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RESEARCH ARTICLE

Comparison of Median and Flank Laparotomy Approaches of Ovariohysterectomy Surgery in Cats

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ABSTRACT

The study aimed to compare the operative and postoperative effects of flank laparotomy and traditional median approach in ovariohysterectomy in healthy female cats. Cats divided into median (MOHE, n=17) and left flank approach (FOHE, n=15) groups. In the intraoperative period, surgery duration, incision length, intraoperative complications and skin suture numbers were monitored. Various variables (aggression, agitation, onset of voluntary food and water intake, overall recovery from anesthesia effect, end of the stumble waking, voluntarily using the litter box, going to food bowl behavior) were monitored to monitor recovery in the early-postoperative period. On the 3rd postoperative day, pain/tenderness, erythema, edema, discharge in the wound and the cats' licking behavior on the wound were monitored. To evaluate the surgical stress response, Interleukin-6 concentration was measured in blood serum at 0 and 2 hours post-surgery. In order to evaluate muscle damage/recovery between groups, Lactate dehydrogenase, Aspartate transaminase and Creatinine kinase enzyme levels were determined in blood serum on day 0, postoperative day 3 and day 10. The incision length in the FOHE group was significantly shorter than the MOHE group ($P<0.05$). The change in Creatinine kinase between the sampling days of each group was significantly different ($P<0.05$). The difference between the other parameters monitored was not significant in the groups ($P>0.05$). In conclusion, lateral laparotomy and median ovariohysterectomy did not differ in terms of operative complications, surgical stress response, postoperative recovery, and complications. Since the methods do not have superiority over each other, it was concluded that the approach to be chosen in elective sterilization according to the vet's preference.

Keywords: Intraoperative Complication, Queen, Spaying, Surgery

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Kedilerde Medyan ve Flank Laparotomik Ovaryohisterektomi Operasyonlarının Karşılaştırılması

ÖZ

Çalışma, sağlıklı dişi kedilerde ovaryohisterektomide flank laparotomik ve geleneksel medyan yaklaşımın operatif ve postoperatif etkilerini karşılaştırmayı amaçladı. Kediler medyan (MOHE, n=17) ve sol flank yaklaşım (FOHE, n=15) gruplarına ayrıldı. İntraoperatif dönemde ameliyat süresi, kesi uzunluğu, intraoperatif komplikasyonlar ve cilt sütür sayıları takip edildi. Ameliyat sonrası erken dönemde iyileşmeyi izlemek için çeşitli değişkenler (saldırganlık, ajitasyon, gönüllü yiyecek ve su alımının başlangıcı, tam uyanma süresi, uygun yürüme süresi, yiyecek ve çöp kutusuna gitme davranışı) izlendi. Ameliyat sonrası 3. günde yarada ağrı/hassasiyet, kızarıklık, ödem, akıntı ve kedilerin yarayı yalama davranışları izlendi. Cerrahi stres yanıtını değerlendirmek için ameliyattan 0 ve 2 saat sonra kan serumunda İnterlöykin-6 seviyesi ölçüldü. Cerrahi yaklaşımlar arasında kas hasarının ve iyileşmesinin değerlendirilmesi amacıyla 0. gün, postoperatif 3. ve 10. gün kan serumlarında Laktat dehidrogenaz, Aspartat transaminaz ve Kreatinin kinaz enzim seviyeleri belirlendi. FOHE grubundaki insizyon uzunluğu MOHE grubuna göre anlamlı derecede kısaydı ($P<0.05$). Her grubun numune alma günleri arasındaki kreatinin kinaz değişimi anlamlı derecede farklıydı ($P<0.05$). Gruplarda izlenen diğer parametreler arasındaki fark anlamlı değildi ($P>0.05$). Sonuç olarak, lateral laparotomi ve medyan ovariohisterektomi ameliyat komplikasyonları, cerrahi stres yanıtı, ameliyat sonrası iyileşme ve komplikasyonlar açısından farklılık göstermedi. Yöntemlerin birbirine üstünlüğü bulunmadığından elektif kısırlaştırmada seçilecek yaklaşımın veterinerin tercihine göre şekillenebileceği kanısına varıldı.

Anahtar kelimeler: Ameliyat, Dişi Kedi, Kısırlaştırma, Postopetarif Komplikasyon

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INTRODUCTION

Cats can give birth to an average of 4 kittens (Kustritz, 2006), complete 2-3 pregnancies during a breeding season (Park, 2015), unwanted estrus symptoms are frequent and intense, and the incidence of accidents increases if they are not sterilized (Gagnon et al., 2020). For these reasons, owners' request for sterilization is the most common reason for coming to the clinic. In Turkey, ovariohysterectomy (OHE) is used as a routine surgical method for spaying female cats and dogs, and basically three different approaches are used: ventral midline open surgical method, laparoscopic method and flank approach. The right or left flank approach is recommended to be applied in wild cats in cases where the mammary glands are overdeveloped and postoperative care and observation are not possible (McGrath et al., 2004; Reece, 2018). Nevertheless, OHE with the flank approach is also widely applied for routine spaying purposes.

Creatinine kinase (CK) has been used mainly as a marker of skeletal muscle damage (Aktaş et al., 1993). Muscle injury causes the release of intracellular enzymes and subsequent increase in CK activity in serum (Shelton, 2010). While CK activity is markedly increased in necrotic (Wells et al., 2009) and inflammatory (Evans et al., 2004) myopathies, it is commonly normal or slightly increased in non-inflammatory muscle diseases. However, its diagnostic specificity in minor extrinsic muscle damage is low due to the short half-life of serum CK activity, approximately 2 hours. It has been stated that following intramuscular drug injections, CK activity reaches its highest level at the 4th hour, shows a consistent increase in the first 24 hours, but decreases to the initial level on the 3rd day. On the other hand, CK that increases steadily or is persistently high may indicate the severity of muscle lesions Although it varies depending on the anesthetic used and the type of surgery, it has been reported that there is an increase in CK activity in serum within 6-12 hours after surgical interventions (Shelton, 2010).

Aspartate aminotransferase (AST), another serum enzyme that reflects muscle damage, is found in all cells and is used as a diagnostic enzyme for liver and muscle diseases due to its high activity in tissues. High CK along with high AST in serum analysis suggests that it is of muscle origin. Its serum concentration increases in case of hereditary myopathy, malignant hyperthermia, hypothyroidism, vitamin E-selenium deficiency, prolonged decubitus, intramuscular injections, surgery. Values of AST have been reported to increase between 12 and 24 hours after muscle damage and remain elevated for 1 or 2 weeks (Alves et al., 2009).

The other serum enzyme associated with muscle damage is Lactate dehydrogenase (LDH), a cytoplasmic isoenzyme that catalyzes the conversion of lactic acid and pyruvic acid (Nagy et al., 2013).

Because LDH is an enzyme found in all organ systems, its serum activity is abnormal in many diseases. LDH is a cell death marker released from cells as a result of necrosis or apoptosis (Johnson-Davis and McMillin, 2010). Increased levels are observed in heart, liver, skeletal muscle and kidney diseases, as well as in various hematological and neoplastic disorders. Increased LDH levels have also been reported in skeletal muscle disorders and some leukemias (Johnson-Davis and McMillin, 2010).

Considerable variation in serum values of various cytokines can be observed in studies comparing surgical methods or different anesthesia protocols. After a surgical procedure, the immune system may be activated or suppressed depending on the type of stress. This response is mediated by cytokines or interleukins (IL), which are low molecular weight immunological proteins produced by the activity of leukocytes, fibroblasts, and endothelial cells (Alazawi et al., 2016). Serum concentrations of proinflammatory cytokines increase within a few hours after the first stimulation and rapidly reach target organs and tissues (Eckersall and Bell, 2010). The pro-inflammatory response is mediated by numerous cytokines, including IL-1, IL-6 and tumor necrosis factor-alpha (TNF-α) (Palmer et al., 2019). It has been reported that IL-6 concentration changes significantly at the 2nd hour after midline OHE in cats (Marinov et al. 2018).

The aim of this study were to clinical and hematological compare the intraoperative and postoperative complications, muscle damage and healing, suture complications, surgical stress response and recovery period of median line and flank laparotomic OHE surgeries, which are commonly used for OHE in cats. Thus, it was aimed to reveal possible differences by making a comprehensive comparison between two frequently applied surgical methods.

MATERIALS and METHODS

The study was conducted with the approval of the Hatay Mustafa Kemal University Local Ethics Committee on Animal Experimentations decision (18/08/2021, no: 2021/05-02).

Study Population

Study animal consisted of female cats that were brought to Hatay Mustafa Kemal University Veterinary Health Practice and Research Hospital with a request for spaying. A total of 32 cats requesting spaying surgery were randomly allocated

into two groups: median OHE (MOHE, n=17) and left flank approach (FOHE, n=15).

Preoperative Interventions and Anesthesia Protocol

Age (months), breed and body weight of the cats were noted before the surgery. Regardless of the surgical method to be applied, cats were premedicated with subcutaneous atropine (Atropin 0.2%, Vetaş ®, Turkey) at a dose of 0.045 mg/kg, and 10 minutes later with intramuscular xylazine (Basilazin 2%, Bavet®, Turkey) at a dose of 2 mg/kg. Then, cats were intubated orotracheally with appropriate endotracheal tubes (no: 3-4). Anesthesia was maintained with isoflurane (1%, Isoflurane, Piramal Critical Care Inc., USA) in oxygen throughout the surgery. Isoflurane dose was 4-5% initial the anesthesia, and continued with 2-3% as the anesthesia deepened. The surgical area was shaved in accordance with the surgical approaches and aseptically prepared for surgery with povidone-iodine solution.

Surgical Methods

In the left flank approach, a skin incision was made by dissecting the skin with tissue scissors from the midpoint of the area between the tuber coxa-last rib-columna vertebralis in the left fossa paralumbalis region. Abdominal muscles and peritoneum were passed through blunt dissection with curved hemostatic forceps, and reached the abdominal cavity. A three-headed retractor (tracheostomy retractor) was used to observe the abdominal cavity clearly. The ovary was reached by observing and removing either the left ovary or the left horn. The suspensory ligament was ligated (PGA, USP: 2/0, Katsan, Turkey) over the left ovary, was dissected, and removed. Subsequently, the left horn was palpated up to the bifurcation area and the right horn was revealed. The right horn was palpated up to right ovary, and the ovary was removed as described for the left ovary. The uterus was exenterated by ligating the cervix from the bifurcation area as close as possible to the uterus. Passive ligatures were used for hemostasis during tissue incisions. The abdominal cavity was closed with the reverdin suture (muscles and peritoneum together and the subcutaneous connective tissue separate). Simple interrupted sutures placed to skin by absorbable suture material (PGA, USP:2/0, Katsan, Turkey).

In the median approach, the skin was incised with a scalpel, starting approximately 3 cm below the belly button and ending 2-3 cm in front of the pubic bone. The muscles were incised from the midline. If the peritoneum was not attached to the abdominal muscles, it was further incised and the abdominal cavity was reached. Any of the uterine horns were captured and the ovaries were subsequently revealed. The ovary was pulled out and the ligamentum suspensorium was ligated from the ovary. The same procedure was applied to the ipsilateral ovary. After the ovaries were dissected, the uterus was ligated and dissected from the junction of the corpus uteri and the cervix uteri. The surgery was completed by closing the peritoneum, abdominal muscles and skin with the method and suture material described in the left flank approach.

Supportive Treatments and Postoperative Care

All cats received intravenous (iv) isotonic saline solution (0.9% NaCl, 50 ml/kg/day, once), iv cefazolin sodium (Eqizolin 1gr, im/iv, 20 mg/kg, once) and meloxicam (Bavet meloxicam, 0.3 ml/5 kg, SC, once) during the intraoperative period. Surgical wounds were covered with dressing bandages. After surgery, all cats were kept under observation in the intensive care unit for 3 hours. In order to prevent possible aspiration in the early postoperative period, a 10-12 hour food and water restriction was recommended for cats. Antibiotic syrup treatment containing Amoxicillin + clavulanic acid was recommended for 1 week postoperatively.

Telephone calls were made to the patient owners at 24 and 48 hours after surgery to evaluate possible complications and overall health. Cats with routine postoperative procedures were given a follow-up appointment on the 3rd postoperative day to check their wounds and change dressings. In case of a non-routine postoperative process (extreme pain, rejection of oral antibiotics, dressing slippage, severe emesis, apathy), patient owners were informed that they should come to the clinic immediately so that appropriate replacement treatments could be applied. Skin sutures were removed on the 10th postoperative day.

Monitored Parameters

Variables monitored during and immediately after surgery in cats are given in Table 1.

Table 1. The parameters monitored during the intraoperative period

Surgery duration (min)	……
Incision length (cm)	…….
Number of skin sutures	…….
İntraoperative complications	☐ No complication ☐Bleeding ☐ Tissue rupture (any of ovary, uterus or suspensory ligaments)

Data collected in terms of clinical recovery, recovery from the effects of anesthesia and surgical stress response of cats housed in their routine places in the early postoperative period (first 48 hours) were obtained through telephone conversations with the patient owners at the 24th and 48th postoperative hours. The information obtained was recorded as shown in Table 2.

If signs of aggression such as hissing, scratching, attacking other pets in the house, and signs of agitation such as shouting, rolling around and hiding behavior were not observed, Score: 0 was noted. If they were seen, they were noted as Score 1a, Score 1b and Score 1c according to the duration of presence (Table 3).

On postoperative day 3 (mid-postoperative period), the surgical wound was examined during dressing change. During the examination, the presence/absence of pain/tenderness in the incision, erythema, edema, discharge and licking behavior were noted. Skin sutures of all cats were removed on the 10th day after surgery.

Collection, Storage and Analysis of Blood Samples

Blood samples were taken from the cats a total of 4 times at the beginning of anesthesia (Hour 0/Day 0), at the 2nd postoperative hour, on the 3rd postoperative day, and on the 10th postoperative day. Plain blood collection tubes were used to collect blood samples taken from V. saphena. Sera of blood samples were removed as quickly as possible by centrifuging at 3000 rpm for 7 minutes. Serum samples were kept in a freezer at -20 ºC until relevant analyses.

Serum IL-6 levels were measured in the 0th and 2nd hour samples of 10 randomly selected cats from each group using the Cat Interleukin 6 ELISA kit (MyBioSource, San Diego, CA, Cat no: MBS284478).

Serum enzyme concentrations (LDH, CK, AST), which may reflect muscle damage, were measured (GESAN, Chem 2000, Automatic Chemistry Analyzer) in blood samples on the 0th, 3rd and 10th days in the MOHE (n=14) and FOHE (n=12) groups

Statistical Analysis

Statistical comparison of 24-48 hour observation results, postoperative 3rd day observation results, and complication rates in MOHE and FOHE groups was made using Fisher's Exact Test. Comparison of LDL, CK, GOT, IL-6 values of MOHE and FOHE groups was made with Mann Whitney U Test. Changes in IL-6 values within the group were determined by Wilcoxon Signed Rank Test; Changes in LDL, CK, AST values were made according to the Friedman Test. The significance level for all analyzes was determined as 0.05.

Table 2. Follow-up parameters of cats in the early postoperative period

	Score 1	Score 2	Score 3	Score 4
	(Hours)			
Overall recovery from anestehesia effect	6-12	12-18	18-24	>24
End of the stumble waking	0-6	6-12	12-24	>24
Onset of voluntarily using the litter box	0-6	6-12	12-24	>24
Going to food bowl behavior	0-6	6-12	12-24	>24
Onset of water consumption without emesis	12-18	18-24	24-48	>48
Onset of voluntary food intake	12-18	18-24	24-48	>48

Table 3. Scoring aggression and agitation in cats

	Score 0	Score 1		
		a	b	c
Aggression	None	0-12	12-24	24-48
Agitation	None	0-12	12-24	24-48

RESULTS

The number of skin sutures, surgery duration (Table 4) and intraoperative complications (Table 5) during the intraoperative period were not statistically different between MOHE and FOHE (P>0.05). The average incision length in the MOHE was significantly longer than the average incision length in the FOHE (P=0.008). Aggression, agitation, overall recovery from anesthesia effect, end of the stumble waking, voluntarily using the litter box, going to food bowl behavior, onset of water consumption without emesis, onset of voluntary food intake parameters

evaluated in the MOHE and FOHE groups by the 24-48 hour postoperative observation of the patient owners, were not significantly different between the groups (Table 6).

The variables monitored in the surgical wound in the mid-postoperative period (postoperative day 3) were not significantly different between the groups (P=0.999). No erythema or discharge was observed in the wound of any cat included in the study (Table 7).

The mean LDH values on day 0 (P=0.936), day 3 (P=0.820), and day 10 (P=0.527) were not significantly different between the FOHE and MOHE groups. LDL values did not change significantly (P = 0.576) in the FOHE (P=0.441) and MOHE groups between the 0th day, 3rd day, and 10th day (Figure 1).

There was no significant difference between the mean CK values between surgical methods on day 0 (P=0.742), day 3 (P=0.595), and day 10 (P=0.212) (Figure 2). In the FOHE group, CK values on day 0, day 3, and day 10 showed significant changes (P=0.002). Similarly, in the MOHE group, CK values on day 0, day 3, and day 10 showed significant changes (P<0.001), (Figure 2).

The mean AST values on day 0 (P=0.940), day 3 (P=0.860), and day 10 (P=0.317) were not significantly different between the FOHE and MOHE groups (Figure 3). While the change within the group between different sample days in the FOHE group was not statistically significant (P>0.05), in the MOHE group, AST values on the 0th day, 3rd day, and 10th day showed a statistically significant change (P<0.05).

The mean IL-6 levels at preoperative (0th hour) (P=0.940) and postoperative 2nd hour (P=0.860) were not significantly different between the FOHE and MOHE groups (Figure 3). Furthermore, there was no difference between the postoperative 2nd hour mean IL-6 level and the preoperative mean IL-6 level in the FOHE and MOHE groups (Figure 4).

The data were analyzed with the SPSS 25.0 statistical software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows). *Shapiro–Wilk* test was used for the prerequisites of homogeneity of variances and normality of variables. The mean ± standard deviation (SD) of normally distributed variables was presented. The variables were evaluated with t-test. Blastocyst rate were analyzed by Chi-square test. At the 95% confidence level (P<0.05), the differences were considered statistically significant.

Table 4. Monitored parameters during the intraoperative period in groups

	FOHE			MOHE			
	Med.	25%	75%	Med.	25%	75%	P
Surgery duration (min)	35,00	28,00	45,00	34,00	30,00	40,00	0,910
Incision length (cm)	2,60	2,10	3,00	3,50	3,00	3,60	0,008
Number of skin sut	5,00	4,00	6,00	5,00	5,00	6,00	0,448

Table 5. Intraoperative complications in groups

	FOHE		MOHE		
	n	%	N	%	P
No Complication	11	73,3	16	94,1	0,158
Bleeding	1	6,7	1	5,9	
Tissue rupture*	3	20,0	0	0,0	

*uterus, ovary or ligaments

Table 6. Monitored early postoperative parameters in cats

		FOHE		MOHE		
		n	%	n	%	P
Aggression	None	9	64,3	11	64,7	0,438
	0-12 h	4	28,6	2	11,8	
	12-24 h	1	7,1	4	23,5	
Agitation	None	8	57,1	12	70,6	0,101
	0-12 h	5	35,7	2	11,8	
	12-24 h	0	0,0	3	17,6	
	24-48 h	1	7,1	0	0,0	
Onset of voluntary food intake	12-18 h	9	64,3	7	41,2	0,440
	18-24h	3	21,4	7	41,2	
	24-48 h	2	14,3	3	17,6	
Onset of water consumption without emesis	12-18 h	4	28,6	8	47,1	0,379
	18-24h	5	35,7	2	11,8	
	24-48 h	4	28,6	4	23,5	
	>48 h	1	7,1	3	17,6	
Overall recovery from anesthesia effect	6-12 h	8	57,1	12	70,6	0,924
	12-18 h	2	14,3	2	11,8	
	18-24h	3	21,4	2	11,8	
	24-48 h	1	7,1	1	5,9	
End of the stumble waking	0-6 h	5	35,7	8	47,1	0,938
	6-12 h	6	42,9	6	35,3	
	12-24 h	2	14,3	2	11,8	
	>24 h	1	7,1	1	5,9	
Going to food bowl behavior	0-6 h	2	14,3	9	52,9	0,053
	6-12 h	7	50,0	7	41,2	
	12-24 h	3	21,4	0	0,0	
	>24 h	2	14,3	1	5,9	
Voluntarily using the litter box	0-6 h	5	35,7	9	52,9	0,157
	6-12 h	6	42,9	7	41,2	
	12-24 h	3	21,4	0	0,0	

	>24 h	0	0,0	1	5,9	

Table 7. Wound Complications in mid-postoperative period in groups

		FOHE		MOHE		
		n	%	N	%	P
Pain	No	11	78,6	14	82,4	0,999
	Yes	3	21,4	3	17,6	
Licking	No	13	92,9	16	94,1	0,999
	Yes	1	7,1	1	5,9	
Edema	No	13	92,9	15	88,2	0,999
	Yes	1	7,1	2	11,8	

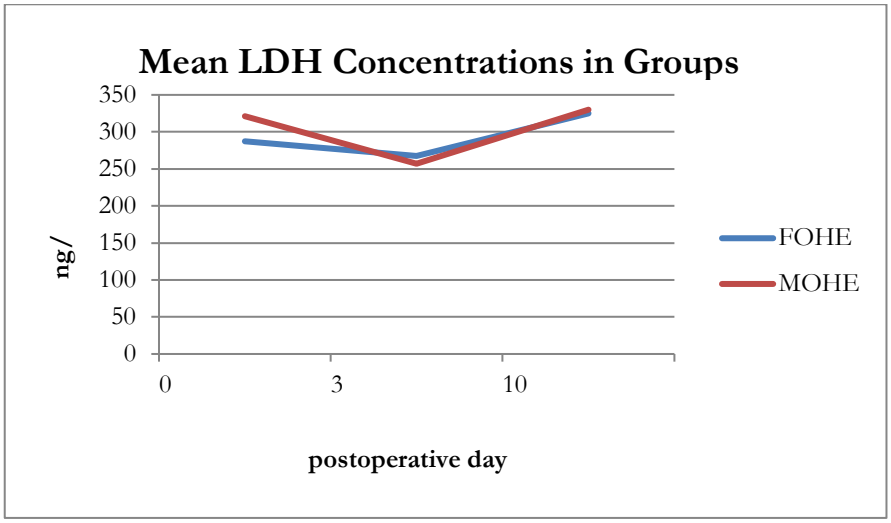

Figure 1. Mean serum LDH concentrations in MOHE and FOHE

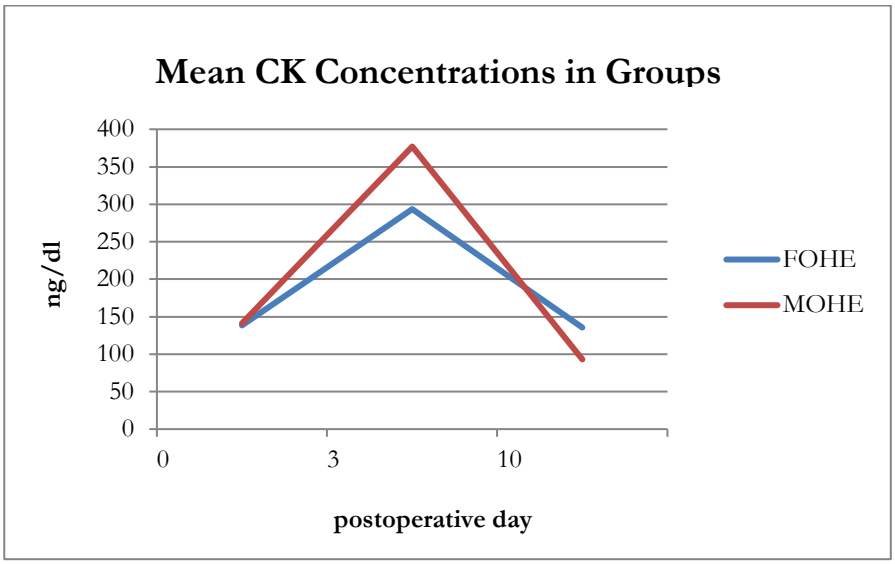

Figure 2. Mean serum CK concentrations in MOHE and FOHE

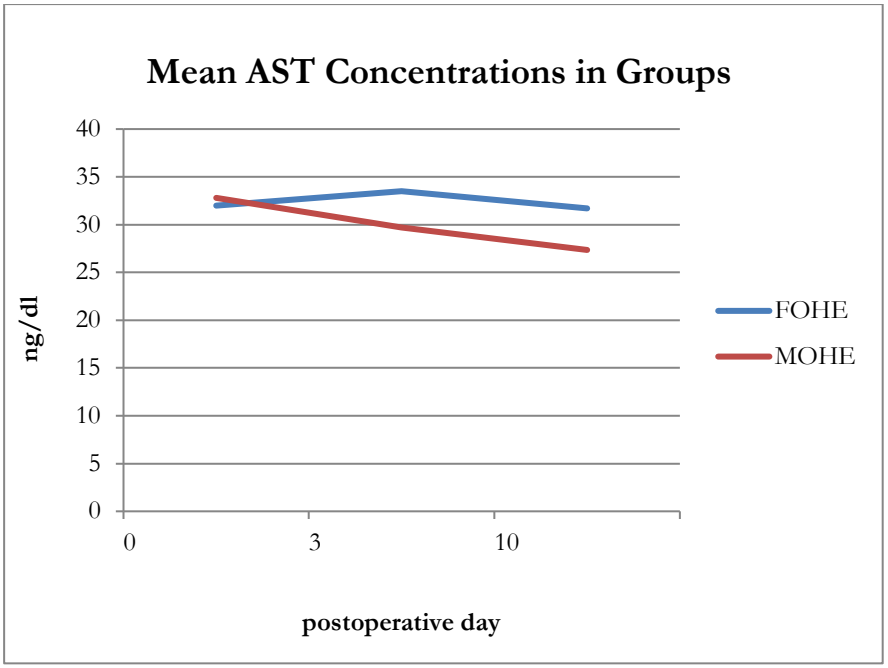

Figure 3. Mean serum AST concentrations in MOHE and FOHE

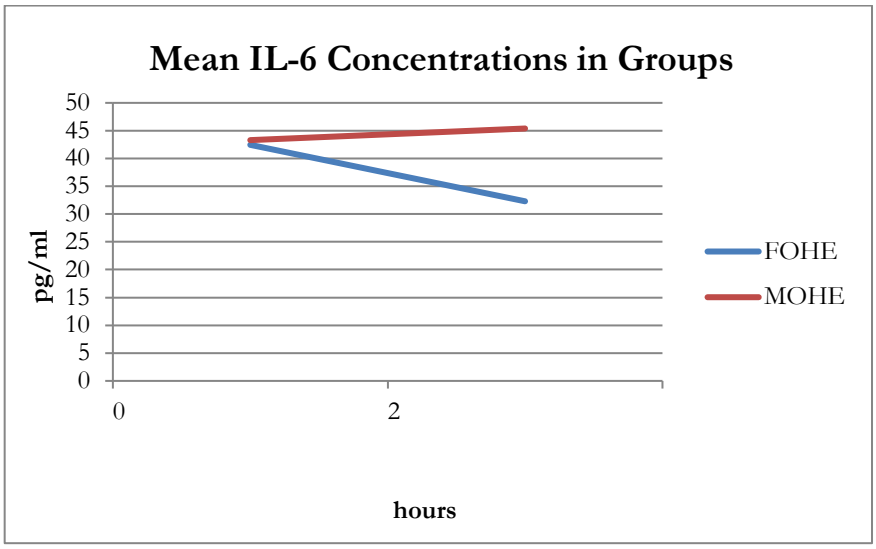

Figure 4. Mean serum IL-6 concentrations in MOHE and FOHE

DISCUSSION

Studies comparing the duration of spaying procedures using the conventional midline and flank approaches have produced conflicting findings. Kiani et al. (2014) reported that the flank approach (23 min) took less time than the median line (31 min) surgery. Similarly, Rana (2007) reported that the flank approach (24±2.65 min) was completed in a shorter time than the median line approach (29±3.51 min) in cats. Conversely, Swaffield et al. (2020) stated that there is no difference between the two methods in terms of completion time of the surgery. Coe et al. (2006) reported that the skin incision and opening the peritoneum phases took longer in the flank approach,

while finding the uterus phase took longer in the midline approach. In this study, spaying took an average of 35 minutes in the FOHE group and 34 minutes in the MOHE group (P>0.05). Unlike Coe et al. (2006) results, finding the uterus in the flank approach and completing the closure sutures in the midline approach were probably the stages that required the longest time. In fact, this study did not analyze the spaying surgeries step by step. However, the authors of this study believe that the reason the two procedures took relatively similar times to be completed was due to differences in the amount of time spent at each stage of the procedure. To clarify this issue, studies evaluating steps such as skin incision, muscle incision, identification of the uterus, and ovarian ligation during lateral and midline neutering procedures in cats are needed.

The length of the flank incision was typically significantly shorter than the midline incision length in studies comparing these two methods (Ghanawat and Mantri, 1996; Shuttleworth and Smythe, 2000; Rana, 2007). According to Coe et al. (2006), typical incision lengths for midline approach of OHE was 3.1±0.6 cm, while for lateral approach of OHE was 2.6±0.2 cm in cats. In this study, the average length of the FOHE incision (2.6 cm) was shorter than the average length of the MOHE incision (3.5 cm) and was found to be compatible with previous studies (P>0.05, Table 4). According to Rana (2007), the reason for the short incision length of the lateral approach is the ease of access to the uterus and ovary. In this examination, after approximately half a centimeter of skin dissection in the lateral approach, the incision line was passively widened with hemostatic forceps. In fact, no surgical incisions are actually made in FOHE cats unless there is intraoperative bleeding. As a result, it is not possible to discuss an actual surgical incision in this study. Regarding this, in addition to the justification stated by Rana (2007), it was thought that a factor that significantly contributed to the statistical difference between the groups was the application that benefited from the natural elasticity of the skin. The length of the skin incision differed between groups, but the average number of skin sutures was the same in both groups (P>0.05), which may be due to more frequent skin sutures in the flank approach.

The rate of surgical complications of OHE in healthy cats and dogs varies between 6.2-20.6% depending on the surgeon's experience (Samojlović et al., 2015). Tektepe (2019) reported that bleeding occurs at a rate of 10% in cats and 20% in dogs during surgery. However, significant bleeding complication that resulted in mortality occurred in just one in every 1450 cats undergoing elective spaying (Adin, 2011). Swaffield et al. (2020) reported that there was no difference in intraoperative complications including hypotension, hemorrhage, and ligature opening in OHE performed from the flank (n = 37) and median line (n = 38) in cats. The difference between intraoperative complications in FOHE and MOHE cats was not significantly different (P>0.05, Table 5). Although "rupture of tissues", one of the

intraoperative complications, occurred only in the FOHE group, since it was possible to control bleeding, the intraoperative bleeding complication was not found to be different between the groups (1 cat in both groups, P>0.05). Many studies classify the complication resulting from the ligament puncturing the tissue (which in this case was classified as tissue tear) as a bleeding complication. The bleeding complication in this study refers to a condition that typically presents as leakage and originates from the broad ligament ovary, or abdominal muscles. In both groups, bleeding was easily controlled by placing additional ligatures. The complication, which is considered as tissue rupture, includes situations that occur before the tissue is removed, easily controlled and re-ligated with the help of hemostatic forceps, and is often caused by excessive tension that occurs during traction at the junction of the ovary and the uterus. Similar complication was reported by Coe et al. (2006) in both the median and lateral flank approaches (opening of the ovarian ligature, cutting the uterine body with the ligature, accidentally cutting the uterus), but the possible cause was not explained. Extreme care should be taken to maintain hemostasis during the estrus period due to increased vascularity and edema of the ovarian and uterine tissues (Bushby, 2012). It was thought that the complication of tissue rupture, which occurred due to the deterioration of tissue strength and the ligatures cutting the tissue, may be caused by differences in the sexual cycle period of cats. However, the sexual cycle periods of cats were not evaluated in this study.

Behavioral changes (general activity level, time spent sleeping, play behaviors, aggressive behaviors, the cat's desire to be closer to a person, the desire to be held, hiding, vocalizations other than purring or hissing) and appetite changes have been reported to occur for several days following surgery in cats recovering at home after ovariohysterectomy (Väisänen and Tuomikoski, 2007). When cats are in pain, they are in a hunched posture, with their noses tense, their eyes narrowed, their ears flattened outward, their whiskers tense, and their heads held below the line of their shoulders. They also exhibit behaviors such as freezing behavior, biting the wound, wagging the tail, hiding behaviors, vocalization when approached (groan, hiss, or growl), and spending extended amounts of time lying down (Steagall and Monteiro, 2019; Brondani et al. 2011). In this study, observational parameters that may reflect pain did not differ between the FOHE and MOHE groups over the 24- to 48-h home monitoring period (P>0.05, Table 6). This finding would suggest that the effects of both surgical techniques on surgical stress and postoperative pain in cats are comparable. However, the validity and reliability of the monitored parameters in reflecting the postoperative process have not been demonstrated, and this makes it difficult to reach a definitive conclusion.

IL-6 levels are significantly increased in various pathological conditions associated with pain and hyperalgesia. Therefore, it has been stated that IL-6 levels can be an objective indicator in the evaluation of pain in animals (Sommer and Kress, 2004). It is known that the serum IL-6 level, which has a short half-life, begins to increase within 30–60 minutes after surgery, and a considerable increase occurs after 2-4 hours. However, it has been stated that it can reach its maximum level at the 24th postoperative hour after invasive surgeries, and this high serum level might last for up to 48–72 hours postoperatively (Desborough, 2000). In this study, it was found that the IL-6 level did not increase considerably by the second hour postoperatively (Figure 4). Moreover IL-6 concentration measured preoperatively and at the 2nd hour postoperatively did not differ significantly between the FOHE and MOHE groups and within the groups themselves (P>0.05). In the study, postoperative meloxicam was applied to both groups at equal doses and at the same times. Meloxicam affects cyclooxygenase activity and blocks prostaglandin synthesis, as well as causing a decrease in cAMP, which is responsible for IL-6 regulation (Mahdy et al. 2002). However, since pain management is a necessity after spaying surgeries, analgesics are routinely applied. Since the aim of this study was to compare two routinely applied OHE approaches within routine practices, the possible effects of analgesics on IL-6, and therefore on surgical stress response and pain, were ignored.

Wound complications (inflammation and suture dehiscence) have been reported to occur 2.95 times more frequently with the median line approach than the flank approach (Robert et al., 2015). Swaffield et al. (2020) noticed that the pain score was higher in the flank group at the first postoperative hour, whereas it was higher in the midline group on the third and tenth postoperative days, and that edema was present in the wound in the median line group in all controls. Another study comparing right flank and median line OHE (Murugesan et al. 2020) found that edema and discharge at the suture line were seen in 5 cats with the flank approach and 3 cats with median line surgery, but there was no difference in postoperative pain scores between the groups. Coe et al. (2006) compared midline (n = 24) and flank approach (n = 17) OHE surgeries and classified wound complications (discharge, excessive licking behavior, edema, suture dehiscence) on the seventh postoperative day as mild, moderate, or severe based on information provided by owners. As a result, significant discharge occurred in five animals in the flank group and one in the midline group; wound edema occurred in three cats in the midline group but not in any of the animals in the flank group. In this study, the presence of pain and/or tenderness, erythema, edema at the suture line, and licking behavior at the time of dressing removal were evaluated in cats in both groups on the 3rd

postoperative day. No discharge or erythema occurred at the suture line in any cats. Pain, edema, and licking behaviors were present at a rate of 35.71% (5/14) in the FOHE group and 35.29% (6/17) in the MOHE group but the difference was not significant (P> 0.05, Table 7). These findings are compatible with those of Murugesan et al. (2020) and Coe et al. (2006). When combined with previous data obtained from the study, it was decided that there was no difference in intraoperative, early, and mid-postoperative complications in cats with OHE performed with median line and flank approach. This research indicates that both methods have comparable effect on clinical recovery in cats.

In cases of muscle damage caused by any reason, there is a significant increase in serum LDH, AST, and, most specifically and strikingly, CK levels. Even in relatively minor muscle damage, such as intramuscular injections or minimal exercise, serum CK levels can increase two or threefold due to its high specific activity in the muscle (Kraemer et al. 2009). Therefore, an increase in serum CK activity is used in the diagnosis of neuromuscular diseases and in the confirmation of muscle damage (Fascetti et al. 1997; Auguste 1992). Although increases are most noticeable in cats with anorexia, they have also been reported to variable levels in heart illness, trauma, bite wounds, bacterial infections, prior general anesthesia, and after intramuscular injections (Aroch et al. 2010). In this study, while CK levels changed within the group on days 0, 3, and 10 in both FOHE ($P<0.05$) and MOHE groups ($P<0.01$), the difference between the groups was not significant ($P>0.05$, Figure 2). This result shows that a similar muscle healing process was formed in both groups.

A study comparing median line and laparoscopic ovariectomy surgeries in cats found that AST levels in the laparoscopic approach were higher than those in the traditional approach, and these high values decreased at the 12th postoperative hour in the median line and at the 24th postoperative hour in the laparoscopic approach (Alves et al. 2009). In this study, the difference in mean serum AST levels on the sampling days was not statistically significant in FOHE and MOHE groups ($P>0.05$). On the other hand, the difference in AST concentration within each group was not significant either ($P>0.05$, Figure 3). It has been reported that the half-life of AST in cats is approximately 1.5 hours (Chapman and Hostutler, 2013) and that the increase in serum AST occurs later than the increase in serum CK (Alves et al. 2009). Serum AST levels increase 12–24 hours after muscle injury and remain elevated for 1 or 2 weeks (Alves et al. 2009). In this study, serum AST levels remained constant despite an increase in blood CK levels on the third postoperative day. The reason for this effect remains unclear. Serum AST levels may have increased earlier in the postoperative period but may have decreased by the day of sampling. When muscle damage occurs, first LDH, then CK, and finally AST are expected to rise in serum (Billings, 2013). In the study, the difference in serum LDH levels between the MOHE and FOHE groups and within each group was not significant ($P>0.05$, Figure 1). Although it is one of the suggested serum enzymes for assessing muscle injury, there is insufficient evidence on the change in serum LDH levels following surgical intervention in cats. In this context, it is believed that more research is needed, particularly in cats.

In conclusion, this study found no difference between flank laparotomy and median line OHE in terms of intraoperative complications, operative time, number of skin sutures, muscle damage, muscle recovery, surgical stress response, postoperative wound healing. The FOHE incision was shorter than the MOHE incision, but this does not appear to affect the healing process. In cats, only serum CK levels change significantly, indicating muscle injury. Serum CK should be monitored as part of the muscle recovery process. Monitoring serum CK is recommended to monitor muscle recovery in cats.

In light of the findings of the study, it is thought that further research is needed to investigate the potential of AST, LDH and CK enzymes, which can evaluate muscle damage in cats, to reflect muscle damage. In order to evaluate the enzymes mentioned above together, the times when they are elevated in serum in cats should be reported. In this context, similar studies are expected to be effective in evaluating serum samples taken at more frequent intervals starting from the first hours after surgery. In addition, examining IL-6 together with other cytokines in the evaluation of surgical stress may highlight the differences between techniques more clearly.

Conflict of interest: The authors have no conflicts of interest to report.

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