12, 18 and 24 hr after endotracheal extubation. Results are reported as mean ± SD. Values of P<0.05 are considered significant.

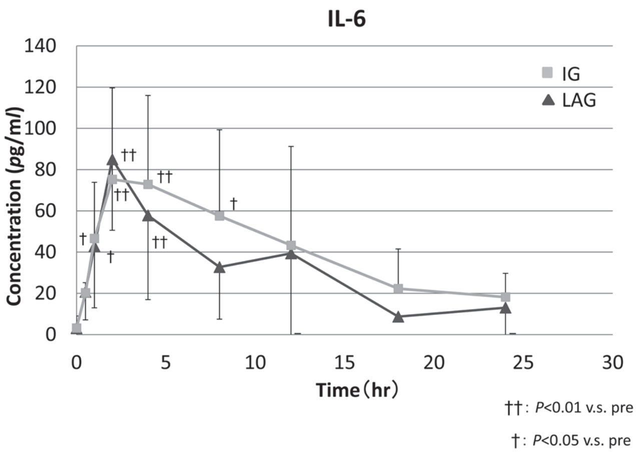

Fig. 7. Interleukin-6 (IL-6) level. IL-6 level is measured at baseline (before surgery) and then at 0.5, 1, 2, 4, 8, 12, 18 and 24 hr after endotracheal extubation. Results are reported as mean ± SD. Values of P<0.05 are considered significant.

higher in the IG group than in the LAG group at 1 hr after extubation (15.9 ± 3.77 μg/dl vs 10.79 ± 3.07 μg/dl; P<0.05). In the LAG group, COR levels were higher at 1 hr after extubation than before surgery (P<0.05) (Fig. 6).

IL-6 level

IL-6 levels tended to increase in both groups for up to 2 hr after extubation, and then decreased over time. In the LAG group, IL-6 levels were 3.04 ± 3.93 *pg*/m*l* (before surgery), 84.99 ± 34.40 *pg*/d*l* (2 hr after extubation), and 57.76 ± 40.79 *pg*/d*l* (4 hr after extubation). In the IG group, IL-6 levels were 0.58 ± 1.17 *pg*/m*l* (before surgery), 83.66 ± 46.04 *pg*/d*l* (2 hr after extubation), and 81.72 ± 44.20 *pg*/d*l* (4 hr after extubation). No significant differences were observed between the groups at any of the time points. In the LAG group, IL-6 levels were higher at 1, 4 and 6 hr after extubation than before surgery. In the IG group, IL-6 levels were higher at 1, 4, 6 and 8 hr after extubation than before surgery (Fig. 7).

DISCUSSION

Recently, laparoscopic surgery has become popular in veterinary medicine. Several studies have compared the postoperative pain and inflammation reaction between laparoscopy and open surgery, but these were limited to ovariohysterectomy. In addition, most of these studies evaluated subjective findings [4–6, 11, 22].

GDV is a well-described condition in dogs. The reported mortality rates associated with GDV range from 15 to 68%.

Retrospective analyses have revealed numerous factors that are common to dogs developing GDV; however, the etiology of this disease remains unknown [12, 34]. Prophylactic gastropexy, which is a preventive procedure, is highly recommended by veterinarians because it prevents the occurrence of GDV that could be life threatening [12, 34].

In this study, we confirmed that LAG produced lower postoperative pain and inflammation reaction than did IG. Some laparoscopic surgeries take more time than do open surgeries [16, 25]. However, LAG had a significantly shorter surgical time than did IG in this study. This shorter time could be attributed to the LAG procedure being simpler than other laparoscopic procedures.

The VAS is generally used to evaluate postoperative pain in human medicine. In veterinary medicine, the method suggested by Holton *et al.* is used [19]. In our study, the VAS scores in both groups were higher at 0.5, 1, 2 and 4 hr after extubation than before surgery, but time-related changes were not significantly different at any of the time points. The UMPS is used for evaluating postoperative pain in veterinary medicine [9, 11, 16, 17]. The UMPS is considered a more objective rating system than is the VAS. In our study, significant differences in the UMPS scores were not recognized. This could be attributed to the fact that the UMPS is a subjective evaluation that takes into account the behavior of the animals. Nevertheless, on the basis of this result, we thought that the evaluation of postoperative pain by using only subjective evaluations such as the VAS and UMPS was insufficient. Therefore, it was necessary to evaluate the surgical stress comprehensively using combination of objective examinations such as surgical time and incision length and measurement of biomarkers such as CRP, COR and IL-6 as well as subjective evaluations such as the VAS and UMPS.

Many variables have been studied in relation to postoperative CRP levels in veterinary medicine [34]. CRP is an acute-phase protein released by the liver in response to inflammation, infection, neoplasia, or tissue damage [34]. In this study, CRP levels were higher in the IG group than in the LAG group at all time points. In both groups, CRP levels were higher at 12 and 24 hr after extubation than before surgery. Recent studies have reported significant differences in CRP levels between different types of ovariohysterectomies, with less invasive procedures producing the smallest increases in CRP levels [21, 35].

COR is secreted by the adrenal glands in response to the release of adrenocorticotrophic hormone from the pituitary gland. Its levels increase transiently in response to stressors such as pain, excitement, fear, or anxiety, and more chronically in long-term stress. Many studies have examined the effect of anesthesia and surgery on COR level changes in dogs [6, 11, 16]. In this study, COR levels tended to increase in both groups for up to 1 hr after extubation and then the levels decreased over time. COR level was higher in the IG group than in the LAG group at 1 hr after extubation. In the LAG group, COR levels were higher at 1 hr after extubation than before surgery. This observation is similar to that of previous reports, in which increases in COR levels were observed after both laparoscopic and open surgeries [16].

IL-6 levels may be useful objective indicators of inflammation in animals [34]. Over the years, numerous studies have been conducted on the role of cytokines in pain control. Elevated serum IL-6 levels have been detected in patients with neurological disorders, musculoskeletal injuries, and autoimmune and inflammatory conditions [34]. In our study, IL-6 levels tended to increase in both groups for up to 2 hr after extubation, and then the levels decreased over time. In the LAG group, IL-6 levels were higher at 1, 4, and 6 hr after extubation than before surgery. In contrast, in the IG group, IL-6 levels were higher at 1, 4, 6 and 8 hr after extubation than before surgery. Therefore, these findings suggest the possibility that inflammation could be relieved earlier in the LAG group than in the IG group. However, IL-6 levels did not significantly differ between the groups at any of the time points in this study. CRP is an acute-phase protein produced in the liver in response to the increased concentration of IL-6 during inflammation. CRP expression is induced by the stimulation of IL-6 alone, but studies have suggested that its expression can occur synergistically when costimulated with IL-1 [27]. Based on the current findings, we think that other inflammatory cytokines (e.g., IL-1) might participate in the expression of CRP.

The findings of this objective study of several factors confirmed that LAG was a more effective and minimally invasive surgery than was IG. On the basis of these results, we think that the evaluation of postoperative pain and inflammation reaction by using subjective measurements is insufficient and that an objective evaluation is necessary to draw valid conclusions.

Most complications in laparoscopic surgery are related to abdominal cavity access and pneumoperitoneum establishment, hemorrhage, viscera perforation, and tissue damage due to pressure application. However, perioperative complications were not observed in any of the dogs treated in this study. These results suggest that the LAG technique is simpler and easier than are other laparoscopic surgeries.

In conclusion, LAG is an easy, safe, and acceptable procedure because of its various advantages, which make it more recommendable than traditional open surgery including midline laparotomy. Nevertheless, this study used experimental models; therefore, it will be necessary to evaluate the usefulness of this technique in future clinical cases. Moreover, our study describes preventive gastropexy. Unlike other laparoscopic surgeries, preventive gastropexy is generally performed in clinically normal dogs. Based on our findings, we think it could be easily applied in clinical cases. Ultimately, the LAG technique may have application as a minimally invasive gastropexy procedure for dogs at risk of developing GDV.

REFERENCES

1. Allen, P. and Paul, A. 2014. Gastropexy for prevention of gastric dilatation-volvulus in dogs: history and techniques. *Top. Companion Anim. Med.* **29**: 77–80. [Medline] [CrossRef]
2. Brockman, D. J., Washabau, R. J. and Drobatz, K. J. 1995. Canine gastric dilatation/volvulus syndrome in a veterinary critical care unit: 295 cases (1986-1992). *J. Am. Vet. Med. Assoc.* **207**: 460–464. [Medline]
3. Bunch, S. E., Polak, D. M. and Hornbuckle, W. E. 1985. A modified laparoscopic approach for liver biopsy in dogs. *J. Am. Vet. Med. Assoc.* **187**:

1032–1035. [Medline]
4. Culp, W. T., Mayhew, P. D. and Brown, D. C. 2009. The effect of laparoscopic versus open ovariectomy on postsurgical activity in small dogs. *Vet. Surg.* **38**: 811–817. [Medline] [CrossRef]
5. Davidson, E. B., Moll, H. D. and Payton, M. E. 2004. Comparison of laparoscopic ovariohysterectomy and ovariohysterectomy in dogs. *Vet. Surg.* **33**: 62–69. [Medline] [CrossRef]
6. Devitt, C. M., Cox, R. E. and Hailey, J. J. 2005. 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. [Medline] [CrossRef]
7. Dujowich, M. and Reimer, S. B. 2008. Evaluation of an endoscopically assisted gastropexy technique in dogs. *Am. J. Vet. Res.* **69**: 537–541. [Medline] [CrossRef]
8. Dye, T. 2003. The acute abdomen: a surgeon's approach to diagnosis and treatment. *Clin. Tech. Small Anim. Pract.* **18**: 53–65. [Medline] [CrossRef]
9. Firth, A. M. and Haldane, S. L. 1999. Development of a scale to evaluate postoperative pain in dogs. *J. Am. Vet. Med. Assoc.* **214**: 651–659. [Medline]
10. Freeman, L. J. 2009. Gastrointestinal laparoscopy in small animals. *Vet. Clin. North Am. Small Anim. Pract.* **39**: 903–924. [Medline] [CrossRef]
11. Freeman, L. J., Rahmani, E. Y., Al-Haddad, M., Sherman, S., Chiorean, M. V., Selzer, D. J., Snyder, P. W. and Constable, P. D. 2010. Comparison of pain and postoperative stress in dogs undergoing natural orifice transluminal endoscopic surgery, laparoscopic, and open oophorectomy. *Gastrointest. Endosc.* **72**: 373–380. [Medline] [CrossRef]
12. Fossum, T. W. 2007. Small Animal Surgery, 3rd ed., Mosby Inc, St. Louis.
13. Glickman, L. T., Glickman, N. W., Pérez, C. M., Schellenberg, D. B. and Lantz, G. C. 1994. Analysis of risk factors for gastric dilatation and dilatation-volvulus in dogs. *J. Am. Vet. Med. Assoc.* **204**: 1465–1471. [Medline]
14. Glickman, L. T., Lantz, G. C., Schellenberg, D. B. and Glickman, N. W. 1998. A prospective study of survival and recurrence following the acute gastric dilatation-volvulus syndrome in 136 dogs. *J. Am. Anim. Hosp. Assoc.* **34**: 253–259. [Medline] [CrossRef]
15. Glickman, L. T., Glickman, N. W., Schellenberg, D. B., Raghavan, M. and Lee, T. 2000. Non-dietary risk factors for gastric dilatation-volvulus in large and giant breed dogs. *J. Am. Vet. Med. Assoc.* **217**: 1492–1499. [Medline] [CrossRef]
16. Hancock, R. B., Lanz, O. I., Waldron, D. R., Duncan, R. B., Broadstone, R. V. and Hendrix, P. K. 2005. Comparison of postoperative pain after ovariohysterectomy by harmonic scalpel-assisted laparoscopy compared with median celiotomy and ligation in dogs. *Vet. Surg.* **34**: 273–282. [Medline] [CrossRef]
17. Hansen, B. D. 2003. Assessment of pain in dogs: veterinary clinical studies. *ILAR J.* **44**: 197–205. [Medline] [CrossRef]
18. Hardie, R. J., Flanders, J. A., Schmidt, P., Credille, K. M., Pedrick, T. P. and Short, C. E. 1996. Biomechanical and histological evaluation of a laparoscopic stapled gastropexy technique in dogs. *Vet. Surg.* **25**: 127–133. [Medline] [CrossRef]
19. Holton, L. L., Scott, E. M., Nolan, A. M., Reid, J., Welsh, E. and Flaherty, D. 1998. Comparison of three methods used for assessment of pain in dogs. *J. Am. Vet. Med. Assoc.* **212**: 61–66. [Medline]
20. Kemp, S. D., Zimmerman, K. L., Panciera, D. L., Monroe, W. E., Leib, M. S. and Lanz, O. I. 2015. A comparison of liver sampling techniques in dogs. *J. Vet. Intern. Med.* **29**: 51–57. [Medline] [CrossRef]
21. Kjelgaard-Hansen, M., Strom, H., Mikkelsen, L. F., Eriksen, T., Jensen, A. L. and Luntang-Jensen, M. 2013. Canine serum C-reactive protein as a quantitative marker of the inflammatory stimulus of aseptic elective soft tissue surgery. *Vet. Clin. Pathol.* **42**: 342–345. [Medline] [CrossRef]
22. Lee, J. Y. and Kim, M. C. 2014. Comparison of oxidative stress status in dogs undergoing laparoscopic and open ovariectomy. *J. Vet. Med. Sci.* **76**: 273–276. [Medline] [CrossRef]
23. Mackenzie, G., Barnhart, M., Kennedy, S., DeHoff, W. and Schertel, E. 2010. A retrospective study of factors influencing survival following surgery for gastric dilatation-volvulus syndrome in 306 dogs. *J. Am. Anim. Hosp. Assoc.* **46**: 97–102. [Medline] [CrossRef]
24. Mayhew, P. D., Culp, W. T., Hunt, G. B., Steffey, M. A., Mayhew, K. N., Fuller, M., Della-Maggiore, A. and Nelson, R. W. 2014. Comparison of perioperative morbidity and mortality rates in dogs with noninvasive adrenocortical masses undergoing laparoscopic versus open adrenalectomy. *J. Am. Vet. Med. Assoc.* **245**: 1028–1035. [Medline] [CrossRef]
25. Mayhew, P. D., Mehler, S. J. and Radhakrishnan, A. 2008. Laparoscopic cholecystectomy for management of uncomplicated gall bladder mucocele in six dogs. *Vet. Surg.* **37**: 625–630. [Medline] [CrossRef]
26. Naan, E. C., Kirpensteijn, J., Dupré, G. P., Galac, S. and Radlinsky, M. G. 2013. Innovative approach to laparoscopic adrenalectomy for treatment of unilateral adrenal gland tumors in dogs. *Vet. Surg.* **42**: 710–715. [Medline] [CrossRef]
27. Nishikawa, T., Hagihara, K., Serada, S., Isobe, T., Matsumura, A., Song, J., Tanaka, T., Kawase, I., Naka, T. and Yoshizaki, K. 2008. Transcriptional complex formation of c-Fos, STAT3, and hepatocyte NF-1 alpha is essential for cytokine-driven C-reactive protein gene expression. *J. Immunol.* **180**: 3492–3501. [Medline] [CrossRef]
28. Pipan, M., Brown, D. C., Battaglia, C. L. and Otto, C. M. 2012. An Internet-based survey of risk factors for surgical gastric dilatation-volvulus in dogs. *J. Am. Vet. Med. Assoc.* **240**: 1456–1462. [Medline] [CrossRef]
29. Rawlings, C. A., Foutz, T. L., Mahaffey, M. B., Howerth, E. W., Bement, S. and Canalis, C. 2001. A rapid and strong laparoscopic-assisted gastropexy in dogs. *Am. J. Vet. Res.* **62**: 871–875. [Medline] [CrossRef]
30. Rawlings, C. A., Mahaffey, M. B., Bement, S. and Canalis, C. 2002. Prospective evaluation of laparoscopic-assisted gastropexy in dogs susceptible to gastric dilatation. *J. Am. Vet. Med. Assoc.* **221**: 1576–1581. [Medline] [CrossRef]
31. Rivier, P., Furneaux, R. and Viguier, E. 2011. Combined laparoscopic ovariectomy and laparoscopic-assisted gastropexy in dogs susceptible to gastric dilatation-volvulus. *Can. Vet. J.* **52**: 62–66. [Medline]
32. Runge, J. J., Mayhew, P. and Rawlings, C. A. 2009. Laparoscopic-assisted and laparoscopic prophylactic gastropexy: indications and techniques. *Compend. Contin. Educ. Vet.* **31**: E2. [Medline]
33. Thieman Mankin, K. M. 2015. Current concepts in congenital portosystemic shunts. *Vet. Clin. North Am. Small Anim. Pract.* **45**: 477–487. [Medline] [CrossRef]
34. Tobias, K. M. and Johnston, S. A. 2012. Veterinary Surgery Small Animal, vol. 1. Elsevier Science & Technology, Oxford.
35. Yamamoto, S., Shida, T., Miyaji, S., Santsuka, H., Fujise, H., Mukawa, K., Furukawa, E., Nagae, T. and Naiki, M. 1993. Changes in serum C-reactive protein levels in dogs with various disorders and surgical traumas. *Vet. Res. Commun.* **17**: 85–93. [Medline] [CrossRef]