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Comparison of three techniques for appendiceal stump closure during laparoscopy

Laparoskopik apendektomide güdük kapatmak için kullanılan üç tekniğin karşılaştırılması

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Abstract

Aim: Laparoscopic appendectomy is the gold standard treatment of acute appendicitis. However, there is no consensus about the technique to apply when closing the appendix stump. This study compares three techniques to close the appendix stump: Laparoscopic purse-string suture (LPS), metal clips, and Hem-o-lok clips. The aim is to evaluate the advantages, safety, and costs of these three methods.

Methods: We conducted a retrospective cohort study which included 220 patients who underwent laparoscopic appendectomy operations for acute appendicitis between May 2017 and December 2019. The cases were divided into three groups and evaluated. Group A received LPS, group B received metal clips, and group C received Hem-o-lok clips. The demographic features of the patients, American Society of Anesthesiology (ASA) scores, duration of surgery, postoperative complications, hospital stay, and cost were evaluated retrospectively from patient files.

Results: There were 79 patients in group A, 91 patients in group B, and 50 patients in group C. There was no difference between the groups with respect to demographic features, ASA physiological state scores, and laboratuary values. The operation time and postoperative complication rates did not differ between groups (P>0.05). Group C had longer hospital stays (P=0.001), and group A had lower costs (P=0.001).

Conclusion: In the laparoscopic appendectomy technique, the use of LPS for appendix stump closure is safe and effective. Furthermore, technical consumables and hospital treatment costs are significantly reduced.

Keywords: Acute appendicitis, Laparoscopic appendectomy, Laparoscopic purse string, Hem-o-lok clip

Öz

Amaç: Laparoskopik apendektomi akut apandisit tedavisinde altın standarttır. Bununla birlikte, apendiks güdüğünü kapatırken uygulanacak teknik hakkında henüz bir fikir birliği yoktur. Bu çalışma, apendiks güdüğünü kapatmak için uygulanan teknikleri karşılaştırmaktadır: Laparoskopik sütur uygulama, metal klips uygulama ve Hem-o-lok klips uygulama. Amacımız bu üç yöntemin avantajlarını, güvenliğini ve maliyetlerini değerlendirmektir.

Yöntemler: Mayıs 2017-Aralık 2019 tarihleri arasında akut apandisit nedeniyle laparoskopik apendektomi operasyonu geçiren 220 hastanın dahil edildiği retrospektif kohort çalışma planlandık. Olgular üç gruba ayrılarak değerlendirildi. A Grubunda apendiks güdüğü laparoskopik sütur yöntemi ile kapatılanlar yer aldı. B grubunda metal klips C grubunda ise Hem-o-lok klips uygulanarak apendiks güdüğü kapatılan olgular yer aldı. Hastaların demografik özellikleri, Amerikan Anesteziyoloji Derneği (ASA) skorları, ameliyat süresi, postoperatif komplikasyonlar, hastanede kalış süresi ve maliyeti değerlendirildi.

Bulgular: Grup A'da 79 hasta, grup B'de 91 hasta ve grup C'de 50 hasta vardı. Demografik özellikler, ASA skorları, laboratuar değerleri açısından gruplar arasında fark yoktu. Ameliyat süresi ve ameliyat sonrası komplikasyon oranları gruplar arasında farklılık göstermedi (P>0,05). Grup C'de daha uzun hastanede kalış süresi vardı (P=0,001) ve grup A daha düşük maliyete sahipti (P=0,001).

Sonuç: Laparoskopik apendektomide, apendiks güdüğünün sütur kullanılarak kapatılması tekniği güvenli ve etkilidir. Ayrıca bu tekniğin sarf malzeme kullanımını ve hastane tedavi maliyetlerini önemli ölçüde azalttığı görülmüştür.

Anahtar kelimeler: Akut apandisit, Laparoskopik apendektomi, Laparoskopik sütur, Hem-o-lok klip

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Introduction

Laparoscopic appendectomy (LA) is a globally accepted surgical method for the treatment of acute appendicitis [1]. The benefits of LA compared to open treatment include faster recovery, less surgical pain, reduced wound infections, shorter hospitalization, and early return to daily activities [1,2]. Although the technique is an accepted method, concerns remain regarding the technique that should be used for appendiceal stump closure [3]. A number of techniques have been described, such as endoloops, the intracorporeal suture technique, bipolar coagulation, metal clips, Hem-o-lok polymeric clips, and endostaplers [3-7]. Discussions about the effectiveness and safety of these new materials are still ongoing [3-9].

All the techniques offer obvious advantages and disadvantages at various clinical stages of acute appendicitis. Prospective clinical studies have evaluated the effectiveness, but the number of patients in these studies is low, and sufficient data on cost are not included [10,11]. Given the materials used in LA surgery, a safe and low-cost technique is required to reduce costs for the hospital and the patient.

A polymeric clip seems easier to use, faster, and at least as secure as a knot. It is also cheaper than an endostapler. Polymeric clips have found a wider range of application in daily practice [7,10,12-14]. With the widespread use of titanium endoclips in surgery, endoscopic procedures have been made easier, and operation times have significantly shortened. They can also be easily applied and do not require surgeons to have advanced surgical skills.

Many studies have been conducted on the use of metal clips to close the appendix stump [3,6,15]. However, there are serious concerns that clips do not provide adequate security, especially in cases where the appendix diameter increases significantly [16]. In a study on laparoscopic purse-string sutures (LPS), no difference was found between the groups regarding the use of polymeric clips and intracorpereal sutures [17].

The aim of the present clinical study is to evaluate the safety and effectiveness of three techniques under routine conditions: LPS, metal clips, and Hem-o-lok clips. The aim is to evaluate the advantages, safety, and costs of the methods.

Materials and methods

The clinical, paraclinical, and intraoperative data files of patients who underwent LA between May 2017 and December 2019 were examined. A retrospective comparative analysis was performed for appendix stump closure for three groups with different surgical techniques. Group A received LPS, group B received metal clips, and group C received Hem-o-lok clips.

Patients were excluded if they had an American Society of Anesthesiology (ASA) score ≥ III, a history of anesthetic or narcotic analgesic allergy, abdominal surgery, were pregnant or aged less than 18 years. The diagnosis of acute appendicitis and surgery was always made by an experienced surgeon. All operations were performed by surgeons who are experienced in LA. The groups were compared in terms of age, gender, ASA score, body mass index (BMI), comorbidity, complications, duration of surgery, length of hospital stay, and cost of hospitalization. After discharge, the patients were followed up in the outpatient clinic at one-week intervals for the monitoring of complications and full recovery. Post-operative outpatient records were reviewed. 220 patients who came to the outpatient clinic controls and whose file records were accessed were included. Fifty patients whose data were missing or did not show up for control visits were excluded from the study.

The surgical procedure followed a standard protocol. All patients were given a dose of first-generation cephalosporin for antibiotic prophylaxis before surgery. LA was performed using the classic three-port technique. Pneumoperitoneum was created using an open technique or a closed Veress needle technique depending on the surgeon's preferences, with carbon dioxide (CO2). Intra-abdominal pressure was adjusted to 10-12 mmHg. An 11-mm trocar (Johnson and Johnson, USA) was placed under the navel. A 5-mm trocar was then inserted into the left lower quadrant with a 5-mm trocar under direct vision of the right iliac fossa.

A 30-degree 10-mm laparoscope and 5-mm laparoscopic instruments such as an endograsper and an endoligasure were used. The patients were placed in the reverse inclined Trendelenburg position. The distal ileum was pushed to the left side of the abdomen to help reveal the appendix. After the appendix became visible, the mesoappendix was ligated with endoligasure (LigaSure, Covidien, Boulder, CO). After the appendix radix was introduced, the appendix stump was managed as follows:

In Group A, two intracorporeal knots and one intracorporeal knot 5 mm above the last were made in the base of the appendix, and resection was performed by cutting between these knots. The specimen was taken out of the abdomen in an endobag. Then, a sac suture was tied with 1.0-cm 3/0 vicryl around the base of the appendix (Figure 1E,F). By holding the two ends of the suture, the stump was inverted, buried, and knotted with the help of an endograsper.

In Group B, two titanium metal clips (LIGACLIP Extra Ligating Clip, Large, Ethicon Endo-Surgery, LLC, Cincinnati, OH) were placed on the base of the appendix, and one metal clip was placed 5 mm above them (Figure 1A,B). Cuts were made just above the two clips on the base of the appendix. The specimen was placed in the endobag and taken out of the abdomen from the 11-mm trocar.

In Group C, two Hem-o-lok clips (Hem-o-lok clips, Weck, Research Triangle Park, NC) were placed on the base of the appendix, and another Hem-o-lok clip was placed 5 mm above them (Figure 1C,D) through the trocar. Cuts were made just above the two Hem-o-lok clips on the base of the appendix. The specimen was placed in the endobag and taken out of the abdomen from the 11-mm trocar.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) 24.0 was used for statistical analysis. A one-way ANOVA test was used for intergroup comparisons of normally distributed parameters. Non-normally distributed parameters, which were presented with descriptive statistics (mean, standard deviation, median, frequency, rate, minimum, maximum) were compared with Kruskall-Wallis test. Pearson's chi-squared test was used to analyze qualitative data. *P*-value <0.05 were considered statistically significant.

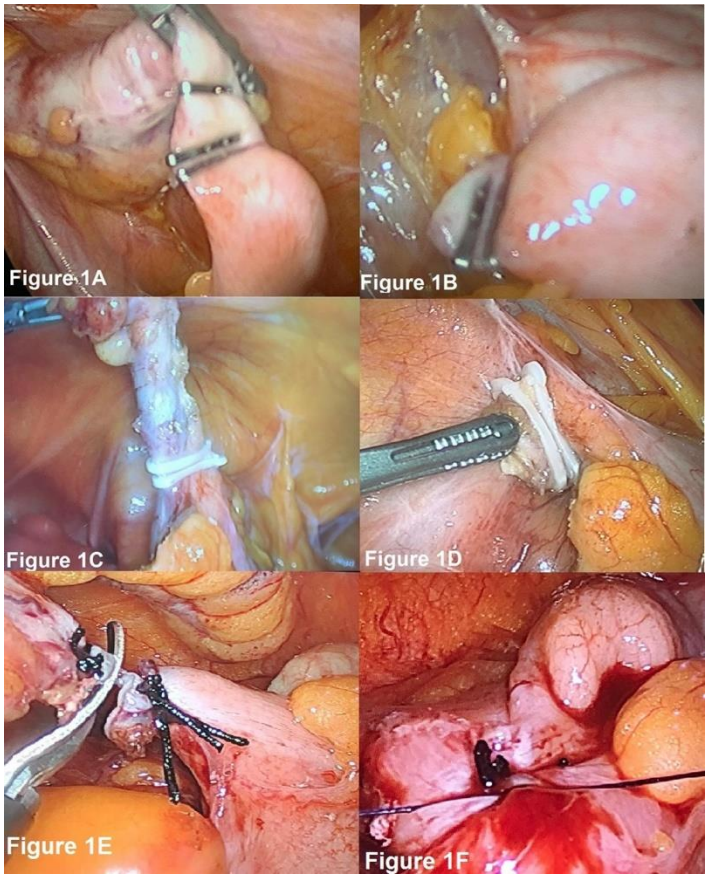

Figure 1: Laparoscopic view of closing the appendix stump. (1A) Intraoperative view of applied metal clips in laparoscopic appendectomy. (1B) Intraoperative view of appendix stump after applied metal clips. (1C) Intraoperative view of applied hem-o-lok clips in laparoscopic appendectomy. (1D) Intraoperative view of appendix stump after applied hem-o-lok clips. (1E) Intraoperative view of intracorporeal knots in laparoscopic appendectomy. (1F) Intraoperative view of appendix stump after applied intracorporeal knots.

Results

This retrospective study initially included 270 patients with acute appendicitis. Their history, physical examination, abdominal ultrasonography, and computerized tomography results were used for the diagnosis. Fifty patients were excluded from the study due to missing data and loss to follow-up. There were 79 patients in group A, 91 patients in group B, and 50 patients in group C. All surgical operations were completed successfully with the laparoscopic technique. The diagnosis was uncomplicated acute appendicitis for 188 patients and complicated acute appendicitis for 32 patients.

There was no significant difference between the two groups with respect to demographic features, ASA scores, white blood cell (WBC) counts, and neutrophil counts (Table 1). The mean durations of the procedure were 53.7 (19.6) minutes in group A, 51.9 (20.2) minutes in group B, and 47.8 (16.3) minutes in group C (Table 2). The rates of postoperative complications did not significantly differ between groups (P=0.474) (Table 2).

Patients were discharged at postoperative days 1–3 and controlled daily for 1 week. The Douglas space was drained due to perforated appendicitis in 8 patients in group A, 8 patients in group B, and 4 patients in group C. All drains were pulled out on postoperative days 5 or 6. There was no significant difference between three groups (P=0.256) (Table 2).

The mean hospitalization period after LA was 27.8 (48.3) hours in group A, 22.8 (19.0) hours in group B, and 34.1 (34.6) hours in group C. The total length of hospital stay varied significantly (P=0.001) (Table 2). According to the binary comparisons, the total length of stay was significantly higher in group C than groups B (P=0.002) and A (P=0.001). There was no significant difference between groups A and B (P=0.785) (Table 3).

The mean cost of the procedure was 247.9 (26.4) dollars in group A, 260.4 (24.9) dollars in group B, and 281.8 (38.5) dollars in group C. The costs differed significantly between groups (P=0.001) (Table 2). According to the binary comparisons, group A's costs were significantly lower than those of group B (P=0.001) and group C (P=0.001). Group B's costs were significantly lower than those of group C (P=0.001) (Table 3).

Table 1: Demographic data of patients

		Suture (n:79)	Metal clip (n:91)	Hem-o-lok clip (n:50)	*P*-value
Age (years) Mean (SD)		30.01 (2.59)	30.07 (13.42)	33.70 (14.74)	[a]0.220
Gender (n)(%)	Male	43(54.4)	59(64.8)	29(58)	[b]0.111
	Female	36(45.6)	32(35.2)	21(42)	
BMI (kg/m2) Mean (SD)		28.12 (4.07)	27.84 (4.52)	28.23 (3.59)	[a]0.912
ASA score (n)(%)	I	44(55.7)	49(53.8)	29(58)	
	II	31(39.2)	32(35.1)	17(34)	[a]0.564
	III	4(5.1)	10(11.1)	4(8)	
WBC (cell/mm3) Mean (SD)		14006 (4049)	14398 (3987)	13381 (3472)	[a]0.335
Neutrophil (cell/mm3) Mean (SD)		11010 (4163)	11785 (3706)	10366 (3507)	[a]0.099
Co-morbidities (n) (%)		18(22.7)	21(23.1)	11(22)	[a]0.756
Diagnostic imaging (n) (%)	CT	54(68.3)	61(67.1)	32(64)	[a]0.876
	US	25(31.7)	30(32.9)	18(36)	

BMI: Body mass index, ASA score: American Society of Anesthesiologists physical classification system, WBC: White blood cell, CT: Computed tomography, US: Ultrasonography

Table 2: The characteristics of the operation results

		Suture (n:79)	Metal clip (n:91)	Hem-o-lok clip (n:50)	*P*-value
LGS* Score (n) (%)	LGS* 0, 1, 2	52(65.8)	78 (85.7)	42 (84)	
	LGS* 3a	12 (15.2)	8 (8.7)	3 (6)	[a]0.032
	LGS* 3b	8 (10.1)	0	0	
	LGS* 4a	3 (3.7)	2 (2.1)	2 (4)	
	LGS* 4b	2 (2.5)	1 (1.1)	1 (2)	
	LGS* 5	2 (2.5)	2 (2.1)	2 (2)	
Postoperative complications (n) (%)		8 (10.1)	5 (5.5)	5 (10)	[b]0.474
Trocar site infection (n) (%)		4 (5.1)	7 (7.7)	7 (14)	[b]0.192
Drain (n) (%)		8 (10.1)	8 (8.8)	4 (8)	[b]0.256
Hospital stay (hours) Mean (SD)		27.8 (48.3)	22.8 (19.0)	34.1 (34.6)	[c]0.001
Operative time (minute) Mean (SD)		53.7(19.6)	51.9 (20.2)	47.8 (16.3)	[a]0.233
Hospital cost (dollar) Mean (SD)		247.9 (26.4)	260.4 (24.9)	281.8 (38.5)	[c]0.001
Price (dollar)		3.2[x]	6.42[y]	20.71[z]	[c]0.001

[a] One-Way Anova Test, [b] Pearson Chi-Square Test, [c] Kruskall Wallis, LGS*: Laparoscopic grading system of acute appendicitis according to Gomes Score [16] (the appendix was graded based upon its appearance: Grade 0 (normal looking), 1 (redness and edema), 2 (fibrin), 3a (segmental necrosis), 3b (base necrosis), 4a (abscess), 4b (regional peritonitis), and 5 (diffuse peritonitis), x: The price of three silk suture, y: The price of three metal clips, z: The price of three Hem-o-lok clips.

Table 3: Post-Hoc results

	Techniques	*P*-value
Hospital stay	Suture/Metal clip	0.785
	Suture/Hem-o-lok clip	<0.001*
	Metal clip/Hem-o-lok clip	<0.002*
Hospital cost	Suture/Metal clip	<0.001*
	Suture/Hem-o-lok clip	<0.001*
	Metal clip/Hem-o-lok clip	<0.001*

Mann Whitney U test, * P<0.01

The total complication rates of Group A, Group B, and Group C were 15.1, 13.1 and 24%, respectively (Table 2). There was no significant difference between the groups in terms of wound infection, intra-abdominal abscess, and postoperative ileus. Antibiotic treatment was administered in 5 patients in Group A, 4 patients in group B, and 4 patients in group C. In group B, 2 patients were treated with USG-guided percutaneous drainage and antibiotic therapy. Ileus developed in 1 patient in each group and healed with medical treatment. Four patients in group A, 7 patients in group B and 7 patients in group C

developed wound infections that were treated with antibiotic therapy.

Discussion

Due to faster recovery, less pain, and less surgical complications in the treatment of acute appendicitis, laparoscopic treatment has been widely accepted worldwide [1,2]. LA is a safe procedure for the treatment of uncomplicated acute appendicitis, but there is no common consensus for the laparoscopic treatment of complicated appendicitis due to studies showing high and low rates of post-operative intra-abdominal abscess (POIAA) [2,18-22]. Peroperative classification of complicated and uncomplicated acute appendicitis is highly valuable [16].

Postoperative complication rates are higher in complicated appendicitis, regardless of the appendix stump closure technique, and include intraabdominal abscess formation, wound infection, and paralytic ileus [1-8,23]. This suggests that the main determinant of postoperative complications depends on the degree of the disease rather than the method used. It is reasonable to consider that the presence and extent of peritonitis may be risk factors for POIAA, and perforated appendicitis without pus in the abdominal cavity may have lower rates than in those complicated with peritonitis.

Despite the shorter hospital stay and lower perioperative complication rates of LA, the hospital cost is still high compared to open appendectomy [22]. The appendix stump closure technique and the materials used are important in LA. Safe closure of the appendix stump is important to prevent potential postoperative complications (such as postoperative peritonitis, sepsis, and fistulas) and reoperation. Numerous studies have been carried out on techniques such as the endoloop, endostapler, metal clips, and Hem-o-lok clips, and intracorporeal knot for the closure of the appendix stump [3-13]. However, there is still no consensus on the ideal technique. The closure technique of embedding the stump used in open appendectomy was attempted using alternative techniques in a laparoscopic procedure.

Studies using endostaples to close the appendix stump have been carried out, but this method requires advanced laparoscopic training [5,11,14,15,24]. Staples are safe to use but very expensive. In addition, lost staple clips have been shown to cause peritoneal adhesions that lead to complications such as small bowel obstruction or ileus [15,24,25]. The appendix stump closure selection is up to the surgeon's preference, but an endostapler is recommended in cases of necrosis and inflammation of the base of the appendix [25].

Endoloops are also widely used and are one of surgeons' preferences [4,5,12,25]. The endostapler and endoloop methods were compared in a clinical prospective, observational, multicenter, high-case cohort study conducted by Van Rossem et al. There was no significant difference between the groups in terms of postoperative intraabdominal infections. Nevertheless, they recommended using endoloops in terms of cost. In this study, a double endoloop proximal to base of the appendix was proposed in the presence of inflammation.

Another method used for appendix stump closure is the titanium metal clip technique. Studies suggest that titanium metal clips are safe and cost effective for fixing the base of the appendix in LA [3,6,16]. In a clinical study, the metal clip technique was evaluated in patients with complicated appendicitis. Acute appendicitis grading was evaluated and classified according to peroperative laparoscopic findings. It was emphasized that the presence of local and diffuse peritonitis does not cause difficulty for the metal clip technique. Nine of twelve patients with appendicular base necrosis were safely treated with laparoscopic suture and laparotomy, and the metal clip technique is not recommended in these cases [16].

Recently, the use of simple non-absorbable clips, such as the Hem-o-lok clip, has become widespread for the closure of the appendix stump. The advantages of these clips are effortless application, low cost, and robust and safe stump closure [10-15]. In a clinical study, Delibegovic et al. stated that the method is effective and safe for closure of the appendix stump.

In our study, a secure closure was achieved by tying the appendix stump with 2 intracorporeal knots, suturing 1 cm from the stump, and embedding it in the cecum. Our technique provides a safe closure in cases with appendix radix necrosis, which is defined as 3D in the classification made by Gomez et al. We defined the LPS technique in our clinical study in 2017 [26]. In a similar study, Shadhu et al. compared the intracorporeal knot, Hem-o-lok clip, and laparoscopic purse string suture techniques and stated that all techniques are safe in cases of complicated appendicitis [17].

The stump closure techniques affect the operation times. While devices such as the Hem-o-lok clip, metal clip, and endostapler can be applied easily [6-13,27], techniques such as the intracorporeal knot, endoloop, and LPS techniques require surgical skills and experience [3-5]. A Cochrane review published in 2017 compared the results of endostapler and ligation methods (endoloop and intracorporeal knot) and found that the endostapler technique significantly reduced the operation time [28]. Again, both Hem-o-lok clip and metal clip applications significantly decreased the operation times compared to ligation techniques.

In a randomized clinical study conducted by Begovic et al. [27], the endoloop group had significantly longer operations than the endostapler group with clip techniques. The metal clip technique had a shorter time than the endostapler technique, but there was no significant difference between the Hem-o-lok clip and the endostapler group. In the same study, the operation time was significantly shorter in the Hem-o-lok group than the metal clip group [27]. In a retrospective clinical study by Shadhu et al. there was no significant difference in the duration of surgery in the intracorporeal knot, Hem-o-lok clip, and LPS techniques. It is much more difficult to apply LPS near the appendicular stump during LA, and it requires some experience in laparoscopic suturing [17].

In our study, even the LPS technique could not be applied in some serious cases due to cecum edema, and partial cecal resection was performed with an endostapler in these cases. The Hem-o-lok polymeric clip technique has been found feasible and safe for the appendicular stump [6-11]. However, the safe use of Hem-o-lok and metal clips is significantly limited by the maximum diameter of the 10-mm closure insert. In our study, the LPS technique was applied to patients who could not receive the Hem-o-lok clip technique.

The most common complications after LA are of infectious origin, and the most serious is intra-abdominal abscess formation [1,2]. This complication has important clinical consequences because frequent intervention or hospitalization is required. In a meta-analysis of 11 studies, wound-related infections were present in 92 (4.2%) of 2175 operated patients with acute complicated appendicitis [29]. In the same study, the postoperative intraabdominal abscess rate was 5.9% (1059/63) [29]. Abundant irrigation of the abdominal cavity with 0.9% saline solution has been stated as a possible cause of this development, and rational local irrigation with aspiration and gauze application was recommended [2]. The type of appendix stump closure has not been proven to affect this complication.

In a Cochrane systematic review, there was no significant difference in the postoperative complications between endoscopic clip and ligation techniques (endoloop and intracorporeal knots) for closure of the appendix stump [28]. This meta-analysis showed a significant decrease in postoperative complications with the use of the endostapler device compared to the ligation techniques [28]. This decrease in postoperative complications revealed that the endostapler technique triggered a reduction in postoperative superficial wound infections compared to ligation techniques.

There was no significant difference between groups in terms of POIAA or postoperative ileus [28]. In a retrospective clinical study, Shadhu et al. stated that there was no significant difference between LPS, Hem-o-lok clip and intracorporeal knot groups in terms of wound infection and POIAA. In our study, no significant difference was found between LPS, metal clips and Hem-o-lok clips in terms of postoperative complications.

It is accepted worldwide that LA is a costly method compared to open appendectomy. For this reason, a safe and low-cost technique is required to close the appendix stump to reduce costs for the hospital and the patient. Cost analysis is limited to data on consumable costs, and data on indirect costs are not available [28]. Consumable prices also differ from country to country [28,30]. Unfortunately, there is no study in which appendix suture closure techniques are compared in terms of hospital costs. Shadhu et al. compared LPS, hemoclip, and intracorporeal knot techniques, but no cost was given.

In our study, hospital costs differed significantly among groups. According to binary comparisons, the hospital costs in LPS were significantly different than those in which clips were used. Hospital costs in patients with metal clips were significantly lower than those with local clips. Consumable costs differed significantly by group.

Limitations

Our study has some limitations. The study was retrospective and allocated to one or another treatment arm because of the individual decision of the treating surgeon, so both groups of patients differed in disease severity. Therefore, no conclusions could be drawn regarding the equivalence of stump closure by LPS, metal clip or Hem-o-lok clip at the same disease stage. In addition, because of inflammation and necrosis (Gomez classification 3B), the LPS technique was applied in patients in which metal clip could not be used, because the appendix stump diameter was over 10 mm.

Conclusion

The use of LPS for appendix stump closure in LA operations is safe and effective. Our data clearly show that a significant percentage of routine LA (32%) is suitable for clip closure without an increase in intra- and postoperative complications. This technique significantly reduces consumables and hospital treatment costs. Our study supports the use of the LPS technique in complicated appendicitis cases with necrosis and perforation of the appendix base.

References

1. Sauerland S, Jaschinski T, Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database Syst Rev. 2010;4;10:CD001546.
2. Pedersen AG, Petersen OB, Wara P, Rønning H, Qvist N, Laurberg S. Randomized clinical trial of laparoscopic versus open appendicectomy. Br J Surg. 2001;88:200-5.
3. Ates M, Dirican A, Ince V, Ara C, Isik B, Yilmaz S. Comparison of intracorporeal knot-tying suture (polyglactin) and titanium endoclips in laparoscopic appendiceal stump closure: a prospective randomized study. Surg Laparosc Endosc Percutan Tech. 2012;22:226-31.
4. Sahm M, Kube R, Schmidt S, Ritter C, Pross M, Lippert H. Current analysis of endoloops in appendiceal stump closure. Surg Endosc. 2011;25:124-9.
5. Safavi A, Langer M, Skarsgard ED. Endoloop versus endostapler closure of appendiceal stump in pediatric laparoscopic appendectomy. Can J Surg. 2012;55:37-40.
6. Rickert A, Bönninghoff R, Post S, Walz M, Runkel N, Kienle P. Appendix stump closure with titanium clips in laparoscopic appendectomy. Langenbecks Arch Surg. 2012;397:327-31.
7. Delibegovic S, Matovic E. Hem-o-lok plastic clips in securing of the base of the appendix during laparoscopic appendectomy. Surg Endosc. 2009;23:2851-4.
8. Martín del Olmo JC, Blanco Alvarez JI, Carbajo Caballero MA, de la Cuesta de la Llave C, Vaquero Puerta C, Arenal J. Laparoscopic appendectomy by ultrasonically activated scalpel in acute appendicitis: preliminary report. J Laparoendosc Adv Surg Tech A. 2002;12:111-3.
9. Suttie SA, Seth S, Driver CP, Mahomed AA. Outcome after intra- and extra-corporeal laparoscopic appendectomy techniques. Surg Endosc. 2004;18:1123-5.
10. Knight SR, Ibrahim A, Makaram N, Patil P, Wilson MSJ. The use of polymeric clips in securing the appendiceal stump during laparoscopic appendicectomy: a systematic review. Eur J Trauma Emerg Surg. 2019;45:665-70.
11. Al-Temimi MH, Berglin MA, Kim EG, Tessier DJ, Johna SD. Endostapler versus Hem-O-Lok clip to secure the appendiceal stump and mesoappendix during laparoscopic appendectomy. Am J Surg. 2017;214:1143-8.
12. Colak E, Kement M, Ozlem N, Mutlu T, Yildirim K, Gurer A, et al. A comparison of nonabsorbable polymeric clips and endoloop ligatures for the closure of the appendicular stump in laparoscopic appendectomy: a prospective, randomized study. Surg Laparosc Endosc Percutan Tech. 2013;23:255-8.
13. Varghese G. Feasibility and efficacy of using Hem-o-lok polymeric clips in appendicular stump closure in laparoscopic appendectomy. Cureus 2018;10(6):e2871.
14. Graham CW, Komidar L, Perger L. Comparison of polymeric clips and endoscopic staplers for laparoscopic appendectomy. J Laparoendosc Adv Surg Tech A. 2019;29:240-2.
15. Kliuchanok K, Keßler W, Partecke I, Walschus U, Schulze T, Heidecke CD, et al. A comparison of non-absorbable polymeric clips and staplers for laparoscopic appendiceal stump closure: analysis of 618 adult patients. Langenbecks Arch Surg. 2019;404:711-6.
16. Gomes CA, Junior CS, de Peixoto RO, Netto JM, Gomes CC, Gomes FC. Appendiceal stump closure by metal endoclip in the management of complicated acute appendicitis. World J Emerg Surg. 2013;18;8:35.
17. Shadhu K, Ramlagun D, Wang Y, Ping X, Chen T, Zhu Y, et al. Re-evaluation of purse string suture in laparoscopic appendectomy. Surg Endosc. 2020;34:779-86.
18. Pokala N, Sadhasivam S, Kiran RP, Parithivel V. Complicated appendicitiseis the laparoscopic approach appropriate? A comparative study with the open approach: outcome in a community hospital setting. Am Surg. 2007;73;737-41.
19. Pirro N, Berdah SV. Appendicitis: yes or no to laparoscopic approach? J Chir (Paris). 2006;143:155-9.
20. Kouwenhoven EA, Repelaer van Driel OJ, van Erp WF. Fear for the intraabdominal abscess after laparoscopic appendectomy: not realistic. Surg. Endosc. 2005;19:923-6.
21. Katkhouda N, Mason RJ, Towfigh S, Gevorgyan A, Essani R. Laparoscopic versus open appendectomy: a prospective randomized double-blind study. Ann Surg. 2005;242:439-48.
22. Biondi A, Di Stefano C, Ferrara F, Bellia A, Vacante M, Piazza L. Laparoscopic versus open appendectomy: a retrospective cohort study assessing outcomes and cost-effectiveness. World J Emerg Surg. 2016;30;11:44.
23. Çalışkan Y. Original Alvarado scoring system in the diagnosis of acute appendicitis: A cohort study. J Surg Med. 2017;1:28-31.
24. Wagner M, Aronsky D, Tschudi J, Metzger A, Klaiber C. Laparoscopic stapler appendectomy. A prospective study of 267 consecutive cases. Surg Endosc. 1996;10:895-9.
25. van Rossem CC, van Geloven AA, Schreinemacher MH, Bemelman WA. Endoloops or endostapler use in laparoscopic appendectomy for acute uncomplicated and complicated appendicitis: No difference in infectious complications. Surg Endosc. 2017;3:178-84.
26. Gunes ME, Gemici E, Donmez T. Comparison of Laparoscopic Embedding Technique and Other Techniques for Appendiceal Stump Closure. Turk J Colorectal Dis. 2019;29:121-6.
27. Delibegović S, Mehmedovic Z. The influence of the different forms of appendix base closure on patient outcome in laparoscopic appendectomy: a randomized trial. Surg Endosc. 2018 ;32:2295-9.
28. Mannu GS, Sudul MK, Bettencourt-Silva JH, Cumber E, Li F, Clark AB, et al. Closure methods of the appendix stump for complications during laparoscopic appendectomy. Cochrane Database Syst Rev. 2017 Nov 13;11:CD006437.
29. Markides G, Subar D, Riyad K. Laparoscopic Versus Open Appendectomy in adults with Complicated Appendicitis: Systematic Review and Metaanalysis. World J Surg. 2010;34:2026-40.
30. Śmigielski J, Piskorz Ł, Koptas W. Comparison of treatment costs of laparoscopic and open surgery. Videosurgery and Other Miniinvasive Techniques 2015;10:437-41.

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