

ORIGINAL ARTICLE

The advantages of the three-port combined technique for laparoscopically assisted extracorporeal base ligation in appendicitis in children

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ABSTRACT

Background: Laparoscopic appendectomy is the treatment of choice for acute appendicitis. The optimal technique of appendiceal stump closure is still under discussion because it is assumed to affect the occurrence of complications. The three-port combined technique with laparoscopically assisted extracorporeal base ligation (mesoappendix hemostasis performed intra-abdominally and the appendix ligated extra-abdominally) represents a novel technique with which to ligate the appendiceal stump following laparoscopic appendectomy. We compared this combined technique with the appendix stump treatment technique using an endoscopic loop, for complicated and uncomplicated appendicitis.

Material and methods: In the period from January 1, 2020 to December 31, 2024, 628 patients under the age of 18 were operated on for appendicitis at the Clinic for Pediatric Surgery of the Clinical Center of the University of Sarajevo, 430(68.5%) with open appendectomy and 198(31.5%) with laparoscopic appendectomy. We divided all the patients into two groups, group A with 102 patients who underwent surgery with a combined laparoscopic method, and group B where the base of the appendix was closed with an endoscopic loop (95 patients).

Results: 198 patients underwent laparoscopic surgery, of which 123 (62%) were boys and 75 (38%) girls. Of these 198 patients who underwent laparoscopic surgery, 102 (52%) were treated using laparoscopically assisted extracorporeal ligation of the base of the appendix, 80 (40%) patients with one endoloop, 15 (8%) with 2 endoloops and only one patient with 1 (0.5%) hem-o-lok and an endoloop. Of the 198 patients who were operated laparoscopically, 108 (54%) had complicated appendicitis, 59 (30%) uncomplicated appendicitis and 31 (16%) chronic appendicitis. The average duration of surgery for patients treated with the combined method was 58.61 minutes and with endoscopic loops 69.41 minutes. The average length of hospitalization for patients treated with the combined method was 3.96 days and with endoscopic loops 4.59 days.

Conclusions: The three-port combined technique for laparoscopically assisted extracorporeal base ligation of the appendix is a safe, useful, and cost-effective alternative to endoscopic loops, with the advantages of less manipulation, fewer complications involving the appendix, and shorter operative times. This technique is particularly acceptable in resource-limited countries.

Keywords: laparoscopy, appendectomy, combined, stump.

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Introduction

Laparoscopic appendectomy is the treatment of choice for acute appendicitis^{1,2}. Its advantages include a shorter hospital stay, earlier return to normal activity, and fewer wound infections. In traditional open appendectomy, the appendiceal stump is fixed and usually inverted into the cecum, but this is omitted in laparoscopic appendectomy, and the stump is closed according to the surgeon's preference. Ligation of the mesoappendix in open surgery has also been replaced by electrocautery in laparoscopic appendectomy. Stump closure can be achieved either through ligature techniques or mechanical devices, with mesoappendix division by simple electrocautery or mechanical devices. The optimal technique for appendiceal stump closure is still under discussion because it is assumed to affect the occurrence of intra-abdominal infection. Endoloops and endostaplers are the most commonly applied techniques for laparoscopic appendectomy³. We recently reported that closure of the appendiceal stump using a combined technique of laparoscopically assisted extracorporeal base ligation instead of endoloops reduces the rate of complications. There are a number of recognised methods for securing the base of appendix, and a 2017 Cochrane review of uncomplicated cases found insufficient evidence to draw any conclusions regarding any recommendation of one method over another.

Material and methods

In this retrospective cohort study, we compared the outcomes of patients treated using the combined technique of laparoscopically assisted extracorporeal base ligation versus endoscopic loops for appendicitis. In the period from January 1, 2020 to December 31, 2024, 628 patients under the age of 18 underwent surgery for appendicitis at the Clinic for Pediatric Surgery of the Clinical Center of the University of Sarajevo: 123 (62%) boys, 75 (38%) girls. Four hundred and thirty (68.5%) underwent open appendectomy and 198 (31.5%) laparoscopic appendectomy (Figure 1).

We divided all the patients into two groups, group A of 102 (52%) patients who underwent surgery using the combined laparoscopic method, and group B of 95 patients (48%) in whom the base of the appendix was closed with endoscopic loops (Figure 2).

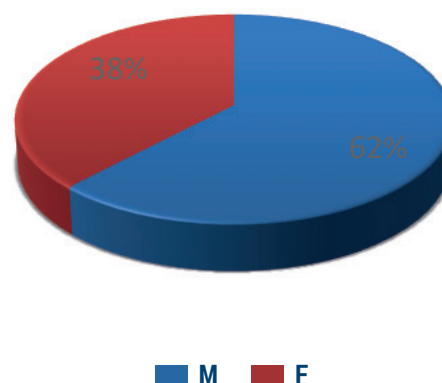
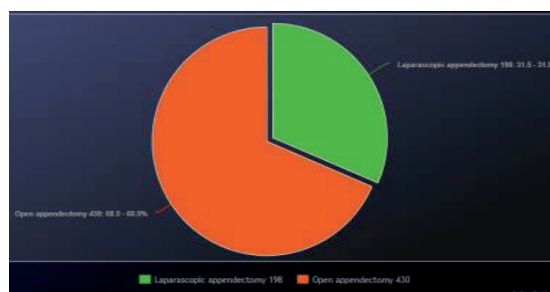


Figure 1. Presentation of open (68.5%) and laparoscopic appendectomies (31.5%).

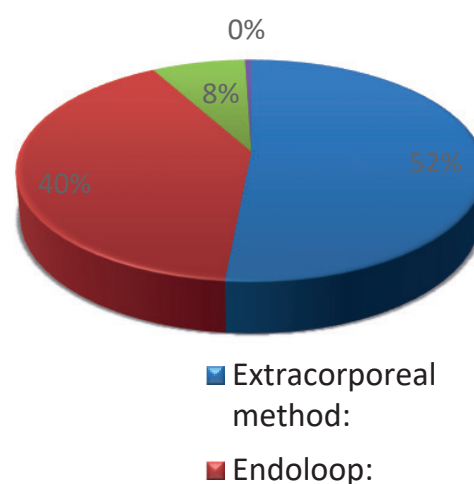


Figure 2. The relationship between the treatment of the appendix base with the combined technique (52% of patients) and the endoloop technique (48% of patients).

The patients were further subgrouped into those with complicated and uncomplicated appendicitis. Complicated appendicitis was defined as perforation or necrosis of the appendix, as well as inflammation at the base of the appendix or cecum. All consecutive patients treated with the combined technique of laparoscopically assisted extracorporeal base ligation, or with endoloops were included. Appendectomies were performed according to the surgeon's preference. If postoperative antibiotics were administered, a combination of either amoxicillin/clavulanic acid or ceftriaxone/metronidazole was given. The exclusion criterion was open appendectomy. The primary outcome was the incidence of postoperative intra-abdominal abscesses.

The secondary outcomes were the readmission rate, the reoperation rate, the length of hospital stay, operation costs, and operative time. The operation costs were calculated as follows: the price of an Ethicon ENDOLOOP® Ligature made with PDS® II was 40 EUR. Due to the retrospective nature of the study, written or verbal informed consent was not applicable or necessary.

The surgical procedure

Single-shot antibiotic prophylaxis was administered to all patients 30 to 60 minutes before surgery (amoxicillin/clavulanic acid at 2 g/200 mg for adults and 33 mg/3mg/kg for children <40 kg or ceftriaxone/metronidazole at 2 g/1 g for adults and 50 mg/7.5mg/kg for children <40 kg). An open technique (Hasson) was used to enter the abdomen under direct vision at the umbilicus. Three-port laparoscopic appendectomy was performed with a 10-mm camera (Olympus) port at the umbilicus and one working port in the left lower quadrant (5mm) for stapled appendectomy and the second above the symphysis (5mm), respectively (Figure 3).

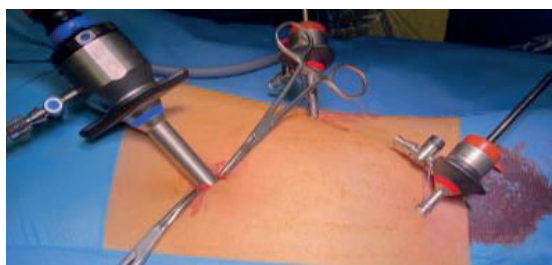


Figure 3. Trocar position (3 port technique).

The pneumoperitoneum was set at a pressure of 12 mmHg. The mesoappendix was divided using a LigaSure device (Covidien) (Figure 4).



Figure 4. Treatment of the mesoappendix using the LigaSure device.

After that, in patients from group A, the camera (5mm) was moved from the umbilical port to the 5mm port in the left iliac region. Through the umbilical port, the appendix was grasped with a grasper and exteriorized outside the abdominal cavity through the 10mm umbilical port (Figures 5,6).



Figures 5 and 6. Grasping the appendix with a grasper and exteriorizing it from the abdominal cavity through the 10mm umbilical port.

The base of the appendix was extracorporeally ligated using two ligatures, and the appendix resected with the LigaSure device (Figure 7, 8).



Figure 7. Extracorporeal ligation of the appendix.



Figure 8. Resection of the appendix with a ligature device.

The base of the appendix and the cecum were placed back into the abdominal cavity. The intracorporeal appearance of the ligated base of the appendix was checked again with the camera, the 3 ports closed and the port entry sites sutured. In patients from group B, after the mesoappendix was divided using the LigaSure device (Covidien), an endoscopic loop was placed at the base of the appendix and the appendix was resected half a centimeter above that location and removed through the 10mm umbilical port (Figure 9).

Results

In total, 198 patients were included in this study. The appendiceal stump was secured using the combined



Figure 9. Endoloops in patients from group B.

technique of laparoscopically assisted extracorporeal base ligation in 102 (52%) patients and using endoscopic loops, in 80 (40%) patients with one endoloop, in 15 patients (8%) with two endoloops and in only one patient with (0.5%) a hem-o-lok and an endoloop. Of the 198 patients who underwent laparoscopic surgery, 108 (54%) had complicated appendicitis, 59 (30%) uncomplicated appendicitis and 31(16%) chronic appendicitis (Figure 10).

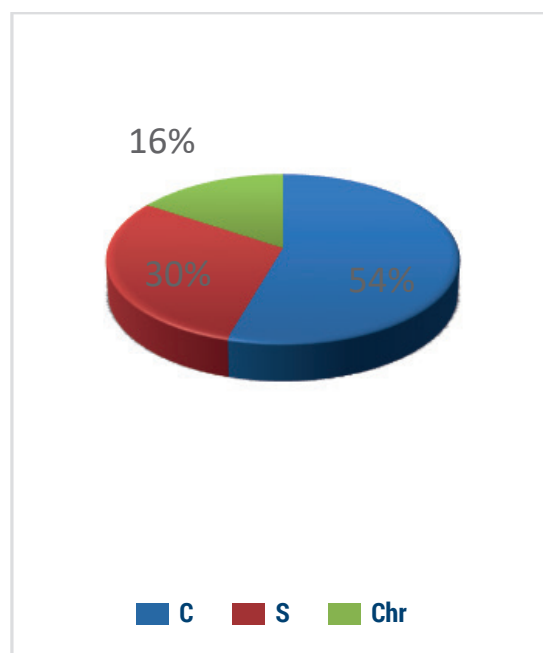
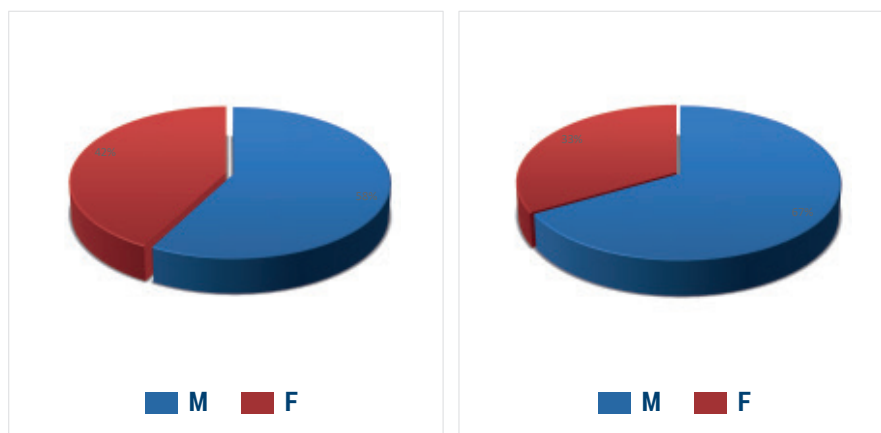


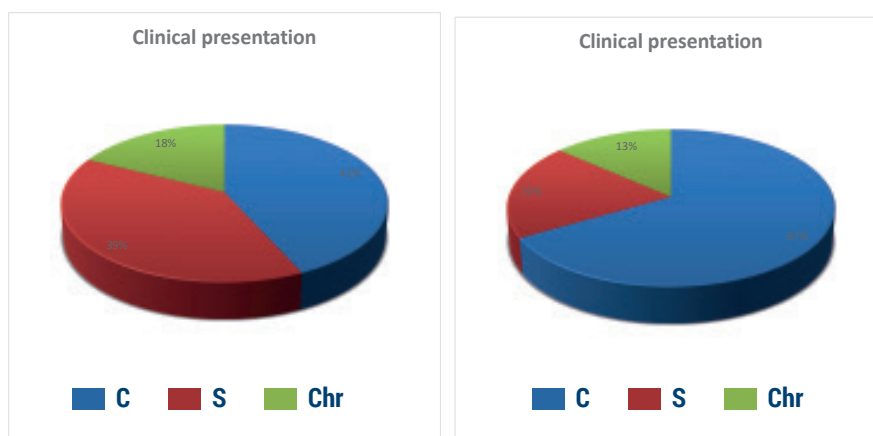
Figure 10. Clinical presentation of patients who underwent surgery for appendicitis.

We analyzed the gender distribution in the examined groups. In group A, 58% were boys and 42% were girls, and in group B, 67% were boys and 33% were girls (Figures 11 and 12).



Figures 11 and 12. Gender distribution in the examined groups (blue male, red female).

We analyzed the clinical presentation of appendicitis. In group A, 43% had complicated appendicitis and in group B, 67% (Figures 13 and 14).



Figures 13 and 14. Clinical presentations in the examined groups (blue complicated, red simple, and green chronic appendicitis).

The patients' characteristics were similar in the groups with the combined technique of laparoscopically assisted extracorporeal base ligation (group A) and those

with endoscopic loops (group B) with regard to sex, the American Society of Anesthesiologists' grade, and preoperative white blood count. (Table 1)

Table 1. Patients' characteristics: group A (combined techniques of laparoscopically assisted extracorporeal base ligation) and group B (endoloop)

Patients	Group A n = 102	Group B n = 96	
Age, years	11 (4-18)	11,7 (5-18)	<0.001
Male/female	59/43 (58%/42%)	64/32 (67%/33%)	1.000
ASA grade I–II/III	425/10 (98%/2%)	230/8 (97%/3%)	0.457
WBC count $\geq 13 \times 10^9/L$	13 (10–16)	13 (11–16)	0.760
CRP ≥ 51 mg/L	14 (4–45)	48 (15–127)	<0.001
Postoperative antibiotic treatment	84 (82,35%)	83 (90,22%)	<0.001
Acute uncomplicated appendicitis	40 (39%)	19 (20%)	<0.001
Complicated appendicitis	44 (43%)	64 (67%)	<0.001
Chronic appendicitis	18 (18%)	13 (13%)	0.229

The patients treated with the combined technique were older than those treated with endoloops ($p < 0.001$), and patients treated with the combined technique had higher preoperative C-reactive protein levels ($p < 0.001$), they had perforated appendicitis more often ($p < 0.001$), and had received postoperative antibiotics more often ($p < 0.001$). Endoloops were

used in the majority of patients with complicated appendicitis (endoloop group, $n = 64$; combined technique group, $n = 44$). The patients' demographics were similar in the two groups, except that perforations occurred more frequently in the endoloop group than in the combined technique group (67% vs. 43%, respectively; $p = 0.024$).

**Figure 15.** Clinical presentations in the examined groups (blue complicated, red simple, and green chronic appendicitis).

We analyzed the average length of hospitalization. The combined technique (group A) involved a significantly shorter average length of hospitalization of 3.96 days than the endoscopic loop technique (group B) where the average length of hospitalization was 4.59 days (Figures 16).

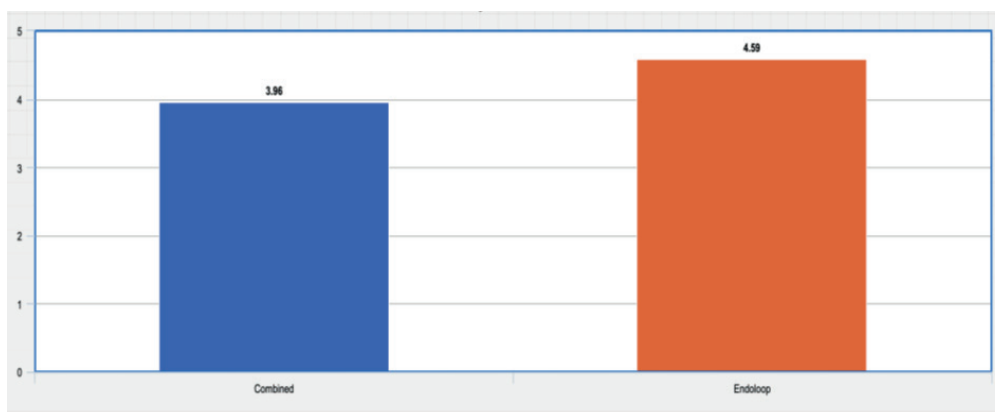


Figure 16. The average length of hospitalization.

Discussion

Different methods are used to close the appendiceal stump, including endoloops, staplers, polymeric clips, and intracorporeal knots. Among these, endoloops and staplers are the most commonly employed^{4,5}. Polymeric clips have primarily been used for vessel and tissue ligation, and have been shown to be a safe alternative to endoloops in the treatment of uncomplicated appendicitis with a non-inflamed or only moderately inflamed appendix base measuring <10 mm⁶⁻⁸. The handling of polymeric clips is technically simple, resulting in a shallow learning curve and shorter operative time^{9,10}. Unlike comparisons between polymeric clips and endoloops, studies assessing appendiceal stump closure with polymeric clips versus staplers are sparse in the literature^{11,12}.

Our data suggest that the three-port combined technique is not inferior to the endoscopic loop technique, and may also be used safely in patients with perforated appendicitis. The endoloop needs to be tightened for ligation, with the disadvantage that the surrounding tissue may be pinched during the tightening process. Endoscopic loops may be associated with more manipulation of the appendiceal stump, which may increase the possibility of iatrogenic perforation of the appendix and increases the operative time. In this study, we were unable to verify the superiority of the combined technique over the endoloop

in laparoscopic appendectomy for uncomplicated appendicitis in terms of shortening the operative time¹³. Stapled appendectomy is expensive, fast and reliable even in cases of inflammation at the base of the appendix¹⁴. With the exception of an inflamed appendix base, staplers do not seem to be superior to endoloops or polymeric clips and are not recommended for use as standard treatment by many authors¹⁵. Non-absorbable polymeric clips were reported as a safe, useful and cost-effective method. The advantage of using polymeric clips is that they can be applied precisely to the desired area. The major limitation of the polymeric clip is that it can be difficult to apply to a thick appendiceal base or an appendiceal base with severe and friable inflammation, and the risk of slippage¹⁶. Closure of the stump of the appendix with a stapler is a simple but more expensive method. Appendectomy with a linear stapler requires a 12-mm trocar for its introduction into the abdominal cavity, which is very often inappropriate in younger children. Metal staples left on the appendiceal stump may cause adhesion-related small bowel obstruction¹⁷.

In a single port approach, the operating telescope is introduced through the umbilical port, and the appendix is grasped through the operating channel of the telescope and brought out along with the port. This approach may be beneficial in early appendicitis, when the appendix and its mesentery is not thick, or in the pediatric age group where the distance

between the umbilicus and the appendicular base is small. This technique requires a surgeon experienced in laparoscopy and it is difficult to control bleeding, in obese patients, and to deal with other associated pathologies. Others have combined the advantages of the operating telescope using the umbilical port with a 5mm suprapubic port, but experience is limited¹⁸.

Two- and three-port laparoscopic assisted open appendectomy is simple, easy to learn and has the combined advantages of open appendectomy and full laparoscopy of the abdomen. It can be converted to open appendectomy very quickly when required, or to a total intracorporeal approach by inserting accessory ports. Compared to the single port approach, it does not require expertise with the operating telescope. The cost is minimized by using a non-disposable port. The overall morbidity is low. There were no specific complications related to this technique and the incidence of port site infection is similar to other approaches of laparoscopic appendectomy¹⁹.

The percentage of patients undergoing laparoscopic assisted appendectomy has steadily increased and the conversion rate has decreased over the years. The disadvantages of the laparoscopic procedure are longer operating time and greater cost²⁰. One technique that can reduce operating room time and cost is a combination of the laparoscopic and open technique known as the three-port combined techniques of laparoscopically assisted extracorporeal base ligation²¹. This technique allows surgeons to use the advantages of the laparoscopic method including visual diagnosis, less postoperative pain, and a quicker return to work. The laparoscopic-assisted appendectomy requires less operating room time and is less costly than the traditional intracorporeal laparoscopic treatment. In essence, it offers the advantages of both the laparoscopic and the open techniques²². Although the present study accurately reflects the daily practice of treating acute appendicitis in our clinic, the study design is a limitation, as this was a single-center, retrospective review in which the surgeon decided on the technique of appendiceal stump closure.

Conclusion

The three-port combined technique with extracorporeal ligation of the appendiceal base is technically relatively easy and quick, especially for pediatric surgeons who are less experienced with intracorporeal suturing.

The three-port combined technique avoids the need for expensive endoloops, staplers, clips or advanced intracorporeal knotting, and involves reduced operative time. It has a short learning curve for surgical trainees and lower costs.

Disclosure statement

The authors report there are no competing interest to declare.

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Author's Contribution

Kenan Karavdic; Data curation, Visualization, Investigation, Writing-Reviewing, Asmir Jonuzi; Data curation, Visualization, Investigation, Nejra Dziho; Conceptualization, Methodology, Emir Milisic; Data curation, Investigation, Azra Karamustafic; Conceptualization, Methodology, Alena Firdus; Data curation, Investigation Writing-Original draft, Enis Goralija; Data curation, Visualization, Investigation.

References

1. Giesen LJ, van den Boom AL, van Rossem CC, den Hoed PT, Wijnhoven BP. Retrospective multicenter study on risk factors for surgical site infections after appendectomy for acute appendicitis. *Dig Surg*. 2017;34: 103-7.
2. Horvath P, Lange J, Bachmann R, Struller F, Konigsrainer A, Zdichavsky M.. Comparison of clinical outcome of laparoscopic versus open appendectomy for complicated appendicitis. *Surg Endosc*. 2017;31:199-205.

3. Sauerland S, Jaschinski T and Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev*. 2010;(10):CD001546.
4. van Rossem CC, van Geloven AA, Schreinemacher MH, Bemelman WA; snapshot appendicitis collaborative study group. Endoloops or endostapler use in laparoscopic appendectomy for acute uncomplicated and complicated appendicitis: no difference in infectious complications. *Surg Endosc* 2017;31:178-84.
5. Beldi G, Vorburger SA, Bruegger LE, Kocher T, Inderbitzin D, Candinas D. Analysis of stapling versus endoloops in appendiceal stump closure. *Br J Surg*. 2006;93:1390-3.
6. Delibegovic S. The use of a single Hemo-lok clip in securing the base of the appendix during laparoscopic appendectomy. *J Laparoendosc Adv Surg Tech A*. 2012;22:85-7.
7. Kazemier G, in't Hof KH, Saad S, Bonjer HJ, Sauerland S. Securing the appendiceal stump in laparoscopic appendectomy: evidence for routine stapling? *Surg Endosc*. 2006;20:1473-6.
8. Delibegovic 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.
9. Swank HA, van Rossem CC, van Geloven AA, in't Hof KH, Kazemier G, Meijerink WJ, et al. Endostapler or endoloops for securing the appendiceal stump in laparoscopic appendectomy: a retrospective cohort study. *Surg Endosc*. 2014;28:576-83.
10. Soll C, Wyss P, Gelpke H, Raptis DA, Breitenstain S. Appendiceal stump closure using polymeric clips reduces intra-abdominal abscesses. *Langenbecks Arch Surg*. 2016;401:661-6.
11. Akkoyun I, Akbiyik F. Closing the appendicular stump with a polymeric clip in laparoscopic appendectomy: analysis of 121 pediatric patients. *Eur J Pediatr Surg*. 2012;22: 133-5.
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. Sahm M, Kube R, Schmidt S, Ritter C, Pross M. Current analysis of endoloops in appendiceal stump closure. *Surg. Endosc*. 2011;25: 124-9.
14. Langer M, Safavi A, Skarsgard ED. Management of the base of the appendix in pediatric laparoscopic appendectomy: clip, ligate, or staple? *Surg Technol Int*. 2013;23: 81-3.
15. Pogorelic Z, Kostovski B, Jeroncic A, Susnjari T, Mrklic I, Jukic M, et al. A comparison of endoloop ligatures and nonabsorbable polymeric clips for the closure of the appendicular stump during laparoscopic appendectomy in children. *J Laparoendosc Adv Surg Tech A*. 2017;27:645-50.
16. Aminian A, Khorgami Z. Hem-o-Lok Clip is Safe in Minimally Invasive General Surgery: A Single Center Experience and Review of Data From Food and Drug Administration. *J Minim Invasive Surg Sci*. 2012;1:52-7.
17. Albuz O, Buluş H, Doğan M. Laparoscopic appendectomy using a linear endostapler to appendicular stump closure. *Ortadoğu medical journal*. 2018;10:98-102.
18. Fazili FM, Al-Bouq Y, El-Hassan OM, Gaffar HF. Laparoscope-assisted appendectomy in adults. *Ann Saudi Med*. 2006;26:100-4.
19. Khan AR. Two port laparoscopically appendectomy in a child with use of the ultrasonically activated endo-sheer. *Pediat Endosurg Innovative Tech*. 2003;7:193-7.
20. McCahill LE, Pellegrini CA, Wiggins T, Helton WS. A clinical outcome and cost analysis of laparoscopic versus open appendectomy. *Am J Surg*. 1996;171:533-7.
21. Konstadoulakis MM, Gomatos IP, Antonakis PT, Manouras A, Albanopoulos K, Nikiteas N, et al. Two-trocar laparoscopic-assisted appendectomy versus conventional laparoscopic appendectomy in patients with acute appendicitis. *J Laparoendosc Adv Surg Tech*. 2006;16: 27-32.
22. Misauno MA, Isichei MW, Ale AF. Laparoscopically assisted appendectomy in adults: a comparative analysis. *J Dental Med Sci*. 2013;24.