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Research article

LIGASURE VS. SUTURE LIGATION FOR FELINE OVARIOHYSTERECTOMY: FASTER OVARIAN PEDICLE DISSECTION, LOWER EARLY PAIN, AND ATTENUATED FIBRINOLYTIC ACTIVATION

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Surgical sterilization in cats is commonly performed using conventional suture ligation, but this method is associated with risks of intraoperative bleeding, prolonged operative time, and postoperative pain. LigaSure, a bipolar vessel-sealing device, has been proposed as an alternative that may enhance surgical efficiency and provide more reliable hemostasis. In this randomized study, twenty healthy female cats underwent ovariohysterectomy with either conventional suture ligation (n = 10) or LigaSure (n = 10), and surgical duration, intraoperative bleeding, postoperative pain scores, analgesic requirements, and selected coagulation parameters (antithrombin III, fibrinogen degradation products, and D-dimer) were assessed. The LigaSure group showed a mean reduction of 5.2 minutes (95% CI: 3.1–7.4) in the ovarian dissection stage, less intraoperative bleeding, lower pain scores at 1 and 2 hours, and reduced need for rescue analgesia. Hemodynamic monitoring indicated attenuated nociceptive responses during ovarian manipulation. Coagulation results revealed smaller increases in fibrinogen degradation products and D-dimer levels in the LigaSure group, while antithrombin III decreased in both groups but remained more stable with conventional ligation. Complication rates were similar between groups. Overall, LigaSure was found to offer significant advantages over suture ligation, including shorter operative time, improved hemostasis, and reduced early postoperative pain, suggesting its value as a safe and effective technique to improve welfare outcomes in routine feline neutering procedures.

Keywords: Feline, LigaSure, Ovariohysterectomy, Hemostasis, Pain, Coagula

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INTRODUCTION

Surgical sterilization remains the primary approach for controlling reproduction in female cats, with ovariectomy and ovariohysterectomy (OHE) being the most commonly employed techniques [1,2]. These procedures are not only used for population control but also to prevent serious health conditions such as pyometra and mammary neoplasia [3-5]. Despite their widespread use, OHE and ovariectomy are associated with potential complications including tissue trauma, hemorrhage, organ manipulation, infection, and postoperative pain, which may lead to delayed recovery or mortality [6]. Therefore, minimizing surgical trauma and reducing operative time, postoperative discomfort, and complication rates has become a clinical priority [7].

Traditional open surgical techniques frequently involve significant tissue manipulation and inflammation, which contribute to morbidity and pain priority [6]. In response, minimally invasive alternatives such as laparoscopic procedures have gained popularity, especially in developed countries, due to their benefits of reduced pain, faster return to function, and improved owner satisfaction [8]. From a surgical perspective, optimal sterilization techniques should ensure efficiency, hemostatic reliability, and minimal collateral damage, while avoiding contamination and postoperative complications [9].

Hemostasis during OHE is conventionally achieved using suture ligation, which, while effective, carries risks such as hemorrhage due to knot failure, vascular rupture, or excessive fat in the ovarian pedicle [10,11]. Hemorrhage is one of the most common intraoperative complications associated with open sterilization in both dogs and cats [12]. To address these limitations, vessel-sealing devices like LigaSure have been introduced as alternatives to traditional ligatures. LigaSure applies bipolar radiofrequency energy to denature collagen and elastin, producing a secure seal for vessels up to 7 mm in diameter, typically within seconds [13]. These systems have been reported to reduce operative time, thermal spread, and intraoperative blood loss in both human and veterinary surgeries [14-16], although their higher cost remains a consideration [17,18].

The objective of the present study was to compare the clinical effectiveness of LigaSure with conventional suture ligation during routine ovariohysterectomy in healthy female domestic cats. The primary outcome measures encompassed surgical duration, pain levels, intraoperative complications, and a selection of coagulation parameters. The hypothesis is that LigaSure may offer advantages over conventional ligation with regard to surgical efficiency, pain reduction and hemostatic stability.

MATERIALS AND METHODS

All procedures conducted on animals adhered to the guidelines the regulations outlined in the European Community Council Directive of 24 November 1986. Ethical approval for these procedures was obtained from the X University Local Board of

Ethics Committee for Animal Experiments (Decision no: 22, X, X). The research findings are presented in accordance with Consort guidelines for randomized, clinical trials.

Animals and experimental groups

This study involved a total of 20 adult female domestic cats, aged 12 to 24 months and weighing between 2 and 4 kg, presented to the X University Faculty of Veterinary Medicine Animal Hospital by their owners for elective sterilization. Prior to study commencement, comprehensive medical evaluations were performed, including physical examination, complete blood count, and serum biochemistry profiles, to assess the overall health status of the cats. Inclusion criteria required the cats to be classified as ASA physical status grade I according to the American Society of Anesthesiologists classification system. Exclusion criteria included body weight below 1 kg, age over 3 years, cardiac arrhythmias, pregnancy or lactation, and a body condition score outside the range of 3 to 7 (on a 9-point scale). Additionally, cats with anemia (hematocrit $< 25\%$), hypoproteinemia (total protein < 59 g/L), baseline pain scores ≥ 3, clinical signs of systemic disease, or exhibiting shyness or fearfulness were excluded from the study. The cats were admitted to the hospital at least 24 hours prior to surgery to allow acclimatization and observer familiarization. They were housed individually in adjacent cages equipped with water and food bowls and litter boxes. Written informed consent was obtained from all owners.

The study population consisted of clinically healthy female cats, which were randomly allocated into two groups based on the hemostatic technique employed: the conventional suture ligation (CSL) group ($n = 10$) and the LigaSure vessel sealing (LVS) group ($n = 10$).

Anesthetic management

Both surgical procedures were performed following an identical anesthesia protocol. Premedication consisted of intramuscular administration of medetomidine (20 µg/kg; Domitor®, Zoetis Orion Corp, Finland) and butorphanol (0.2 mg/kg; Butomidor 10 mg/mL, Richter Pharma, Austria). After a 15-minute waiting period, the skin over the left cephalic vein was aseptically prepared to place a 22-gauge catheter, through which lactated Ringer's solution was infused at 5 mL/kg/h until extubation. Anesthesia induction was achieved via intravenous propofol (Propofol 1%, Fresenius, Istanbul, Turkey) at a dose sufficient to enable endotracheal intubation with an appropriately sized cuff. General anesthesia was maintained using 2% Isoflurane (Isoflurane, Piramal Critical Care Inc., USA) in 100% oxygen throughout the operation. Spontaneous respiration was preserved during anesthesia. The same anesthetist managed all anesthetic procedures. Animals were placed in dorsal recumbency on a heated stainless steel surgical table covered with cotton surgical drapes; the table heating was activated whenever rectal temperature dropped below 37 °C.

Surgical technique

All surgical procedures were performed by the same surgical team. Animals were positioned in lateral recumbency on a heated stainless-steel surgical table covered with sterile surgical drapes for the lateral flank approach. Table heating was activated whenever rectal temperature fell below 37 °C. The surgical site was shaved and prepared using standard aseptic and antiseptic techniques. A vertical skin incision approximately 2 cm in length was made at a point equidistant from the last rib, the tuber coxae, and the vertebral column. Following removal of both uterine horns, ovaries, and oviducts, hemostasis was achieved using different techniques depending on the group: in the CSL group, 2-0 absorbable poliglecaprone 25 sutures (Monocryl®, Ethicon, Johnson & Johnson, Pomezia, Italy) were used, whereas in the LVS group, a LigaSure™ Small Jaw Open Sealer/Divider (LF1212A, Medtronic, Minneapolis, MN, USA) was utilized.

In the CSL group, after transection of the ovarian ligaments, each ovarian pedicle was ligated using two surgeon's knots, and then transected. The broad ligament was manually dissected along the uterine horns down to the cervix, and the uterine vessels were ligated with a single surgeon's knot. In the LVS group, the vessel-sealing device simultaneously sealed and transected the ovarian pedicles, broad ligament, and uterine vessels. The ovaries and the bifurcation region were grasped with the device's jaws, sealed by activating the device, and transected by pulling the trigger. Following excision, the surgical site was inspected for hemorrhage and the abdomen was closed routinely. All cats were monitored in the critical care unit and followed until discharge.

Surgical time

The total surgical time was defined as the interval between the initial incision and the completion of intradermal suturing. These steps will be performed in a consistent manner for each cat by a single individual.

Intraoperative monitoring

Vital variables were monitored using a multi-parameter device (Comen C80-V, Shenzhen, China). Heart rate (HR) was obtained from electrocardiographic leads attached to the limbs. Respiratory frequency (f_R) was assessed manually by the anesthesiologist by observing thoracic movements at each predefined time point. Peripheral capillary oxygen saturation (SpO_2) was measured with a clip probe placed on the tongue. Mean arterial blood pressure (MAP), systolic arterial blood pressure (SAP), and diastolic arterial blood pressure (DAP) were measured non-invasively using a cuff sized at 40% of the right forelimb circumference and placed proximal to the carpus. The fraction of expired carbon dioxide ($EtCO_2$) was monitored using a nasal tube inserted into the nostril and connected to the capnograph. Rectal temperature (RT) was measured using a rectal probe inserted to a depth of 5 cm. All vital variables were recorded at baseline (T_0), T_1: After skin incision, T_2: After left ovary manipulation, T_3: After left ovary resection, T_4: After right ovary manipulation, T_5: After right ovary resection, T_6:

After clamping of the cervix, T_7: After abdominal muscle closure by the same person who was unaware of the group allocation.

Postoperative evaluation

In accordance with previous studies [19], postoperative rescue analgesia was provided with IM 0.1 mg/kg morphine when MCPS scores reached or exceeded 6. Furthermore, the number of cats that require rescue analgesia and the number of morphine doses administered were documented. In the event that an animal did not require rescue analgesia during the 12-hour assessment period, 0.2 mg/kg meloxicam (Bavet Meloxicam, Bavet, Turkey) was administered subcutaneously. Following the surgical procedures, the animals were administered amoxicillin with clavulanic acid (20 mg/kg, IM) for a period of seven days. The general condition and wound line of the cats were monitored for seven days following surgery.

Postoperative pain evaluation

Postoperative complications were defined and recorded as such for a period of two months following abdominal Postoperative Pain Assessment The assessment of postoperative pain will be conducted 24 hours prior to extubation (T_b) and immediately after extubation (T_0), and at 1 (T_{1h}), 2 (T_{2h}), 4 (T_{4h}), 8 (T_{8h}), 12 (T_{12h}), and 24 (T_{24h}) hours post-extubation. This assessment was performed by a blinded individual who was unaware of the group allocation of the animals. The UNESP-Botucatu multidimensional composite pain scale (MCPS) was employed to assess pain. This scale ranges from 0 (no pain) to 30 (maximum pain) and evaluates pain across three dimensions: pain expression, psychomotor changes, and physiological variables [20]. To evaluate the scores, a preliminary assessment of each cat was conducted within the cage for a period of one minute. Subsequently, the cat was permitted to move, and its responses and activity were evaluated. Subsequently, the abdomen and the region surrounding the abdominal incision were palpated gently with two to three fingers, and the cat's response was evaluated and documented. To evaluate the appetite of the animal in the immediate postoperative period, a small quantity of wet food was administered immediately following the animal's emergence from anesthesia.

Postoperative pain assessments were performed by the same veterinarian, who was blinded to group allocation and trained in the use of the UNESP-Botucatu multidimensional composite pain scale before the beginning of the study. Pain parameters were recorded on standardized monitoring forms at each predefined postoperative time point.

Assessment of intra – and postoperative complications

Complications associated with the surgical process are classified under two main headings: intraoperative and postoperative. Intraoperative complications are defined as all adverse events that occur between the initial skin incision and the closure of the skin. Complications evaluated in this context include uncontrollable bleeding, tissue integrity disruption, anesthetic-related physiological instabilities, and other sudden developments related to the surgical site. All surgical procedures were performed by the same experienced surgeon in each case, ensuring standardization of practice. Postoperative complications are defined as adverse events that occur during the two-month follow-up period after abdominal surgery and are considered to be directly related to the initial surgical intervention. The aforementioned complications encompass wound healing disorders (e.g. suture reaction, seroma, swelling or bruising at the incision site, incisional hernia), signs of infection, and discharge from the incision line. Each case was subjected to clinical evaluation at regular intervals, and complications were documented in accordance with the established criteria.

Evaluation of coagulation markers

D-dimer levels were measured using an enzyme-linked immunosorbent assay (ELISA) based on antigen-antibody binding. Similarly, fibrinogen concentration was quantified by an ELISA method employing antigen-antibody interactions. Antithrombin III activity was also determined via ELISA utilizing the same antigen-antibody binding principle. All assays were performed according to the manufacturers' protocols at specified preoperative and postoperative time points to evaluate changes in coagulation and fibrinolytic status during the study period.

Statistical analysis

Sample size estimation was based on the primary biochemical outcome, antithrombin III concentration G*Power software (version 3.1.9.6, Heinrich-Heine University, Germany). A minimum detectable difference of 10% between time points was considered clinically and biologically significant, as defined a priori based on the anticipated changes observed in preliminary data from this study. Using the standard deviation derived from pre-study measurements and assuming a two-tailed α of 0.05 and power ($1–\beta$) of 0.90, the analysis indicated that a minimum of 10 animals per group would be required to detect a statistically significant difference. This sample size was deemed sufficient to ensure adequate power for detecting relevant changes in antithrombin III levels across time and between experimental groups.

All statistical analyses were performed using SPSS (version 25.0, IBM Corp., Armonk, NY, USA). Descriptive statistics for all continuous variables were expressed as mean ± standard deviation (SD). The normality of data distribution was evaluated using the Shapiro–Wilk test. All data were tested for normality using the Shapiro–Wilk test. Repeated measures ANOVA was used to assess within-group changes over time for both physiological (MAP, SAP, DAP, HR, f_R, SpO_2, RT) and biochemical parameters (antithrombin III, fibrinogen degradation products, and D-dimer), followed by Tukey's post-hoc test for multiple comparisons. Between-group differences at each individual time point were analyzed using independent samples t-tests. A p-value < 0.05 was considered statistically significant.

RESULTS

There was no statistically significant difference in total surgical time between the CSL group (15.0 ± 4.9 minutes) and the LVS group (13.1 ± 3.8 minutes, p = 0.10). However, the duration required solely for the OVH procedure was significantly shorter in the LVS group (4.2 ± 0.9 minutes) compared to the CSL group (6.3 ± 1.7 minutes, p = 0.005).

Throughout the surgical procedure, physiological parameters remained generally stable in both groups. HR, fR and SpO_2 did not show statistically significant differences between the CSL and LVS groups at any time point (p > 0.05).

Nevertheless, significant differences were observed between groups in certain hemodynamic parameters, particularly during the ovarian manipulation stages. At time point T_4 (after right ovary manipulation), MAP (120 ± 17.6 mmHg), SAP (141 ± 13.3 mmHg), and DAP (106 ± 16.9 mmHg) in the CSL group were significantly higher than those in the LVS group (99 ± 19.4, 124 ± 15.1, and 86 ± 19.7 mmHg, respectively; p < 0.05, Table 1). Although these parameters were also lower in the LVS group at T_3 (after left ovary resection), the differences were not statistically significant. Rectal temperature values remained similar between the groups at all time points, with no statistically significant differences observed (p > 0.05). The lowest average temperatures were recorded at T_5 (after right ovary resection), though the reduction did not reach statistical significance (LVS: 36.8 ± 0.7°C; CSL: 37.3 ± 0.9°C).

Both groups exhibited a gradual decrease in pain scores during the first 24 hours postoperatively. Notably, at one hour after extubation (T1h), the MCPS scores in the LVS group were significantly lower than those in the CSL group (p = 0.029). At two hours after extubation (T2h), the LVS group also showed a faster return to baseline pain levels. However, at subsequent time points (T12h and T24h), no significant differences were observed between the groups (p > 0.05). Additionally, the requirement for rescue analgesia was higher in the CSL group compared to the LVS group (3 vs. 1), although the number of animals receiving morphine within the 24-hour period did not differ significantly between groups (p = 0.131).

All procedures were completed successfully. Among the 20 female cats included in the study, perioperative complications were observed in two cases. The incidence of intraoperative bleeding was significantly higher in the CSL group compared to the LVS group (p < 0.05). In two cats within the CSL group, intraoperative hemorrhage occurred due to loosening of the ligature on the ovarian pedicle, necessitating removal of the suspensory ligament and application of an additional ligature.

Table 1. Hemodynamic, respiratory, and thermoregulatory parameters during different time points of surgical manipulation in ligation and LigaSure groups.

Variables	Group	Time of surgical manipulation						
		T1	T2	T3	T4	T5	T6	T7
HR (bpm)	Ligation	101 ± 22.9	121 ± 35.4	119 ± 27.5	133 ± 19.1	121 ± 22.6	124 ± 25.1	113 ± 22
	LigaSure	109 ± 18.3	118 ± 17.4	130 ± 23.5	130 ± 17.2	127 ± 20.1	136 ± 26.3	122 ± 23.3
fR (breath/min)	Ligation	31 ± 7.6	29 ± 5.5	28 ± 6.6	30 ± 4.5	30 ± 5.8	29 ± 8.8	26 ± 6
	LigaSure	28 ± 8.9	29 ± 7.4	29 ± 7.2	30 ± 7.9	32 ± 9.9	31 ± 9.3	27 ± 6.9
SpO2 (%)	Ligation	97 ± 4	98 ± 2	97 ± 3	96 ± 3	97 ± 3	97 ± 3	96 ± 5
	LigaSure	97 ± 3	98 ± 2	98 ± 2	98 ± 2	98 ± 2	97 ± 3	97 ± 4
MAP (mmHg)	Ligation	105 ± 21.7	112 ± 21.7	103 ± 15.5	120 ± 17.6*	103 ± 14	106 ± 20.8	87 ± 24.5
	LigaSure	97 ± 25.4	107 ± 27	104 ± 24.6	99 ± 19.4*	95 ± 31.7	101 ± 21.6	86 ± 40.2
SAP (mmHg)	Ligation	129 ± 14	132 ± 17.9	125 ± 10.2	141 ± 13.3*	127 ± 14.7	128 ± 23.5	111 ± 21.6
	LigaSure	118 ± 20.9	135 ± 23.8	132 ± 19.6	124 ± 15.1*	119 ± 30	125 ± 19.8	120 ± 28.8
DAP (mmHg)	Ligation	97 ± 13.3	98 ± 13.9	90 ± 18.1	106 ± 16.9*	84 ± 20.4	93 ± 20.8	74 ± 22.9
	LigaSure	86 ± 23.6	93 ± 26.1	88 ± 23.1	86 ± 19.7*	81 ± 31	80 ± 24.5	77 ± 33.1
RT °C	Ligation	37.7 ± 1.1	37.3 ± 0.9	37.3 ± 0.9	36.8 ± 0.7	37.3 ± 0.7	37.7 ± 0.8	37.1 ± 0.8
	LigaSure	37.6 ± 0.9	37.2 ± 0.5	37.2 ± 0.5	37.2 ± 0.6	37.2 ± 0.6	37.2 ± 0.8	37.2 ± 0.6

$\mathbf{T_1}$: After skin incision, $\mathbf{T_2}$: After left ovary manipulation, $\mathbf{T_3}$: After left ovary resection, $\mathbf{T_4}$: After right ovary manipulation, $\mathbf{T_5}$: After right ovary resection, $\mathbf{T_6}$: After clamping of the cervix, $\mathbf{T_7}$: After abdominal muscle closure. Data are expressed as mean ± standard deviation. *****Indicate significant difference between groups at the same time point ($p < 0.05$).

There was no statistically significant difference in overall complication rates between the LVS and CSL groups ($p > 0.05$). None of the defined postoperative complications were observed in any of the cats. These complications were not detected in either the CSL or LVS group.

In addition to hemodynamic parameters, biochemical markers related to coagulation were also evaluated. For antithrombin III, a statistically significant difference was found between the ligation and LVS groups at the Tpre time point ($p = 0.033$); however, no significant differences were detected at Tpost0 and Tpost24 ($p > 0.05$). In the LVS group, the Tpre value was significantly different from both Tpost0 ($p = 0.0008$) and Tpost24 ($p = 0.0004$), while in the LVS group, no significant differences were observed between Tpre and the subsequent time points ($p > 0.05$, Table 2).

Regarding fibrin degradation products (FDPs), there were no significant differences between groups at the Tpre and Tpost24 time points ($p = 0.168$ and $p = 0.917$, respectively), but a statistically significant difference was noted at Tpost0 ($p = 0.034$). In the CSL group, Tpost0 ($p = 0.004$) and Tpost24 ($p = 0.022$) values differed significantly from Tpre, while in the LVS group, no significant differences were observed between Tpre and other time points ($p > 0.05$, Table 2). For D-dimer levels, significant differences were observed between groups at the Tpre ($p = 0.044$) and Tpost24 ($p = 0.029$) time points, although no significant difference was detected at Tpost0 ($p = 0.072$). In intragroup comparisons, no statistically significant differences were found between Tpre and the subsequent time points in either the ligation or LVS groups ($p > 0.05$, Table 2).

Table 2. Antithrombin III, fibrinogen degradation products, and D-dimer levels measured at different time points in the ligation and LigaSure groups.

Variables	Group	Time of surgical manipulation		
		Tpre	**Tpost0**	**Tpost24**
Antithrombin III (ng/ml)	Ligation	313 ± 62*	288 ± 52	317 ± 34
	LigaSure	367 ± 56*	303 ± 58†	308 ± 28†
Fibrinogen Degradation Product (pg/ml)	Ligation	533 ± 70	620 ± 106*†	495 ± 62†
	LigaSure	498 ± 59	534 ± 80*	497 ± 43
D-Dimer (ng/ml)	Ligation	758 ± 119*	721 ± 135	809 ± 49*†
	LigaSure	847 ± 85*	815 ± 111	871 ± 82*†

T_{pre}: immediately before surgery, T_{post}: Immediately after last skin suture, T_{post24}: 24 hours after last skin suture. Data are expressed as mean ± standard deviation. *Indicate a significant difference between groups at the same time point ($p < 0.05$). †Indicate a significant difference from T_{pre} within the same group ($p < 0.05$).

DISCUSSION

The present study demonstrated that OHE performed using the LigaSure system significantly reduced surgical time and intraoperative pain scores compared to the conventional suture ligation technique. Although total surgical duration was not statistically different between the groups, the time from identification of the first ovary to uterine removal was significantly shorter in the LVS group. LigaSure effectively seals vessels 1–7 mm in diameter using advanced bipolar electrocautery that denatures collagen and elastin, forming a permanent hemostatic seal. The system includes a generator and forceps that deliver mechanical and electrical energy, guided by a feedback-controlled loop that adjusts the energy based on tissue impedance and temperature. This process, lasting 1–6 seconds, facilitates a rapid and safe vessel occlusion without the need for dissection, thereby reducing surgical time, limiting anesthetic exposure, and enhancing recovery [21-24].

OHE procedures involve manipulation of highly innervated ovarian structures, which may elicit nociceptive and autonomic responses, particularly during traction and clamping of the ovarian pedicle and suspensory ligament [25,26]. In the present study, MAP and DAP values were lower during ovarian manipulation in the LVS group than in the CSL group. These findings may indicate an attenuated autonomic/hemodynamic response to surgical stimulation in cats treated with LigaSure. This interpretation is consistent with previous reports suggesting that less traumatic or minimally invasive surgical techniques may reduce intraoperative nociceptive responses and early postoperative pain [27–29]. However, oscillometric non-invasive blood pressure measurement should not be interpreted as a direct measure of intraoperative pain, because it may be influenced by cuff size, cuff placement, limb position relative to the right atrium, peripheral perfusion, anesthetic depth, and patient-related factors. Therefore, the observed MAP and DAP differences should be considered only as indirect indicators of intraoperative autonomic response rather than definitive evidence of reduced pain. The lower postoperative MCPS scores observed during the early recovery period provide additional clinically relevant support for reduced postoperative discomfort in the LVS group. Future studies using invasive arterial blood pressure monitoring and objective nociception indices would provide more precise assessment of intraoperative nociceptive responses.

Consistent with previous findings, postoperative pain scores at 1 hour were significantly lower in the LVS group, although no differences were noted at later time points. This suggests that LigaSure may reduce acute postoperative pain following OHE in cats [30,31]. Other studies have similarly reported reduced pain scores when vessel-sealing devices are used in dogs and cats, while traditional suturing increases discomfort [32]. However, divergent results in rabbits—where early postoperative pain scores were initially higher—highlight species-specific variability and challenges in pain assessment, particularly in animals like lop-eared rabbits using the Rabbit

Grimace Scale [33]. Overall, the LigaSure system appears to induce less acute pain and potentially improves early postoperative comfort.

The lack of statistically significant differences in overall complication rates between groups indicates that both methods were safe when performed under appropriate surgical and aseptic conditions [34]. Although intraoperative bleeding was observed more frequently in the CSL group in the present study, this finding should not be interpreted as evidence that conventional ligation is inherently unsafe or technically challenging. Secure suture ligation of the ovarian pedicle is a well-established and reliable technique when performed by an experienced surgeon. The bleeding episodes observed in the CSL group may instead reflect case-specific factors, such as ovarian pedicle handling, tissue tension, or ligature security during manipulation. Therefore, this result should be interpreted cautiously and confirmed in larger studies. The CSL group exhibited a more pronounced increase in fibrinogen degradation products (FDP), which may suggest a greater perioperative fibrinolytic response. Conversely, the LVS group showed a lower perioperative increase in FDP levels, suggesting that vessel sealing may be associated with reduced tissue handling and fibrinolytic activation. However, because baseline differences were present for some coagulation markers, particularly antithrombin III and D-dimer, these biochemical findings should be interpreted with caution [35–38].

Perioperative preventive analgesia is essential for controlling postoperative pain in cats undergoing ovariohysterectomy. Rabbani et al. reported that a gabapentin–tramadol multimodal regimen resulted in lower IVAS and composite pain scores, higher mechanical nociceptive thresholds, and lower serum cortisol concentrations compared with meloxicam–tramadol or tramadol-based regimens in cats undergoing OHE. These findings highlight the importance of multimodal analgesia in reducing postoperative pain and stress responses. Therefore, although the present study focused on the surgical hemostatic technique, the early postoperative pain reduction observed in the LVS group should be interpreted alongside the broader role of adequate perioperative analgesic management. LigaSure may reduce tissue handling and early discomfort, but it should complement rather than replace preventive multimodal analgesia [39].

Despite promising outcomes, this study has several limitations. The relatively small sample size may limit the statistical power to detect differences in rare complications or delayed pain responses. Additionally, pain assessment relied on hemodynamic and behavioral parameters, which can be subjective in animals due to the absence of objective nociceptive biomarkers. The surgeries were performed under controlled conditions by experienced surgeons, which may not fully reflect clinical variability. Moreover, the study population was homogeneous in terms of health status, age, and breed, potentially limiting generalizability. The lack of long-term follow-up also precluded evaluation of chronic pain or adhesion formation. Future studies with larger, more diverse populations and long-term monitoring would improve external validity.

CONCLUSION

In conclusion, this study supports the LigaSure system as a viable and potentially superior alternative to traditional ligatures in feline open OHE procedures. LigaSure significantly shortened operative time, reduced intraoperative bleeding, and demonstrated advantages in minimizing pain and coagulation activation. Its ease of use, limited training requirements, and enhanced safety profile make it suitable for routine and high-risk procedures alike. Although initial investment costs are higher, benefits such as reduced suture use, minimized foreign body reactions, and lower complication risks justify its clinical value. Continued research is necessary to explore its long-term advantages, but current findings indicate that LigaSure improves surgical efficiency and animal welfare, while reducing stress for veterinary surgeons [40-43].

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Authors' contributions

DTO conceived and designed the study, coordinated the research process, contributed to the literature review, drafted the manuscript, critically revised it for important intellectual content, and supervised the preparation of the final manuscript. SÖZ, ŞEA, ED, and ŞD carried out the laboratory analyses, including the molecular/genetic and biochemical components of the study, and contributed to the interpretation of the related findings. SO performed the statistical analysis and contributed to the interpretation of the data. AYÇ, ŞA, VT, AGB, BB, and ŞE contributed to the literature search, collection and evaluation of relevant scientific sources, and preparation of the manuscript background. All authors contributed to the critical revision of the manuscript, read and approved the final version, and agree to be accountable for all aspects of the work.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Statement of Informed Consent

The owner understood procedure and agrees that results related to investigation or treatment of their companion animals, could be published in Scientific Journal Acta Veterinaria-Beograd.

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LIGASURE U POREĐENJU SA LIGATUROM PRI OVARIOHISTEREKTOMIJI MAČAKA: BRŽA DISEKCIJA OVARIJALNOG PEDIKLA, NIŽI INTENZITET RANOG POSTOPERATIVNOG BOLA I REDUKOVANA FIBRINOLITIČKA AKTIVACIJA

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Sterilizacija mačaka se najčešće obavlja konvencionalnom ligaturom šava, ali ovaj metod je povezan sa rizikom od intraoperativnog krvarenja, produženog trajanja operacije i postoperativnog bola. LigaSure, bipolarni uređaj za zatvaranje krvnih sudova, predložen je kao alternativa koja može poboljšati hiruršku efikasnost i obezbediti pouzdaniju hemostazu. U ovoj randomizovanoj studiji, dvadeset zdravih ženki mačaka podvrgnuto je ovariohisterektomiji sa konvencionalnom ligaturom šava (n = 10) ili korišćenjem LigaSure uređaja (n = 10), a procenjeni su trajanje operacije, intraoperativno krvarenje, postoperativni bol, potreba za analgeticima i odabrani parametri koagulacije (antitrombin III, produkti degradacije fibrinogena i D-dimer). Grupa tretirana LigaSure uređajem pokazala je prosečno skraćenje vremena disekcije jajnika za 5,2 minuta (95% CI: 3,1–7,4), manje intraoperativnog krvarenja, niže skorove bola na 1. i 2. satu i manju potrebu za dodatnom analgezijom. Hemodinamski nadzor ukazao je na slabiji nociceptivni odgovor tokom manipulacije jajnicima. Rezultati koagulacije pokazali su manji porast produkata degradacije fibrinogena i nivoa D-dimera u grupi LigaSure, dok je antitrombin III opao u obe grupe, ali je ostao stabilniji kod konvencionalne ligature. Stopa komplikacija bila je slična u obe grupe. Sveukupno, utvrđeno je da LigaSure nudi značajne prednosti u odnosu na ligaturu šava, uključujući kraće trajanje operacije, poboljšanu hemostazu i smanjen rani postoperativni bol, što ukazuje na njegovu vrednost kao bezbedne i efikasne tehnike za poboljšanje dobrobiti u rutinskim postupcima sterilizacije mačaka.