pISSN 1598-298X
J Vet Clin 31(6) : 477-482 (2014)

Journal of Veterinary Clinics
www.ksvc.or.kr

Comparison of LigaSure™ and Bipolar Vessel Sealing System for Laparoscopic Ovariectomy in Cats

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(Accepted: December 08, 2014)

Abstract : The aim of this study was to investigate and compare technique, surgical time, and complications of laparoscopic ovariectomy using LigaSure™ and bipolar vessel sealing system in cats. Laparoscopic ovariectomy was performed under general anesthesia on 10 healthy female cats admitted for elective ovariectomy. Surgery was performed through three midline portals. Each ovary was randomly-assigned to removal by use of either LigaSure™ or bipolar vessel sealing system. Duration of predetermined surgery intervals and complications were compared. Bipolar OVE (2:16 ± 1:14 minutes) took significantly longer surgical time compared to the LigaSure™ OVE (1:24 ± 0:59 minutes, $P = 0.021$). The ovarian pedicle fat and obesity did not influence surgery duration. Intraoperative hemorrhage occurred with bipolar OVE in three cats, but had no significant influence on surgical time. The results suggest that both LigaSure™ and bipolar devices appear to be effective, but LigaSure™ can be used as a stand-alone device that decreases surgical time and complication compared with bipolar vessel sealing system.

Key words **:** cat, laparoscopic ovariectomy, LigaSure™, bipolar.

Introduction

Ovariectomy is an effective and less invasive method for routine neutering of female dogs and is not associated with an increased risk of complications when compared to traditional ovariohysterectomy (1,13,15). And laparoscopic procedures are superior to open surgery due to reduced morbidity caused by less incisional trauma, wound complications, adhesion formation (5,14), peri- and post-operative pain (3,6) and physical stress response (9,10), as well as more postoperative activity (2). Therefore, laparoscopic ovariectomy has been accepted in dogs, cats, and other animals, because it has all advantages of ovariectomy and laparoscopic surgery.

In dogs and cats, laparoscopic ovariectomy or ovariohysterectomy has been performed using several techniques, for example, monopolar and bipolar electrocoagulation (12,16, 17,19), surgical laser (17,19), ultrasonic devices (6,12), and different vessel-sealing devices (2,4,11). As a result, most of the devices were safe and effective, and have pros and cons according to the use for laparoscopic ovariectomy and ovariohysterectomy. Among those devices, LigaSure™ (Valleylab, Boulder, CO, USA) desiccates vascular tissues using a feedback-programmed amount of bipolar diathermy (7). This method of vessel sealing relies on the application of a precise amount of bipolar electrocoagulation of the collagen and elastin in vessel walls (8). In addition, this vessel sealing system uses high-current and low-voltage energy, which differ from bipolar cautery with high voltage and low current (7). The technique is able to seal vessels of up to 7 mm in diameter (8). Once the vessel is completely sealed, the surgeon manually cuts the tissue with a function available on the hand-piece (12). Bipolar has been described for many laparoscopic surgeries in dogs, cats, and is a generally accepted technique. Meanwhile, there is no report that compares of LigaSure™ and bipolar for laparoscopic ovariectomy in small animal.

Therefore, the aim of this study was to compare the effect of using LigaSure™ versus bipolar on surgical time and complications during laparoscopic ovariectomy in cats.

Materials and Methods

Animals

Ten female cats of Korean short hair were admitted for elective laparoscopic ovariectomy. A standard questionnaire about the cat (the patient's age, breed, general health status, diet, previous estrus cycles and pregnancies) was completed by the owner. Each cat had a complete physical examination. Body weight was measured and body condition was scored, ranging from 1 (thin) to 5 (obese). In addition, preoperative complete blood count and serum biochemical profiles were performed in all cats.

The cats were randomly divided into two groups, A and B. Group A had the left ovary removed with LigaSure™ and the

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Table 1. Cats included in the study; group (A or B), body weight, body condition score, ovarian pedicle fat score. (Group A: Left-LigaSure™ OVE, Right- bipolar OVE, Group B: Left-bipolar OVE, Right-LigaSure™ OVE)

Group	No.	Breed	Body weight (kg)	Body condition score	Ovarian pedicle fat score
A	1	Korean domestic short hair	2.9	4	1
	3	Korean domestic short hair	3	3	0
	5	Korean domestic short hair	3.2	3	0
	7	Korean domestic short hair	2	2	0
	9	Korean domestic short hair	2.1	2	1
B	2	Korean domestic short hair	3	3	0
	4	Korean domestic short hair	3.5	3	0
	6	Korean domestic short hair	2.1	2	0
	8	Korean domestic short hair	2.6	2	0
	10	Korean domestic short hair	1.9	2	0
Mean			2.63	2.6	0.2

right ovary removed with bipolar electrocoagulation forceps (n = 5). Group B had the left ovary removed with bipolar electrocoagulation forceps and the right with LigaSure™ (n = 5) (Table 1).

Anesthesia

All cats received general anesthesia according to a standard protocol. The cats were sedated using 40 μg/kg medetomidine (Domitor, Pfizer, USA) IM. After placement of a catheter in the cephalic vein, general anesthesia was induced with 3 mg/kg propofol (Provive 1%, Myungmoon pharm, Korea) intravenously titrated to effect and administered to effect preceding tracheal intubation. Anesthesia was maintained with isoflurane (Ifran, Hana pharm, Korea) in 100 percent oxygen via endotracheal intubation in a circle rebreathing system. Additional analgesia was accomplished by administering 0.2 mg/kg butorphanol (Butophan, Myungmoon pharm, Korea) IV, 0.2 mg/kg meloxicam (Metacam, Boehringer Ingelheim, Germany) SC. Monitoring consisted of electrocardiography, capnography, pulse oximetry, respiratory rate, and body temperature. Body temperature was maintained at 38-39°C with a circulating water blanket (Medi-Therm, Gaymer, USA) and lactated Ringer's solution was administered IV during the procedure at a rate of 10 ml/kg/h. Sedation was reversed using atipamezole (Antisedn, Pfizer, USA), 100 μg/kg IM.

Surgery

The surgical field was prepared aseptically after clipping the hair between the nipples from sternum to os pubis. Patients were positioned on a surgical table (Tippy table, Biovision Technologies, USA) designed to facilitate the rotation of the animal from dorsal recumbency to right or left lateral recumbency while maintaining an aseptic surgical field. Pneumoperitoneum was induced by insertion of CO_2 gas into the abdominal cavity through a Veress needle which was inserted after the stab skin incision on the caudal portion of the xiphoid process. Throughout the entire surgical procedure, a maximum abdominal pressure of 4 mmHg was maintained. A three portal technique was used with 5 mm cannulas. The first portal was placed 1 cm caudal to the umbilicus. After making a 5 mm skin incision, a 5 mm sharp-tipped trocar-cannula assembly was inserted into the abdomen. Through this port, a 30° forward oblique, 5 mm laparoscope (Panoview Plus, Richard Wolf, Germany) with a 1-CCD video camera (Single Chip Camera 5512, Richard Wolf, Germany) and a light source (Auto LP 4251, Richard Wolf, Germany) were inserted and any damage and hemorrhage upon insertion of the trocar was evaluated. Under laparoscopic observation, two additional instrument portals were established in the same manner. The second and third 5 mm portal was made midway between os pubis and umbilicus and midway between umbilicus and xiphoid. 5 mm grasping forceps (Atraumatic grasping forceps, Richard Wolf, Germany) were used to locate and grasp the ovaries from the cranial instrument portal.

In all cats, the left ovary was removed first. Using the surgical table, the cat was rotated about 90° to the right so left ovary was uppermost. A 5 mm grasping forceps was inserted through the cranial instrument portal. The left ovary was grasped and lifted upward using the grasping forceps. The LigaSure™ device or 5 mm bipolar forceps (Universal bipolar grasping forceps, Richard wolf, Germany), depending on group, was introduced via the caudal instrument portal and used to remove the ovary, starting with the proper ligament and working towards the suspensory ligament. LigaSure™ generator was set at power level 2. LigaSure™ generator has a feedback mechanism providing the surgeon with an audible tone when the sealing process is complete. The surgeon then divides the fused tissue manually with a function on the hand-piece. Bipolar forceps coagulated the tissues, and these structures were then cut using 5 mm endoscopic scissors (Monopolar Metzenbaum scissors, Richard wolf, Germany).

After complete resection, the ovary was removed from the abdomen through the cranial portal, without the need for portal enlargement. After reinsertion of the cranial trocar, the surgeon and assistant turned to the other side of the surgical table, and the same procedure was performed for the right ovary using bipolar instead of LigaSure™ or vice-versa (group B). The portal site was closed with separate sutures in the abdominal musculature, subcutaneous tissue and skin (Fig 1).

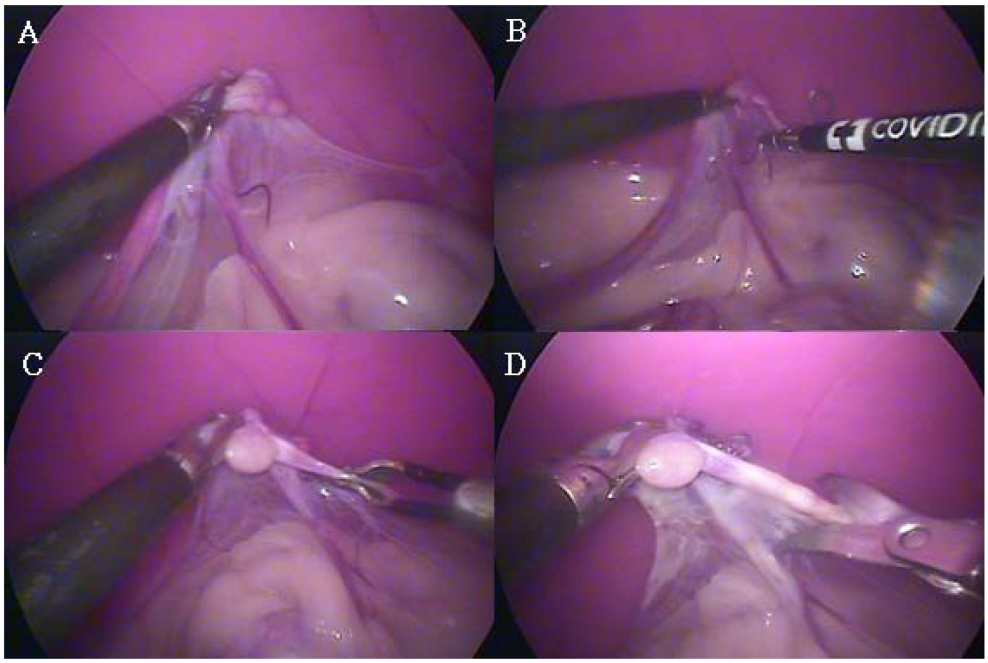

Fig 1. Ovary resection procedure through the abdomen in a cat. A. Searching the ovary. Then the ovary is grasped and lifted upward using the grasping forceps. B. The ovary is removed by LigaSure™. C. Bipolar forceps coagulated tissues surrounding the opposite side ovary. D. These structures were then cut using 5 mm endoscopic scissors.

Measured variables

Recorded surgical times were as follows: (1) First skin incision; (2) Insert all trocars; (3) searching for the left ovary; (4) excision of the left ovary; (5) removal of the left ovary; (6) searching for the right ovary; (7) excision of the right ovary; (8) removal of the right ovary; (9) end of the suture; and (10) total surgical time (defined as the time form skin incision for portal placement to the end of skin suturing).

Other recorded intraoperative parameters were occurrence of hemorrhage during surgery, the amount of fat in the ovarian pedicle (0 (no fat), 1 (moderate amount of fat), 2 (large amount of fat) (18), smoke production (yes or no), other complications.

Statistical analysis

A paired sample t-test was used to test for differences in duration of defined surgical stages of left versus right and LigaSure™ versus bipolar. An independent samples t-test was used to test for other (unpaired) variables such as influence of intraoperative hemorrhage and smoke production on surgical time. Influences of BCS and ovarian pedicle fat were evaluated using one-way ANOVA tests. Chi-square test was used to test for influence of complications on surgical time. $P < 0.05$ (2-tailed) were considered significant. Resulted are reported as means ± SD.

Results

Mean bodyweight was 2.63 ± 0.57 kg (range 1.9 to 3.5 kg). The dogs had a mean body condition score of 2.6 ± 0.70 (range 2 to 4), and mean ovarian pedicle fat score was 0.2 ± 0.42 (range 0 to 2). Bodyweight, body condition score or ovarian pedicle fat score was not found to statistically affect the outcome regarding surgical times or intra-operative complications.

Surgery time intervals

The time intervals were compared for the left side versus the right side, and excision (OVE) time was also compared for LigaSure™ versus Bipolar. There were no significant differences in surgical time intervals between the left and the right sides (Fig 2). The increased duration of OVE of the right ovary (2:08 ± 1:13 minutes) compared to the left ovary (1:31 ± 0:55 minutes) was not significant ($P = 0.134$). There was a significant difference in duration between LigaSure™ resection of the ovary (LigaSure™ OVE, 1:08 ± 0:43 minutes) and bipolar resection of the ovary (Bipolar OVE 1:55 ± 1:00 minutes; $P = 0.005$) only for the left ovary (Fig 3). Difference in duration between LigaSure™ OVE (1:40 ± 1:13

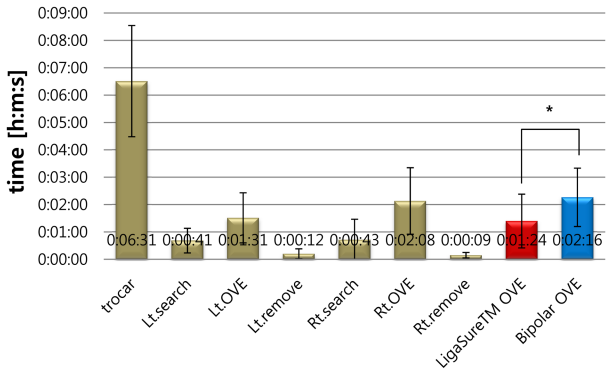

Fig 2. Means (± SD) surgical time intervals for placement of trocar, searching, resection (OVE) and removal of the ovary from the abdomen, LigaSure™ resection (LigaSure™ OVE) and bipolar resection (bipolar OVE) of the ovary (h: hour, m: minute, s: second, Rt: Right, Lt: Left; *indicates significant difference, $P < 0.05$).

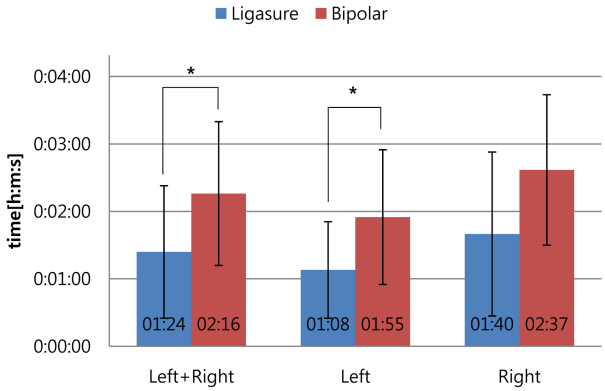

Fig 3. Mean (± SD) surgical time for different side of the ovary for LigaSure™ OVE and bipolar OVE. Significant difference in duration of surgical resection of the left side of the ovary was detected. (h: hour, m: minute, s: second, *indicates significant difference, $P < 0.05$).

minutes) and Bipolar OVE (2:37 ± 1:07 minutes; $P = 0.87$) for the right ovary was not significant. Bipolar OVE (2:16 ± 1:14 minutes) took significantly longer compared to LigaSure™ OVE (1:24 ± 0:59 minutes, $P = 0.021$). Mean overall surgery duration was 24:18 ± 6:36 minutes (range 14:25-33:17 minutes).

Complications

Intraoperative hemorrhage

Intraoperative hemorrhage occurred with the bipolar OVE in 3 cats (30%), which was managed properly using bipolar forceps. Hemorrhage had no significant effect on OVE duration ($P = 0.147$).

Abdominal wall damage

Abdominal wall damage occurred with the bipolar OVE in 1 cat (10%).

Body condition score and ovarian pedicle fat score on surgical time

One of 10 cats was considered over weight; four cats were ideal, and the other five cats were under weight. Body condition score was not correlated with the ovarian pedicle fat score. Neither BCS nor ovarian pedicle fat score had a significant effect on OVE duration.

Follow-up

Postoperative appetite and activity were unchanged compared with preoperative assessment. Mean period for complete recovery was 0.8 ± 0.63 days (range 0-2). All owners were satisfied with the procedure and results.

Discussion

In this experiment the LigaSure™ and bipolar vessel sealing system were examined for laparoscopic ovariectomy in cats. We found that LigaSure™ and bipolar vessel sealing system were both useful and safe instrument for laparoscopic ovariectomy in cats. However, in surgical time, LigaSure™ decreased surgical time significantly ($P < 0.05$) compared with bipolar. The most reasonable explanation for this finding is that LigaSure™ is able to perform vessel-sealing and division of the tissue without the need for instrument exchange (12).

In addition, a precise amount of energy is delivered to the tissue, and then the vessel is completely sealed. The device gives a sound signal for the surgeon to manually activate the cutting mechanism available on the hand-piece (12). Therefore it can minimize surgeon's unnecessary movement for surgery. However, there were no significant differences between LigaSure™ and bipolar in surgical time for the right ovariectomy. This probably resulted from anatomical location of ovaries. The right ovary is more cranially located than the left ovary. This makes more difficult working sight for the right ovariectomy.

There were no significant differences between the left ovary searching time and the right ovary searching time. In previous study, access to the right ovary is more demanding compared to the left ovary in dogs and cats (17,18). But in this study, there were no significant differences between the left ovary searching time (0:41 ± 0:27 minutes) and the right ovary searching time (0:43 ± 0:45 minutes, $P = 0.91$). During searching for the left ovary, the ovary was hided under the spleen (n = 5) because of the tippy table. The spleen changes position in right lateral recumbency, and covers the left ovary.

Body condition score had no significant effect on any surgery time. In previous study, ovarian pedicle fat score was increased in obese dogs and surgical time increased with increasing ovarian pedicle fat score (17). In contrast, laparoscopic ovariectomy time was not affected by obesity in cats (18). In this study, there was no relationship between body condition score and ovarian pedicle fat score. This probably explains why laparoscopic ovariectomy time was not related to body condition score. But, it is difficult to define the relationship between body condition score and ovarian pedicle fat in cat clearly, because there was no cat of body condition scored 5 and ovarian pedicle fat scored 2.

There were two complications during the procedures. Intraoperative hemorrhage occurred with bipolar OVE (30%). The bleeding needed no intervention because it stopped spontaneously during monitoring, or it could be cauterized immediately by using bipolar. One possible explanation may be that the hemostatic capacity of bipolar is decreased on thin tissue. In our experience, the thin tissue, such as ovarian pedicle, proper ligament and suspensory ligament of cat, can be torn before complete hemostasis. LigaSure™, a feedback-controlled bipolar cutting device, reduces thermal spread, and the risk of injury to adjacent structures may be reduced (12). However, intraoperative hemorrhage had no significant effect on surgery time. The other complication was abdominal wall damage. Surrounding tissue was cauterized by working shaft of bipolar during the hemostasis. This is because the bipolar working shaft is relatively big and high thermal conductivity. Bipolar has a bigger working shaft than LigaSure™, and in our experience, its jaw was slightly big for laparoscopic ovariectomy in cat. LigaSure™, which has a working shaft diameter of 10 mm, was easier to work than bipolar in cat. Therefore, during the hemostasis, the surgeon has to pay

attention to avoid touching the surrounding tissue.

Smoke was produced by LigaSure™ (30%) and bipolar (30%) during electro cauterization and reduced visibility inside the abdomen. We encountered a less clear image because of smoke production during bipolar OVE when compared with LigaSure™ OVE. But smoke had no effect on surgery. The amount of smoke is changed by histopathological characteristics of tissue.

Conclusion

This study shows that LigaSure™ and bipolar vessel sealing system are both effective and safe instruments for laparoscopic ovariectomy in cats. Although LigaSure™ is relatively expensive, it significantly decreases surgical time compared with bipolar. Thus, LigaSure™ is a viable option for laparoscopic ovariectomy in cats.

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복강경을 이용한 고양이의 난소 절제술에서 지혈기구인 LigaSure™와 양극 전기 응고 장치(bipolar)의 비교

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요 약 : 본 연구에서는 복강경을 이용한 고양이의 난소절제술에서 지혈 장치로서 LigaSure™와 양극 전기 응고 장치(bipolar)의 효과를 수술시간, 부작용에 대하여 비교해 보고자 하였다. 10마리의 고양이를 각각 5 마리씩 A군과 B군으로 무작위로 나누었고, A군은 좌측 난소는 LigaSure™로, 우측 난소는 양극 전기 응고 장치(bipolar)로 절제하였다. 반대로 B군은 좌측 난소는 양극 전기 응고 장치(bipolar)로, 우측 난소는 LigaSure™로 절제하였다. 수술은 three midline portals로 하였으며, 수술시간, Body Condition Score, ovarian pedicle fat과 부작용 등을 체크하였다. 그 결과, 총 수술시간은 평균 24:18 ± 6:36분 이었으며, LigaSure™ (1:24 ± 0:59 분)가 양극 전기 응고 장치(bipolar) (2:16 ± 1:14 분, $p = 0.021$)에 비하여 난소절제에 유의적으로 더 짧은 시간이 걸렸다. BCS와 ovarian pedicle fat은 수술시간에 유의적인 영향을 미치지 않았으며, 부작용으로는 미약한 출혈, 복벽 손상, smoke 발생 등이 있었는데 수술시간에 유의적인 영향을 미치지 않았다. 이러한 결과들은 LigaSure™가 비교적 고가의 수술장비라는 단점이 있음에도 불구하고 복강경을 이용한 고양이의 난소절제술에 유용한 수술적 활용 방법이 될 수 있을 것이라는 것을 보여준다.

주요어 : 고양이, 복강경 난소절제술, LigaSure™, 양극 전기 응고 장치