ORIGINAL ARTICLE

Comparison of three different methods for stump closure in laparoscopic appendectomy: Endoloop, Hem-o-lok clip, and endostapler

Sefa Ergun,[1] Pırıltı Ozcan,[1] Fatma Ipek Gunaydin,[1] Egemen Ozdemir,[1] Selen Soylu Yalıman,[1] Yasemin Pekmezci,[1] Engin Hatipoglu,[1] Ahmet Bas,[2] Osman Simsek,[1] Salih Pekmezci[1]

[1]Department of General Surgery, Istanbul University- Cerrahpasa Cerrahpasa Medical Faculty, İstanbul-*Türkiye*

[2]Department of Radiology Istanbul University- Cerrahpasa Cerrahpasa Medical Faculty, İstanbul-*Türkiye*

ABSTRACT

BACKGROUND: Acute appendicitis is a common surgical emergency that causes acute abdominal pain and affects approximately 7-8% of the population during their lifetime. The closure of the appendix stump during laparoscopic appendectomy is one of the most critical steps of the surgery to prevent life-threatening complications such as postoperative fistula, peritonitis, and sepsis. The material chosen for appendix stump closure must be effective, safe, and economical. However, there is still no consensus on the optimal method for stump closure. In this study, we aimed to compare the advantages and reliability of three different methods used for appendix stump closure.

METHODS: At Istanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty, Department of General Surgery, cases that underwent laparoscopic appendectomy for acute appendicitis between January 2022 and April 2024 were retrospectively analyzed using the hospital's data system. The patients' demographic data, laboratory values, pathology reports, surgical notes, duration of hospital stay, duration of surgery, total hospital costs, complications related to the surgery within 30 days postoperatively, and the management of these complications were examined.

RESULTS: The study included a total of 150 individuals, with 83 (55.33%) males and 67 (44.67%) females. The average age of the participants was 38.45±14.48 years. In terms of the materials used for stump closure, endoloop was used in 82 (54.67%) cases, Hem-o-lok clip in 30 (20.00%) cases, and endostapler in 38 (25.33%) cases. In 144 (96%) cases, no Clavien-Dindo (CD) complications were observed, while complications occurred in six (4%) cases. These six complications included two intra-abdominal abscesses (CD Grade 3), two wound infections (CD Grade 1), one case of bleeding (CD Grade 2), and one pulmonary embolism (CD Grade 4).

CONCLUSION: The use of endoloop, polymeric clips, and endostapler in laparoscopic appendectomy is safe and effective for appendectomy. All three methods can be successfully applied without an increase in intraoperative or postoperative complications. However, due to the higher treatment costs associated with endostapler, its use should be reserved for situations where securing the appendix stump cannot be achieved with endoloop or Hem-o-lok clip.

Keywords: Laparoscopic appendectomy; stump closure; endoloop; Hem-o-lok clip; endostapler.

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Address for correspondence: Pırıltı Ozcan

Department of General Surgery, Istanbul University- Cerrahpasa Cerrahpasa Medical Faculty, İstanbul, Türkiye

E-mail: piriltiozcan@gmail.com

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INTRODUCTION

Acute appendicitis (AA) is a common general surgical emergency that causes acute abdominal pain and affects approximately 7-8% of the population during their lifetime.[1-4] Laparoscopic appendectomy (LA), first described by Semm in 1983, has proven to be a safe and effective treatment for AA and is now the gold standard surgical treatment method.[5] The closure of the appendix stump (AS) is one of the most critical steps in the surgery to avoid life-threatening complications such as postoperative fistula, peritonitis, and sepsis. Studies have shown that the technique used for AS closure affects the incidence of postoperative infectious complications, leading to prolonged hospital stays, interventional procedures, and the need for reoperations due to resulting complications.[6] Minimizing the risk and reducing the potential for postoperative complications, such as abscess and peritonitis, has become one of the most important criteria during the selection of materials for AS closure. Therefore, the material chosen for AS closure must be effective, safe, and economical. There is still no consensus on the optimal technical method for AS closure. Various methods are available for AS closure, including endostaplers, absorbable and non-absorbable polymeric clips (such as Hem-o-lok), and endoloops.[7-12] Today, polymeric clips are the most preferred method for AS closure due to their ease of use and cost-effectiveness.[13] Factors such as surgeon preference, AS width, and cost can influence the choice of AS closure method. In this study, we aimed to compare the advantages and reliability of these three methods used for AS closure.

MATERIALS AND METHODS

At Istanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty, Department of General Surgery, cases that underwent laparoscopic appendectomy for acute appendicitis between January 2022 and April 2024 were retrospectively analyzed using the hospital's data system. Ethical approval for the study was obtained from the Ethics Committee of İstanbul University- Cerrahpaşa, Cerrahpaşa Medical Faculty, with the approval number 2024/1075698. The patient's demographic data, laboratory values, pathology reports, surgical notes, hospital stay durations, surgery durations, total hospital stay costs, complications related to the surgery within 30 days postoperatively, and the management of these complications were examined. Complications were classified according to the Clavien-Dindo (CD) grading system. Patients were divided into three groups based on the AS closure technique: Hem-o-lok clip, endoloop, and endostapler. A 30-day follow-up was completed for all patients. The study included cases aged 19-76 who underwent laparoscopic appendectomy for acute appendicitis.

In contrast, cases that underwent open appendectomy, appendectomy for reasons other than acute appendicitis, and patients under 18 years old were excluded.

The diagnosis of acute appendicitis was based on clinical examination, laboratory tests showing leukocytosis and elevated C-reactive protein, transabdominal ultrasound, and, in cases where clinical suspicion was high but insufficient to confirm or exclude the diagnosis, computed tomography. After the induction of general anesthesia, patients were placed in the supine position. The abdomen was entered below the umbilicus using a Veress needle or the open Hasson technique. After placing the camera port, carbon dioxide (CO_2) was insufflated at a pressure of 10-12 mm Hg. Laparoscopic appendectomy was performed in all cases using three trocars (one 5 mm and two 10 mm) with a 5 mm trocar in the midline just above the pubic bone and a 10 mm trocar in the left iliac fossa. The appendix and the abdominal cavity were explored, and appendicitis was confirmed. The appendicular mesentery was grasped with endograspers, avoiding damage to the appendicular wall. After freeing the mesoappendix, the appendix stump was closed according to the surgeon's preference using endostaplers (4.5 mm x 2.5 mm linear cutting stapler, Endo GIA™ Stapler, Medtronic, Dublin, Ireland), absorbable and non-absorbable polymeric clips (Hem-o-lok, Weck Surgical Instruments, Teleflex Medical, Durham, NC, USA), or an endoloop. The choice among the techniques was based on surgeon preference, AS width, and perforation status at the base of the appendix. The appendix was then removed from the abdomen through a 10 mm port using an Endobag or a sterile glove. A drain was placed at the surgeon's discretion.

Statistical analyses were performed using SPSS version 25.0 software. The normal distribution of the variables was assessed using visual methods (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Descriptive analyses included mean, standard deviation, median, and minimum-maximum values. The Pearson Chi-Square Test was used for 2 x 2 tables. For tables larger than 2 x 2, Bonferroni correction and post-hoc analyses were applied. In cases where the data did not show a normal distribution, more than two groups were evaluated using the Kruskal-Wallis test, followed by post-hoc analysis. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study included 150 individuals, with 83 (55.33%) males and 67 (44.67%) females. The average age of the participants was 38.45±14.48 years. Examining the distribution of the materials used, endoloop was used in 82 (54.67%) cases, Hem-o-lok clip in 30 (20.00%) cases, and endostapler in 38 (25.33%) cases. In 144 (96%) cases, no Clavien-Dindo complications occurred, while complications were observed in six (4%) cases. These six complications included two intra-abdominal abscesses (CD Grade 3), two wound infections (CD Grade 1), one bleeding (CD Grade 2), and one pulmonary embolism

(CD Grade 4). Of the two cases with intra-abdominal abscesses, one was treated with drainage by interventional radiology, while the other was managed with antibiotics, resulting in abscess regression. The two wound infections resolved with dressing changes and antibiotic therapy. The patient with bleeding received a transfusion of 1 unit of red blood cell suspension, and the bleeding was controlled conservatively. The patient with pulmonary embolism was treated with low molecular weight heparin.

In terms of pathology, acute appendicitis was found in 144 (96.00%) cases, low-grade mucinous neoplasm in one (0.67%) case, neuroendocrine tumor in three (2.00%) cases, and sessile serrated lesion with dysplasia in two (1.33%) cases. Perforation was not detected in 140 (93.33%) cases, while it was found in 10 (6.67%) cases (Table 1).

The preoperative average white blood cell (WBC) count was 13.23±4.95; C-reactive protein (CRP) was 69.43±88.16; appendix diameter was 10.89±6.1 mm; length of hospital stay was 2.05±1.33 days; average surgery duration was 47.93±9.3 minutes (Table 2). The average material cost was $25±3.2 for endoloop, $18±1.55 for Hem-o-lok clip, and $50±5.2 for cases where staplers were used. Gender, postoperative complications, pathology, and perforation status were compared according to the materials used for AS closure, and no significant differences were found between the groups (Table 3).

The averages of age (years), surgery duration (minutes), preoperative WBC, preoperative CRP, length of hospital stay (days), appendix diameter (mm), and total cost (dollars) were compared among the materials used for AS closure. The average surgery duration (minutes) for those using endoloop was higher than for the other groups ($p<0.001$). The preoperative CRP average for those using staplers was higher than for those using endoloop ($p=0.025$). The average length of hospital stay (days) for those using staplers was higher than for the other groups ($p<0.001$). The average material cost (dollars) for those using Hem-o-lok clip was lower than for the others, while the total cost (dollars) for those using endostapler was higher than for the other groups ($p<0.001$). The total cost (dollars) for those using Hem-o-lok clips was lower than for the others ($p<0.001$) (Table 2).

DISCUSSION

Laparoscopic appendectomy is currently considered the gold standard treatment for acute appendicitis due to its shorter hospital stay, lower incidence of wound site infections, faster return to normal activities, shorter postoperative ileus duration, less postoperative pain and analgesic requirement, and better cosmetic results.[14-15] One of the most important steps of the appendectomy procedure is the closure of the appendiceal stump. From past to present, the safe closure of the AS remains the most crucial step in preventing poten-

Table 1. Distribution of patient groups who underwent laparoscopic appendectomy with the diagnosis of acute appendicitis

	n/Average±SD	%/Median (Min-Max)
Gender		
Male	83	(55.33)
Female	67	(44.67)
Age (years)	38.45±14.48	34.5 (19-76)
Material		
Endoloop	82	(54.67)
Hem-o-lok clip	30	(20.00)
Stapler	38	(25.33)
Post-Operative Complication		
No	144	(96.00)
Yes	6	(4.00)
Pathology Result		
Acute appendicitis	144	(96.00)
Low-grade mucinous neoplasm	1	(0.67)
Neuroendocrine tumor	3	(2.00)
Sessile serrated lesion with dysplasia	2	(1.33)
Perforation		
No	140	(93.33)
Yes	10	(6.67)

N: Number; SD: Standard Deviation; %: Percent.

Table 2. Clinical, laboratory, and cost values according to appendix stump closure methods

	Material						p
	Endoloop		Hem-o-Lok Clip		Stapler		
	Average±SD	Median (Min-Max)	Average±SD	Median (Min-Max)	Average±SD	Median (Min-Max)	
Age (years)	36.23±13.24	32 (19-69)	39.13±15.75	34 (19-76)	42.71±15.38	41.5 (19-74)	0.087
Operation Time (minutes)	51.74±9.44	52 (30-74)	45±7.35	45 (30-60)	42±5.95	42 (28-56)	<0.001
Preoperative WBC	12.6±5	12.75 (1.5-31.6)	13.49±5.14	11.75 (4.01-27.4)	14.37±4.58	14.5 (4.5-22.78)	0.098
Preoperative CRP	49.08±69.18	19.63 (0-347.41)	77.13±75.36	60 (0-220.77)	107.27±118.04	58.57 (0.51-436.41)	0.025
Length of Stay (days)	1.82±0.86	2 (1-4)	1.5±0.63	1 (1-3)	3±1.97	3 (1-12)	<0.001
Appendix Diameter (mm)	10.77±6.27	10 (3-50)	9.43±2.9	10 (3-18)	12.29±7.31	10 (4-50)	0.097
Cost of Material (dollars)	25±3.2	25 (20-35)	18±1.55	18 (16-21)	55±4.5	55 (53-56.8)	<0.001
Total Cost (dollars)	475.65±49.77	488 (380-598)	459.47±31.66	465 (343-517)	536.97±45.5	535.5 (485-698)	<0.001

Kruskal-Wallis Test (Post-Hoc analysis). WBC: White Blood Cell; CRP: C-Reactive Protein; mm: Millimeter; SD: Standard Deviation.

Table 3. Demographic, clinical, and pathological data according to appendix stump closure methods

	Material						p
	Endoloop		Hem-o-Lok Clip		Stapler		
	n	%	n	%	n	%	
Gender							
Male	46	(56.10)	16	(53.33)	21	(55.26)	0.967
Female	36	(43.90)	14	(46.67)	17	(44.74)	
Post-Operative Complication							
No	78	(95.12)	30	(100.00)	36	(94.74)	0.456
Yes	4	(4.88)	0	(0.00)	2	(5.26)	
Pathology Result							
Acute appendicitis	79	(96.34)	30	(100.00)	35	(92.11)	0.270
Low-grade mucinous neoplasm	0	(0.00)	0	(0.00)	1	(2.63)	
Neuroendocrine tumor	1	(1.22)	0	(0.00)	2	(5.26)	
Sessile serrated lesion with dysplasia	2	(2.44)	0	(0.00)	0	(0.00)	
Perforation							
No	76	(92.68)	30	(100.00)	34	(89.47)	0.211
Yes	6	(7.32)	0	(0.00)	4	(10.53)	

Ki-Kare Test; n: Number; %: Percent.

tial serious postoperative complications.[16-18] Many different methods have been described for the closure of the AS.[19] Despite numerous studies, no universal consensus exists on any method, and no specific method is recommended in the literature.[20] Nowadays, the most commonly used surgical techniques for AS closure during LA include endoloop, titanium endoclips, non-absorbable polymer clips (such as Hem-o-lok clips), and endostaplers. While each method has its advantages and disadvantages, the most commonly preferred methods are endoloop, Hem-o-lok clips, and endostaplers.[16,19-20]

The use of endoloop in laparoscopic appendectomy has become widespread in clinics due to its cost-effectiveness and easy accessibility. Nowadays, the use of commercially available endoloops is common.[21] Although this procedure initially appears challenging laparoscopically, it is performed in

shorter times as experience with LA increases. However, the laparoscopic suturing technique can be technically demanding.[16] Endoloops may require more manipulation on the appendiceal stump, depending on experience, and there is a potential risk of slippage, which can lead to complications such as intra-abdominal abscesses. Furthermore, endoloops are not considered safe for the closure of the cecum in cases of AS perforation or cecal inflammation.[7,10] In a prospective randomized controlled trial involving 271 cases, Beldi et al. investigated the impact of closing the AS with one or two endoloops on complications. They reported no statistically significant difference between the two groups.[22] In a single-center prospective randomized study comparing polymeric clips and endoloops, Çolak et al. found no statistically significant difference between the groups regarding hospital stay duration, surgical site infection, intra-abdominal abscess, or non-surgical complications.[23] In a prospective study involving 277 cases, Pogorelić et al. compared the clinical outcomes of using non-absorbable polymeric clips versus endoloops for laparoscopic AS closure in children, reporting no intraoperative complications and postoperative complications in 17 (6.1%) patients, with no significant difference between the groups regarding postoperative complications (p=0.546). Additionally, they reported that the median operation time was 10 minutes shorter (p<0.001), and the median hospital stay was shorter in the polymeric clip group (p=0.008). Our study found that the median operation time was shorter in cases where endostaplers were used compared to Hem-o-lok clips and endoloops, which was statistically significant (p<0.001). The cost of polymeric clips was significantly lower than endoloops (€17.64 vs. €34.16).[10] Okamoto et al. investigated whether endoloops or endostaplers could reduce the incidence of postoperative abdominal abscess in a study of 231 cases. They reported no significant difference between the purse-string suture and endostapler groups regarding patient characteristics and postoperative complications, including abdominal abscess.[24]

The safety of using the non-absorbable polymer clip, Hem-o-lok, for the ligation of vessels, ureters, and bile ducts is well-documented.[25] In recent years, the Hem-o-lok clip has become popular for the closure of the appendiceal stump due to its safety, ease of use, and low cost. Recent studies have also reported that polymeric clips are a cheaper and less time-consuming alternative to endoloops.[6,10,17,23,26] In their research, Özdemir et al. stated that non-absorbable polymer clips are the most preferred method because they are safe, practical, and cost-effective, and their locking system makes them safer. They also reported that a Hem-o-lok clip costs $16.9, whereas an endoloop costs $24, and clips shorten operation time and are less expensive.[27]

Marcinkeviciute et al., in a retrospective study comparing the safety of polymeric clips with endoloops in 515 cases, found no significant difference in complication rates between the two groups within the postoperative 30-day period. However, they determined the cost of stump closure with polymeric clips (Hem-o-lok) to be €7.69, with Vicryl loops €91.35, with polydioxanone (PDS) loops €96.51, and with a stapler €514.50. They concluded that polymeric clips are a safe, effective, and cost-efficient method for AS closure. In a randomized controlled study involving 1,100 cases, Lv et al. investigated the safety and efficacy of absorbable and non-absorbable polymeric clips. They found no statistically significant difference between the groups in terms of intra-abdominal abscess, stump leakage, superficial wound infections, postoperative abdominal pain, general adverse events, or operation and hospital stay durations. They reported that both types of Hem-o-lok clips are safe and effective devices for AS closure.[29] Our study found no superiority among the methods of AS closure regarding complications, which is consistent with the literature. However, we identified a statistically significant difference in hospital stay durations, with the endostapler group having a longer hospital stay than the other two groups (p<0.001).

Linear staplers are much more expensive than endoloops and Hemo-o-lok clips; they require a 12 mm port for placement and leave metal clips on the stump, which can cause short bowel obstruction due to adhesions.[10] The use of staplers significantly increases the cost and duration of the operation. Therefore, surgeons should consider using staplers only in certain situations where indicated (such as when the appendix base is inflamed, the appendix base is thick, or if the appendix is not visible).[6,7,8,30] In a prospective randomized study by Delibegovic et al. comparing the outcomes of closure methods for the appendix stump in 120 cases of acute appendicitis, the cases were divided into four groups: 1) endoloop (n=30), 2) Hem-o-lok clips (n=30), 3) titanium clips (n=30), and 4) endostapler (45 mm) (n=30). No morbidity was recorded in any group within a 30-day follow-up period.[31] A recent meta-analysis of 996 cases by Zorzetti et al. showed that endoloop and endostapler are both safe for appendix stump closure with no difference in postoperative complication rates.[32] In a prospective non-randomized study by Partecke et al. comparing the ease of use, morbidity, and cost-effectiveness of Hem-o-lok clips and endostaplers in AS closure in 82 cases, no significant difference in morbidity was found between the two groups. They reported that the cost of a set of Hem-o-lok clips was negligible compared to staplers (€19.94 vs. €356.43). They recommended using a single clip as the standard procedure for AS closure in laparoscopic appendectomy whenever possible.[11] In our clinic, the average cost was $25±3.2 for endoloop, $18±1.55 for Hem-o-lok clip, and $55±4.5 for endostapler. The average material cost (dollars) for those using Hem-o-lok clips was lower than for others, while the average material cost (dollars) for those using endostaplers was higher than for other groups (p<0.001). The average total cost (dollars) for those using endostaplers was also higher than for others (p<0.001). Due to the high cost, the use of endostaplers is consistent with the literature as a last resort treatment method. Hanssen et al. also re-

ported in their study investigating the postoperative course of AS using polymeric clips and endostaplers that, while there was no difference in complications, endoscopic staplers were more expensive than polymeric clips, with a significant difference in procedural costs.[33]

In our clinic, we use all three methods for AS closure. In our study, 54% of the cases were closed using endoloop, 25% with endostapler, and 20% with Hemo-o-lok clips. We found that the rate of AS closure with endostapler in our clinic is higher than reported in the literature. We attribute this to our university hospital accepting complicated and severe cases from other hospitals. The surgery duration was longer in the endoloop group, which we believe is due to the training of new assistant surgeons.

The limitations of our study include the small sample size, the retrospective nature of the analysis, and the heterogeneity of patient groups. Additionally, the lack of a common consensus for AS closure in our clinic, the fact that these procedures were among the first performed by junior surgical assistants under supervision, and the closure method preference made by the assistants themselves are further limiting factors.

CONCLUSION

Using endoloop, polymeric clips, and endostapler during LA is safe and effective for appendectomy. All three methods can be successfully applied without an increase in intraoperative and postoperative complications. Due to the rise in treatment costs, an endostapler should be reserved for situations where securing the appendix stump cannot be achieved with an endoloop or Hem-o-lok clip.

Ethics Committee Approval: This study was approved by the Istanbul University- Cerrahpasa Cerrahpasa Medical Faculty Ethics Committee (Date: 27.08.2024, Decision No: 1062085).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Laparoskopik apendektomide güdük kapatmada üç farklı yöntemin karşılaştırılması: Endoloop, hem-o-lok klip ve endostapler

Sefa Ergun,[1] Pırıltı Ozcan,[1] Fatma Ipek Gunaydin,[1] Egemen Ozdemir,[1] Selen Soylu Yalıman,[1] Yasemin Pekmezci,[1] Engin Hatipoglu,[1] Ahmet Bas,[2] Osman Simsek,[1] Salih Pekmezci[1]

[1]İstanbul Üniversitesi-Cerrahpaşa Cerrahpaşa Tıp Fakültesi Genel Cerrahi Anabilim Dalı, İstanbul, Türkiye
[2]İstanbul Üniversitesi-Cerrahpaşa Cerrahpaşa Tıp Fakültesi Radyoloji Anabilim Dalı, İstanbul, Türkiye

AMAÇ: Akut apandisit, karın ağrısına neden olan ve popülasyonun yaklaşık %7-8'ini yaşamları boyunca etkileyen yaygın bir genel cerrahi acilidir. Laparoskopik apendektomi sırasında apendiks güdüğünün kapatılması, postoperatif fistül, peritonit ve sepsis gibi hayatı tehdit eden ciddi komplikasyonlardan kaçınmak için ameliyatın en kritik adımlarından biridir. Apendiks güdüğünün kapatılması için seçilen malzeme etkili, güvenli ve ekonomik olmalıdır. Güdük kapatmaya yönelik kesin bir teknik üzerinde hâlâ bir fikir birliği yoktur. Bu çalışmada apendiks güdük kapatmada kullanılan bu üç yöntemin avantajlarını ve güvenilirliğini karşılaştırmayı amaçladık.

GEREÇ VE YÖNTEM: İstanbul Üniversitesi-Cerrahpaşa Tıp Fakültesi Genel Cerrahi Anabilim Dalı'nda Ocak 2022 ile Nisan 2024 tarihleri arasında akut apandisit nedeniyle laparoskopik apendektomi yapılan olgular, hastanenin veri sistemi kullanılarak retrospektif olarak analiz edildi. Hastaların demografik verileri, laboratuvar değerleri, patoloji raporları, ameliyat notları, hastanede kalış süreleri, ameliyat süreleri, toplam hastanede kalış süresi içindeki maliyetleri, ameliyat sonrası 30 gün içinde ameliyata bağlı komplikasyonlar ve bu komplikasyonların yönetimi incelendi.

BULGULAR: Araştırmaya 83'ü (%55.33) erkek, 67'si (%44.67) kadın olmak üzere toplam 150 kişi alındı. Katılımcıların yaş ortalaması 38.45±14.48 yıldı. Kullanılan malzemelerin dağılımı incelendiğinde 82 (%54.67) olguda Endoloop, 30 (%20.00) olguda hem-o-lok klip, 38 (%25.33) olguda endostapler kullanıldı. Vakaların 144'ünde (%96) Clavien-Dindo (CD) komplikasyonu görülmezken, 6 (%4) vakada komplikasyon görüldü. Bu 6 komplikasyon arasında 2 karın içi apse (CD Derece 3), 2 yara enfeksiyonu (CD Derece 1), 1 kanama (CD Derece 2) ve 1 pulmoner emboli (CD Derece 4) yer almaktadır.

SONUÇ: Laparoskopik apendektomi sırasında endoloop, polimerik klipler ve endostapler kullanımı apendektomi için güvenli ve etkilidir. Her üç yöntem de intraoperatif ve postoperatif komplikasyonlarda artış olmadan başarıyla uygulanabilmektedir. Tedavi maliyetlerindeki artış nedeniyle endostapler kullanımı, apendiks güdüğünün endoloop veya hem-o-lok klip ile kapatılmasının sağlanamadığı durumlarda tercih edilmelidir.

Anahtar sözcükler: Güdük kapatma endoloop; hem-o-lok klip ve endostapler; laparoskopik apendektomi.

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