Original Article

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Comparison of Burying the Appendiceal Stump Using Laparoscopic and Open Methods in Complicated Acute Appendicitis

Komplike Akut Apandisitte Laparoskopik ve Açık Yöntemle Güdük Gömmenin Karşılaştırması

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ABSTRACT

Objective: *The choice of laparoscopic technique in the treatment of complicated acute appendicitis (CAA) harbours debatable evidence because of higher rates of surgical complications such as postoperative intraabdominal abscess (POIIA). The aim of this study is to compare postoperative results of appendiceal stump (AS) ligation and its burial into the cecum using laparoscopic or open surgical techniques in patients with CAA.*
Method: *This is a single-center and retrospective analysis of patients with CAA operated between May 2018 and April 2020. AS was intracorporeally knotted with silk and buried in the cecum with a purse-string suture (PSS). The patients were divided into open appendectomy (OA) and laparoscopic appendectomy (LA) groups. Data concerning demographic characteristics, intraoperative variables, hospital stay, surgical complications, morbidities, and postoperative findings were compared.*
Results: *A total of 66 patients including 36 patients (54.54%) underwent LA and 30 patients had OA were enrolled in the study. Partial resection of cecum was performed in one patient in the OA group and two patients in the LA group with the help of a stapler due to cecal floor necrosis. The operative time and duration of hospital stay were significantly shorter in the LA group compared to the OA group. Surgical site infection and POIAA were significantlymore frequent in the OA group (p<0.001).*
Conclusion: *In acute complicated appendicitis, laparoscopic method can be applied as an effective method by closing the appendiceal stump and burying into the cecum with a purse-string suture.*

Keywords: *complicated acute appendicitis, open appendectomy, laparoscopic appendectomy, purse- string suture*

ÖZ

Amaç: *Ameliyat sonrası intraabdominal apse (POIIA) gibi daha yüksek cerrahi komplikasyonlar nedeniyle komplike akut apandisiti (CAA) olan hastalarda laparoskopik yaklaşımın kullanımına ilişkin tartışmalı kanıtlar vardır. Bu çalışmanın amacı, CAA'lı hastalarda laparoskopik veya açık cerrahi teknik kullanılarak apendiks güdüğünün ligasyonu ve çekuma gömülme yönteminin postoperatif sonuçlarını karşılaştırmaktır.*
Yöntem: *2Mayıs 2018'den Nisan 2020'ye kadar ameliyat edilen CAA hastalarının klinik kayıtlarının tek merkezli retrospektif bir analizidir. Apendiks güdük intrakorporeal olarak ipekle düğümlendi ve kese ağzı sütürü (PSS) ile çekuma gömüldü. Hastalar açık apendektomi (OA) ve laparoskopik apendektomi (LA) olarak iki gruba ayrıldı. Demografik veriler, intraoperatif değişkenler, hastanede kalış süreleri, cerrahi komplikasyonlar, morbidite ve ameliyat sonrası bulgular karşılaştırıldı.*
Bulgular: *Çalışmaya 36 LA (% 54,54) ve 30 OA olmak üzere toplam 66 hasta dahil edildi. Çekum taban nekrozu nedeniyle OA grubunda 1, LA grubunda 2 hastaya stapler yardımı ile parsiyel çekum rezeksiyonu yapıldı. LA grubunda ameliyat süresi ve hastanede kalış süresi OA grubuna göre anlamlı olarak daha kısaydı. Cerrahi alan enfeksiyonu ve POIAA OA grubunda LA grubuna göre anlamlı derecede yüksekti (p <0.001).*
Sonuç: *Akut komplike apandisitte laparoskopi, apendiks güdüğünün kapatılması ve çekumun kese ağzı sütürü ile gömülmesiyle güvenli ve etkili bir yöntem olarak uygulanabilir.*

Anahtar kelimeler: *komplike akut apandisit, açık apendektomi, laparoskopik apendektomi, gömme, kese ağzı sütürü*

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INTRODUCTION

Acute appendicitis is seen in 25% of the patients admitted to the emergency department due to abdominal pain [1,2]. Laparoscopic appendectomy has been shown to result in less postoperative pain, reduced hospital stay, better cosmetic results and faster return to normal activities compared to open appendectomy [3-5]. Because of these features, minimally invasive techniques are preferred for surgical surgery. Complicated acute appendicitis (CAA) can be seen in 20-30% of acute appendicitis cases. In the literature, it is a difficult decision to prefer LA in the treatment of complicated appendicitis (CA). However, new studies argue that LA is preferable in CAA [6,7]. LA opponents for complicated appendicitis emphasize fascial perforation and abscess as a relative contraindication to the laparoscopic approach [8].

Postoperative peritonitis, fistula and life-threatening conditions such as sepsis may occur due to ineffective closure of the appendicular stump (AS). For this reason, stump closure is critical during appendectomy surgery. Two techniques have been described for AS closure: as burying the AS after closure or simply closing the stump [9]. While OA can be easily applied using these two techniques, more easily applicable methods have been developed in LA. Different techniques using endo-stapler, endo-loop, metal endo-clip and hem-o-lok clip have been employed to close the stump in LA [10-13]. However, the application of these techniques may not always be possible in complicated appendicitis. If the diameter of the appendix is increased significantly, then necrosis and perforation are close to the base of the appendix, and these techniques may be impossible to apply.

In CAA, OA is also preferred as a safe method for the closure, inversion, and then burying the AS into in the cecum. In our retrospective clinical study, we compared the OA and laparoscopic PSS techniques in CA closure of the AS.

MATERIAL and METHODS

This retrospective study was conducted from February 2017 to November 2019. We analyzed 66 patients with CAA who underwent either open or laparoscopic technique. Ultrasonography and CT were applied to the patients as radiological imaging. CAA was detected using either USG (n=20) or CT (n=46). Surgical techniques were preferred by the surgeon. After surgery, patients were divided into two groups: Group OA (n:30), and Group LA (n:36). Surgical techniques (LA and OA) that the patients would choose were explained to the patients before the surgery. The surgeon informed the patients that the laparoscopic technique can be converted to an open technique and signed their approval.

Data concerning demographic characteristics, C-reactive protein (CRP), white blood cell (WBC) values and comorbidities of the patients were retrieved from the patient files and the computer system. Operation time, hospital stay, postoperative complications and time to enteral feeding were calculated and evaluated.

Ethics Approval

Approval of the Local Ethics Committee was obtained on December 3, 2018 (approval number: BEAH/2018-22).

Surgical Techniques

The operation started after standard general anesthesia. Preoperatively all patients were given 500 mg ciprofloxacin + 500 mg metronidazole iv.

In the first group, the transrectal incision was made at the Mc-Burney point in open appendectomy. After entering the peritoneal cavity, a retractor was inserted into the wound. Mesoappendix was found and tied. AS was held and inverted, and buried in the cecum with a purse- string suture.

In Group 2, a laparoscopic knot-purse-string suture technique was performed. The trocar was entered into the intraperitoneal area and pneumoperitoneum was created. Additional trocars were entered through the appropriate ports. The operating table was tilted to the Trendelenburg position and remained at that position until the end of the surgery. Diagnosis of CA was confirmed by exploration (Figure 1A). The appendix and meso-appendix were separated using 5 mm LigaSure®. The AS was tied with an intracorporeal knot (ICK) using a multifilament non-absorbable suture near the base of the appendix (Figure 1B). Two knots were placed in the first step and one knot in the next step. After the appendix was excised, it was taken out of the abdominal cavity with an endobag. The pelvic area was checked for pus. If there was pus, the area was aspirated. A purse-string suture, which was placed 1 cm away from the stump, was realized using a multifila-

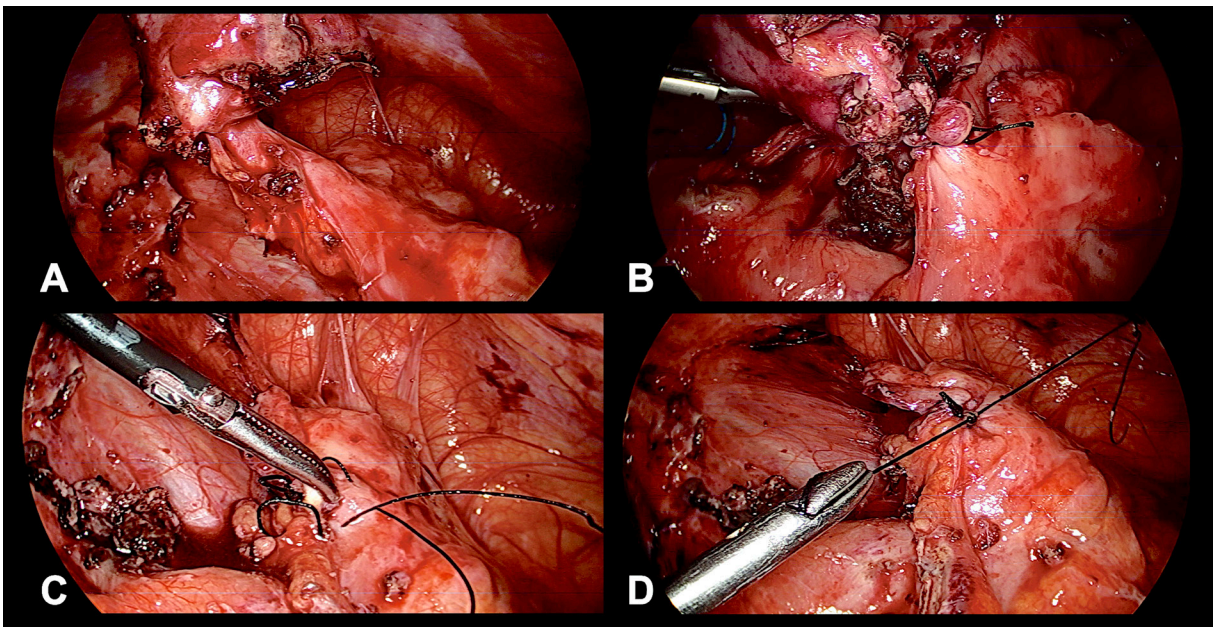

Figure 1A: Intraoperative view The appearance of complicated acute appendicitis. 1B: Intraoperative view: The appendiceal stump was tied close to the base of the appendix with 2/0 silk and an intracorporeal knot. 1C: Intraoperative view: The purse string using atraumatic 3/0 silk thread that will be passed through the 1 cm-thick stump 1D: Intraoperative view the appendiceal stump is inverted and buried in the cecum

ment non-absorbable suture. AS was inverted and buried in the cecum (Figures 1C and D).

All patients, except those with gastrointestinal complaints, started oral intake at the postoperative 4th hour. A nonsteroidal anti-inflammatory agent was used for the treatment of postoperative pain. Patients were followed for four weeks after surgery. Wound infections, conditions of the suture, complications and patients' complaints were recorded.

Statistical Analysis

Descriptive statistics were used to present the demographic characteristics of the study population. Differences between these groups were tested using the Pearson or Fisher's test for categorical variables, and Mann-Whitney U test or independent t-test were used for continuous variables. All analyzes were done using JMP Statistics on the computer. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Sixty-six patients were operated on with the diagnosis of CAA. The laparoscopic technique was applied to 36, and open technique to 30 patients. There was not any significant intergroup difference as for demographic data, levels of CRP and WBC (Table 1).

Table 1. The demographic characteristics, ASA scores, comorbidities and blood values of the patients are shown in the table.

Variables	Group 1 (n:30)	Group 2 (n:36)	Total (n:66)	p value
Age (median (±SD))	37.33 (±17.24)	36.03 (±13.28)	36.62 (±15,10)	0.852
Gender (%)	30 (45)	36 (55)	66 (100)	0.601
Female	9 (30)	13 (36.1)	22 (33.3)	
Male	21 (70)	23 (63.89)	44 (66.67)	
BMI (kg/m²) (median (±SD))	27.44 (±3.57)	27.55 (±5.26)	27.5 (±4.54)	0.918
ASA† classification (n (%))				0.241
I (normal healthy patient)	16 (53.33)	24 (66.67)	40 (60.61)	
II (mild systemic disease)	13 (43.33)	9 (25)	22 (33.33)	
III (severe systemic disease)	1 (3.33)	3 (8.33)	4 (6.06)	
Co-morbidities (n (%))	4 (13.33)	6 (16.67)	10 (15.15)	0.473
Diabetes Mellitus	0 (0)	2 (5.56)	2 (3.03)	
Hypertension	3 (10)	3 (8.33)	6 (9.09)	
Chronic Heart Disease	1 (3.33)	1 (2.78)	2 (3.03)	
WBC‡ (10^3/mm^3) (median (±SD))	15033.33 (±5052)	15208.33 (±3570)	15128.79 (±4273)	0.752
CRP (mg/dl) (mean (±SD))**	10.73 (±4.95)	10.36 (±6.34)	10.53 (±5.71)	0.457

**BMI:Body mass index, †ASA: American Association of Anesthesiology Score, ‡WBC:White blood cell,*
***CRP:C reactive protein*

Diffuse peritonitis was observed in 14 (46.66%) of 30 patients who underwent OA and 21 (58.33%) of 36 patients who had LA without any significant difference between both groups (p: 0.586) (Table 2). The cecum was partially resected with a linear stapler in 3 patients due to cecal necrosis in Groups LA (2/36; 6.56%) and OA (1/30; 3.33%) (Table 2).

Table 2. The operation time, duration of hospital stay, presence of drain, closure of the appendix stump, morbidity of the patients who underwent surgery are shown in the table.

Variables	Group1 (n:30)	Group 2 (n:36)	Totally (n:66)	p value
Operative time (min (±SD))	85.03 (±32.48)	65.67 (±9.88)	74.47 (±24.85)	0.002
Drain insertion (n (%))	27 (90)	22 (61,11)	49 (74,24)	0.008
Hospital Stay (hour (±SD))	156.8 (±101.77)	51 (±31.78)	99.09 (±89.35)	0.001
Conversion	0	0	0	N/A
Appendiceal stump (n (%))				0.876
Ligation and PSS*	29 (96.67)	34 (94.44)	62 (95.46)	
Linear stapler/ End-GIA	1 (3.33)	2 (6.56)	3 (4.54)	
Periperative diagnosis (n (%))				
Peritonitis	14 (46.66)	21 (58.33)	35 (53.03)	0.586
Abscess	16 (53.34)	15 (41.67)	31 (46.97)	
30-day morbidity (n (%))				
SSI†	6 (20)	4 (11.11)	10 (15.15)	0.001
POIAA‡	5 (16.67)	1 (2.78)	6 (9.09)	0.001
PI§	2 (6.67)	2 (5.56)	4 (6.06)	0.120
ASL††	0	0	0	N/A

**PSS; Purse string suture*
†SSI; Surgical site infection
‡POIAA; Postoperative intraabdominal abscess
§PI; Postoperative ileus
††ASL;Appendiceal stump leakage

Operation time was statistically significantly different between the two groups. The mean duration of operation was calculated as 65.67± 9.88 minutes in the Group LA and 85.03±32.48 minutes in the Group OA (p < 0.001) (Table 2). There was a significant difference in the mean hospital stays between both groups (156.8 ± 101.77 hours and 51 ± 31.78 hours in the Groups OA and LA, respectively (p < 0.001) (Table 2).

A drain was inserted in 90% of the patients in the Group OA and in 61.11% of the patients in the Group LA. Surgical site infection (SSI) occurred in 4 LA (11.11%) and in 6 OA patients (20%) (p: 0.001).

Postoperatively, 6 patients had POIAA (Group OA:, n=5; Group LA, n=1) (p: 0.001)) (Table 2). All patients were primarily treated with a drain inserted under USG guidance.

DISCUSSION

The use of LA in the management of uncomplicated appendicitis was reported in 1980 by Seem et al. It is still a reliable and effective technique since then [3]. Studies have shown that LA is more preferable to OA. Lesser postoperative pain, scarring and faster return to normal life are the most important advantages of LA [2-5]. Morbidity rates increase especially in perforated appendicitis. Surgical treatment of CA is usually associated with greater surgical stress, extended abdominal incision and a longer operative time compared to surgery performed for uncomplicated appendicitis [14-16].

Should the AS be buried after its closure? This remains to be a controversial subject? In particular, two techniques have been described in open appendectomy—that is, the closure and burying of the stump [9,17]. Results from a prospective randomized clinical study performed by Jacops et al. suggested that the AS should be buried in OA due to the possibility of infection, postoperative ileus and cecal fistula [17].

In a meta-analysis comparing closure and burial of the AS in OA, the rates of postoperative fever and wound infection were found to be similar between OA, and LA. When compared as for operative time, postoperative ileus and recovery rate, and closure of the AS, LA was found to be a relatively superior technique [18].

In uncomplicated acute appendicitis, there is a tendency in the literature for the AS to be closed only instead of buying it. Unfortunately, there was insufficient data on complicated appendicitis in another analysis that compared the closure and burial of the AS between both techniques. There is no evidence indicating that burying the AS improves postoperative results, as there are not enough studies on complicated appendicitis. Some studies suggest that postoperative ileus and length of hospital stay may adversely affect out-

comes. However, the scientific quality of these studies is not adequate to effectively stop surgeons from burying the AS [18,19].

In laparoscopic appendectomy, the closure of the AS is the most controversial issue. Although many authors have described AS closure techniques using new technological materials, a common consensus has not been achieved in this regard. In a clinical study by Gomez et al., the authors did not recommend the metal clip technique for AS closure, whereas the metal clip technique is inexpensive and easy to apply. However, they used this technique in cases where the diameter of the appendix is more than 1 cm and in cases of complicated acute appendicitis with perforation and necrosis at the base of the appendix or near the base [20]. In the AS closure, the clip method is presented as a cost-effective, easily applicable and safe technique [10,21,22]. In the study of Delibegovic et al., the authors suggested the use of endo-stapler in cases where the diameter of the inflamed appendix is more than the clip length since the use of the clip cannot provide a safe closure. It is said that the use of an endo-stapler for AS closure is safer than the laparoscopic endo-loop method in terms of preventing intraabdominal abscess formation [21]. Anyway, using endo-loops can reduce the cost of the surgery about 10 times, and also eliminates the risk of creating ileus from staples slipped into the abdomen [11,21,23]. Some studies have also reported that in open appendectomy closure of AS is successfully applied in the laparoscopy technique by ligating AS with a suture, passing it through PSS in the cecum and inverting it into the cecum [24,25]. In our retrospective clinical study, the AS was safely closed using this method, and no stump leak was observed in any of our patients. However, partial resection of cecum was performed in one patient in the OA group with large cecal floor necrosis and in two patients in the LA group with an endo-stapler to protect the ileocecal valve. In both groups, AS closure was successfully performed in cases of perforation or necrosis at or near the base of the appendix. The laparoscopic PSS technique is cheaper than other available techniques, but it requires advanced laparoscopic experience.

In our study, the OA group had significantly longer operation times than the LA group (85 vs. 65.7 minutes, p: 0.002). Other publications report longer or shorter operation times for LA when compared with OA [26,27]. Differences in studies may be related to surgeons' laparoscopic experience.

It is well-known that laparoscopy causes less postoperative adhesions and lower rates of mechanical intestinal obstruction [27]. However, in some studies, publications are indicating that rates of postoperative ileus may be higher in LA [28]. In our study, no difference was found between the LA group and the open group in terms of mechanical intestinal obstruction. We think that postoperative ileus may be caused by CAA that results in widespread peritonitis in both groups.

In most publications related to CAA, there is no clear consensus for categorizing CAA. Perforated appendicitis and peritonitis are the most important criteria for the classification of CAA [26-28]. In the literature, POIAA is more common after LA performed for CAA [26-28]. In a retrospective clinical study of 1516 patients, Horvath et al. stated that the reason why POIAA was significantly at a lower rate in the OA group was that during OA, the appendix was buried in the cecum after the stump was ligated, preventing contamination of the intraperitoneal area [27].The reason for the much greater incidence of POIAA in LA may be the position of the abdomen during the aspiration and leakage of the perforation fluid after removal of the sample. The patients were turned upside down and to the left to standardize the appearance of the operating field. Studies have shown that this position can spread the contamination inside the other quadrants of the abdomen [26-29]. Therefore, additional stump inversion is routinely performed during LA, further reducing endo-bag contamination [29]. Limited irrigation of the operating area is recommended in the Trendelenburg position [26-28]. In our study, POIIA was less common in the LA group compared with the OA group (1 vs. 5 patients, respectively). We think that the reason for our reduced POIIA rate may be due to the burying of the AS in the laparoscopic technique and the aspiration-irrigation performed in the supine position. In the OA group, we think that the perforation fluid in the intraabdominal cavity where cannot be reached through an open incision can lead to abscess formation. Indeed, in our study, subhepatic abscess detected in 4 patients of the OA group supports this assumption. POIIA cavities in both groups were emptied with percutaneous drainage under the guidance of USG.

SSI occurred more frequently in the OA group, but

intergroup difference was not statistically significant. Studies have shown that wound contact and not using endo-bags are among the reasons for the higher SSI rates in the OA group [26-28,30]. The inflamed appendix may have more tissue contact in the OA group. Since there is a smaller incision in LA, the contact is minimal [26-28]. All SSI patients were treated with antibiotherapy.

In randomized clinical trials comparing LA and OA, performed for CAA, a conversion rate of 0-16% to open technique has been reported. In our study, there was no patient in the LA group that required conversion to open technique. However, this technique could not be applied to 2 patients in the LA group due to large necrosis of the cecum floor, and partial resection of the cecum was performed in these patients.

Conclusion

The technique of burying AS applied in the open method can be safely practiced by experienced surgeons using the laparoscopic method in complicated CAA. This technique is effective, safe, and inexpensive.

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Contribution Details

Concept: SF, TD; design: SF, SY; definition of intellectual content: AS; literature search: SF, SA; clinical studies: TD, SF; experimental studies: MK; data analysis: SA; statistical analysis: SF; manuscript preparation: SY, AS; manuscript editing and manuscript review: TD, MK

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Informed Consent: Informed consent was obtained from all individual participants included in the study.

REFERENCES

1. Addiss DG, Shaffer N, Fowler BS, Tauxe RV. The epidemiology of appendicitis and appendectomy in the United States. Am J Epidemiol. 1990;132(5):910-25. https://doi.org/10.1093/oxfordjournals.aje.a115734
2. Ates M, Sevil S, Bulbul M. Routine use of laparoscopy in patients with clinically doubtful diagnosis of appendicitis. J Laparoendosc Adv Surg Tech A. 2008;18(2):189-93. https://doi.org/10.1089/lap.2007.0040
3. Semm K. Endoscopic appendectomy. Endoscopy. 1983;15(2):59-64. https://doi.org/10.1055/s-2007-1021466
4. Sauerland S, Jaschinski T, Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database Syst Rev. 2010;(10):CD001546. https://doi.org/10.1002/14651858.CD001546.pub3
5. Pedersen AG, Petersen O, Wara P, Rønning H, Qvist N, Laurberg S. Randomized clinical trial of laparoscopic versus open appendicectomy. Br J Surg. 2001;88(2):200-5. https://doi.org/10.1046/j.1365-2168.2001.01652.x
6. Penninga L, Gluud C, Wetterslev J. Meta-analysis of randomised trials on laparoscopic versus open surgery for acute appendicitis: has firm evidence been reached? J Gastrointest Surg. 2014;18(7):1383-4. https://doi.org/10.1007/s11605-013-2264-8
7. Ingraham AM, Cohen ME, Bilimoria KY, Pritts TA, Ko CY, Esposito TJ. Comparison of outcomes after laparoscopic versus open appendectomy for acute appendicitis at 222 ACS NSQIP hospitals. Surgery. 2010;148(4):625-37. https://doi.org/10.1016/j.surg.2010.07.025
8. Bonanni F, Hartzell G, Trostle D, Boorse R, Gittleman M, Cole A. Laparoscopic versus conventional appendectomy. J Am Coll Surg. 1994;179(3):273-8.
9. Blanc B, Pocard M. Surgical techniques of appendectomy for acute appendicitis. J Chir (Paris). 2009;146:22-31. https://doi.org/10.1016/j.jchir.2009.08.004
10. Graham CW, Komidar L, Perger L. Comparison of polymeric clips and endoscopic staplers for laparoscopic appendectomy. J Laparoendosc Adv Surg Tech A. 2019;29(2):240-2. https://doi.org/10.1089/lap.2018.0173
11. Beldi G, Vorburger S, Bruegger L, Kocher T, Inderbitzin D, Candinas D. Analysis of stapling versus endo-loops in appendiceal stump closure. Br J Surg. 2006;93(11):1390-3. https://doi.org/10.1002/bjs.5474
12. Suttie S, Seth S, Driver C, Mahomed A. Outcome after intra-and extra-corporeal laparoscopic appendectomy techniques. Surg Endosc. 2004;18(7):1123-5. https://doi.org/10.1007/s00464-003-9135-4
13. Cristalli BG, Izard V, Jacob D, Levardon M. Laparoscopic appendectomy using a clip applier. Surg Endosc. 1991;5(4):176-8. https://doi.org/10.1007/BF02653257
14. Tuggle KR-M, Ortega G, Bolorunduro OB, Oyetunji TA, Alexander R, Turner PL, et al. Laparoscopic versus open appendectomy in complicated appendicitis: a review of the NSQIP database. J Surg Res. 2010;163(2):225-8. https://doi.org/10.1016/j.jss.2010.03.071
15. Markides G, Subar D, Riyad K. Laparoscopic versus open appendectomy in adults with complicated appendicitis: systematic review and meta-analysis. World J Surg. 2010;34(9):2026-40. https://doi.org/10.1007/s00268-010-0669-z
16. Lin HF, Lai HS, Lai IR. Laparoscopic treatment of perforated appendicitis. World J Gastroenterol. 2014;20(39):14338-47. https://doi.org/10.3748/wjg.v20.i39.14338
17. Jacobs P, Koeyers G, Bruyninckx C. Simple ligation superior to inversion of the appendiceal stump; a prospective randomized study. Ned Tijdschr Geneeskd. 1992;136(21):1020-3. PMID: 1603146.
18. Qian D, He Z, Hua J, Song Z. Stump invagination versus simple ligation in open appendicectomy: a systematic review and meta-analysis. Int Surg. 2015;100(7-8):1199-206. https://doi.org/10.9738/INTSURG-D-15-00074.1
19. Blake L, Som R. Best evidence topic: What is the best management of the appendix-stump in acute appendicitis: Simple ligation or stump invagination? Int J Surg. 2015;24(Pt A):20-3. https://doi.org/10.1016/j.ijsu.2015.10.012
20. Gomes CA, Junior CS, de Peixoto RO, Netto JMB, Gomes CC, Gomes FC. Appendiceal stump closure by metal endoclip in the management of complicated acute appendicitis. World J Emerg

Surg. 2013;8(1):35.
https://doi.org/10.1186/1749-7922-8-35
21. 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(5):2295-99.
https://doi.org/10.1007/s00464-017-5924-z
22. 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(6):1143-8.
https://doi.org/10.1016/j.amjsurg.2017.08.031
23. Sajid MS, Rimple J, Cheek E, Baig MK. Use of endo-GIA versus endo-loop for securing the appendicular stump in laparoscopic appendicectomy: a systematic review. Surg Laparosc Endosc Percutan Tech. 2009;19(1):11-5.
https://doi.org/10.1097/SLE.0b013e31818a66ab
24. 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.
https://doi.org/10.4274/tjcd.galenos.2019.78857
25. 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(2):779-86.
https://doi.org/10.1007/s00464-019-06828-5
26. Horvath P, Lange J, Bachmann R, Struller F, Königsrainer A, Zdichavsky M. Comparison of clinical outcome of laparoscopic versus open appendectomy for complicated appendicitis. Surg Endosc. 2017;31(1):199-205.
https://doi.org/10.1007/s00464-016-4957-z
27. Quezada F, Quezada N, Mejia R, Brañes A, Padilla O, Jarufe N, et al. Laparoscopic versus open approach in the management of appendicitis complicated exclusively with peritonitis: a single center experience. Int J Surg. 2015;13:80-3.
https://doi.org/10.1016/j.ijsu.2014.11.027
28. Taguchi Y, Komatsu S, Sakamoto E, Norimizu S, Shingu Y, Hasegawa H. Laparoscopic versus open surgery for complicated appendicitis in adults: a randomized controlled trial. Surg Endosc. 2016;30(5):1705-12.
https://doi.org/10.1007/s00464-015-4453-x
29. 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;11(11):CD006437.
https://doi.org/10.1002/14651858.CD006437.pub3
30. Thomson J-E, Kruger D, Jann-Kruger C, Kiss A, Omoshoro-Jones J, Luvhengo T, et al. Laparoscopic versus open surgery for complicated appendicitis: a randomized controlled trial to prove safety. Surg Endosc. 2015;29(7):2027-32.
https://doi.org/10.1007/s00464-014-3906-y