Different techniques for closure of appendicular stump in laparoscopic appendectomy – are they safe and applicable?

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Background
Laparoscopic appendectomy (LA) is globally accepted as a less-invasive surgical approach for acute appendicitis. LA has many advantages over open appendectomy like less postoperative pain, earlier recovery, better cosmetic results, and shorter hospital stay. For appendicular stump closure, there are different techniques: endoligature [including preformed suture loops (endo-loops), extracorporeal sutures using knot pushers, and intracorporeal knot-ligature sutures], bipolar coagulation, endoscopic linear GIA staplers, metal clips, or hem-o-lock.
Aim
To compare among four methods for closure of the appendicular stump regarding their safety, applicability, competence, and complications.
Patients and methods
The study was conducted between December 2017 and March 2021 in Tanta University hospitals. The study included 260 patients with acute appendicitis who were randomly divided into four groups. In the first group, the base of the appendix was secured using intracorporeal knot, extracorporeal sutures using knot pushers in the second group, metallic clip in the third group, and Hem-o-lock clip in the fourth group. The primary outcome was assessment of safety and applicability of appendicular stump closure using four different techniques. Secondary outcomes were operative time, hospital stay time, and surgical outcome.
Results
A total of 260 patients (128 females and 132 males) were enrolled into the study. The mean age in group A was 27.30 ± 8.79 years, in group B was 28.94 ± 12.86 years, in group C was 25.96 ± 10.03 years, and in group D was 26.90 ± 6.07 years. A statistically significant difference was observed among the four groups regarding the time for stump closure (P<0.001) and in the operative time (P<0.001), as longer operative and stump closure times were reported in group A. No statistically significant difference was found among the four groups concerning superficial wound infection.
Conclusion
Application of all four methods of stump closure is safe, reliable, and applicable and enhances the surgical hand skills.

Keywords:
acute appendicitis, Hem-o-lock clip, laparoscopic appendectomy

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Introduction

Open appendectomy is the standard treatment for acute appendicitis. Nowadays, laparoscopic appendectomy (LA) has been globally accepted as a less-invasive surgical approach to acute appendicitis. LA was first described by Semm in 1983 as a minimal invasive approach for acute appendicitis. A recent survey showed that ~86% of appendectomies were performed laparoscopically [1]. LA has many advantages over open appendectomy such as less pain, earlier return to work, better cosmetic results, and shorter hospital stay, but LA has some disadvantages such as high cost, long operation time, and the high rate of intra-abdominal abscess [2]. Another major advantage of LA over open surgery is that LA is considered as diagnostic laparoscopy in doubtful diagnosis initially in patients of acute abdomen, especially in females [3].

Appendicular stump closure is considered the most crucial part of LA. Its importance is to avoid serious complications such as postoperative fistula, peritonitis, and sepsis. Appendicular stump closure has been a debatable issue and research of numerous studies. This may be owing to variable different techniques such as endoligature [including preformed suture loops (endo-loops) [4], extracorporeal sutures using knot pushers [5], and intracorporeal knot-ligature sutures [6]], bipolar coagulation [7], endoscopic linear GIA staplers [8], metal clips, or Hem-o-lock [9,10].

All these different techniques have their own advantages and disadvantages in terms of expenses, gradient of learning curve, and operative times. The size of the appendix can affect the choice of the technical procedure used for appendicular stump closure. When the size of the appendicular stump is enlarged as in perforated cases, it is sometimes very difficult to place a standard metallic clip [11].

Complications of appendicular stump closure are rare, so large studies are needed to show the superiority of either technique [12]. This study aimed to determine the optimal technique for appendicular stump closure in LA regarding their safety, applicability, and competence using data available in the current literature.

Patients and methods

This was a prospective study that was carried out in Tanta University Hospital on 260 patients who had LA performed following a diagnosis of acute appendicitis between December 2017 and March 2021. Local research ethics committee approval was obtained for the study. Exclusion criteria included any of the following: patients with grade IV American Society of Anesthesiologists classification, pregnancy, patients diagnosed intraoperatively with different pathology, and complicated cases that were diagnosed either radiologically before the operation or intraoperatively with the need for open surgery. Full history taking, complete physical examination, laboratory tests, and radiological methods were used for the diagnosis of acute appendicitis. Advanced radiological methods such as computed tomography and MRI were done when indicated.

According to the appendicular stump closure technique, our patients were classified into four groups (using closed envelope method): group A (intracorporeal knot-ligature suture), group B (extracorporeal sutures using knot pusher), group C (metallic clip), and group D (Hem-o-lock).

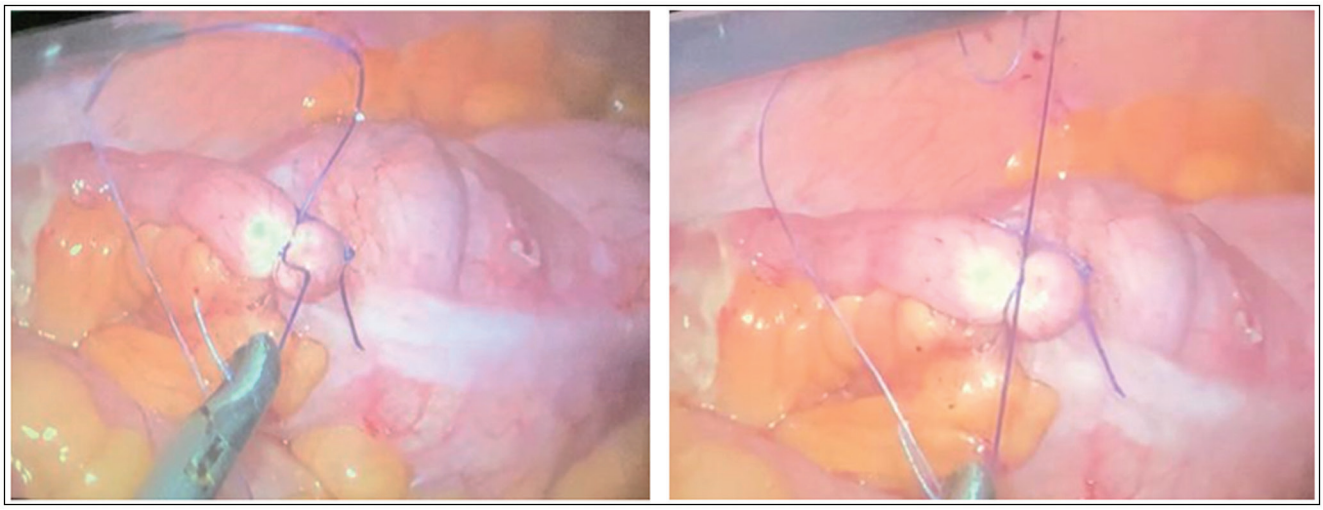
Before surgery, all patients received only one dose of third-generation cephalosporin as antibiotic prophylaxis. LA was carried out using classic three-port technique. Before inserting the trocar, veress needle was introduced into the abdomen by making a perpendicular incision in the umbilicus. The laparoscopic approach was standardized with the use of a 10-mm infra-umbilical optic port with an intra-abdominal pressure of 10–12 mmHg. A 30°, 10-mm laparoscope was inserted to visualize the abdominal cavity for abdominal exploration to confirm our preoperative diagnosis and excluding any other pathology, with a 5-mm port inserted in the lower left abdomen and a 5-mm port in the lower right abdomen. The mesoappendix was dissected using a monopolar coagulation probe with Maryland forceps until the base of the appendix. Appendicular stump closure was done using one of the four different techniques in our study (Figs 1–4). In the presence of collection during operation and abscess without perforation, intra-abdominal drain was inserted.

Patients' characteristics including age, sex, BMI, and preoperative laboratory test including white blood cells and C-reactive protein were recorded. Operative details including operative time, stump closure method, time for stump closure, and operative drainage were also recorded. All patients signed an informed consent before enrollment in the study.

Statistical analysis

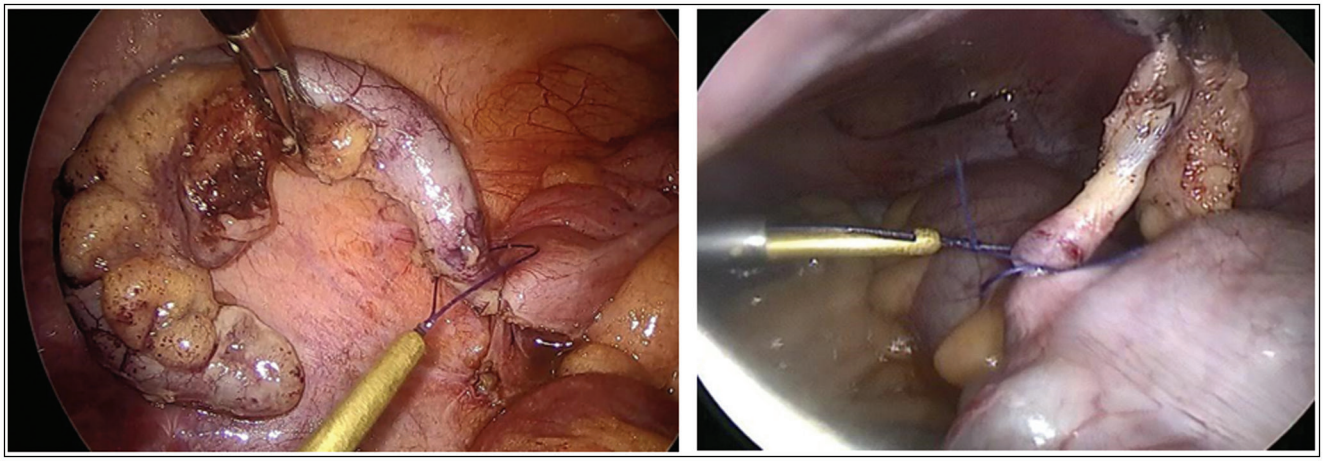
Statistical analyses were performed using NCSS (Number Cruncher Statistical System) 2007 statistical

Figure 1



Appendicular stump closure by intracorporeal knot.

Figure 2

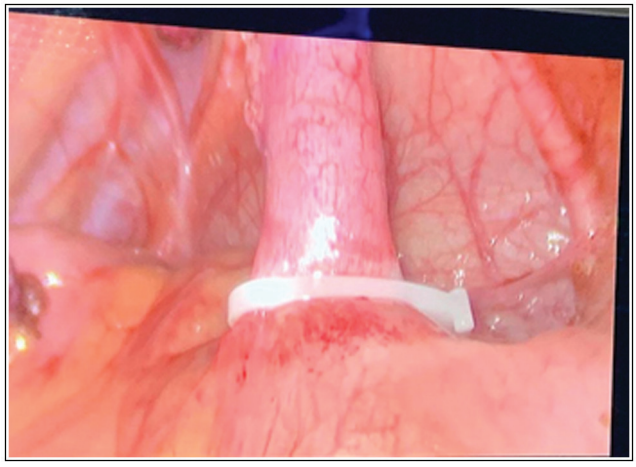


Appendicular stump closure by extracorporeal knot and knot pusher.

Figure 3

Appendicular stump closure by metallic clip.

Figure 4



Appendicular stump closure by Hem-o-lock.

software (NCSS, Kaysville, Utah, USA). Data were evaluated by descriptive statistical methods (mean and SD). For comparison of two independent groups, the *t* test was used, and for the comparison of qualitative data, the χ^2 test was used. A *P* value of less than 0.05 was considered statistically significant.

Result

Of the 267 patients screened in this prospective study, 260 patients were finally included in the study (128 females and 132 males). Seven cases were excluded from the study because more than one technique was used in appendiceal stump closure. The patients in our study were divided into four groups: group A (108 patients), group B (64 patients), group C (48 patients), and group D (40 patients).

The demographic data of the study groups were as follows (Table 1):

The mean age was 27.30 ± 8.79 years in group A, 28.94 ± 12.86 years in group B, 25.96 ± 10.03 years in group C, and 26.90 ± 6.07 years in group D. Regarding sex distribution, there were 64 (59.3%) males in group A, 32 (50.0%) males in group B, 20 (41.7%) males in group C, and 21 (52.5%) males in group D. The mean BMI of group A was 31.70 ± 6.11 kg/m^2, in group B was 30.19 ± 3.57 kg/m^2, in group C was 30.02 ± 3.78 kg/m^2, and in group D was 31.10 ± 3.06 kg/m^2. No statistically significant difference was found regarding age, sex, and BMI among all groups.

A statistically significant difference was found between the groups regarding the time for stump closure (*P*<0.001) and the operative time procedure (*P*<0.001) (Table 2).

The time of application was statistically significantly longer in the group A than in group B (*P*<0.001),

Table 1 Patients' characteristics in the study

	Range	Mean±SD	*F* test	*P* value
Age				
Intracorporeal	14–45	27.30±8.79	0.901	0.441
Knot pusher	12–70	28.94±12.86		
Clip	11–46	25.96±10.03		
Hemo-o-lock	16–35	26.90±6.07		
BMI				
Intracorporeal	24–45	31.70±6.11	2.058	0.106
Knot pusher	24–35	30.19±3.57		
Clip	24–36	30.02±3.78		
Hemo-o-lock	26–37	31.10±3.06		
WBCs				
Intracorporeal	4800–13 500	8676.39±5860.04	0.829	0.479
Knot pusher	5800–12 000	8543.75±1985.65		
Clip	4000–14 000	7708.33±2186.01		
Hemo-o-lock	4000–12 300	7892.50±2147.08		
CRP				
Intracorporeal	5–60	25.22±18.71	1.253	0.291
Knot pusher	4–48	21.34±15.35		
Clip	4–48	23.31±17.81		
Hemo-o-lock	5–52	19.93±13.40		

CRP, C-reactive protein; WBC, whote blood cell.

Table 2 Application and operative time in the studied groups

	Range	Mean±SD	*F* test	*P* value	Post-hoc test			
Application time								
Intracorporeal	2–6	3.89±1.00	143.376	0.001*	*P*1	0.570	*P*4	0.001*
Knot pusher	2–3	2.19±0.39			*P*2	0.001*	*P*5	0.178
Clip	2–3	2.08±0.28			*P*3	0.426	*P*6	0.001*
Hemo-o-lock	2–2	2.00±0.00						
Operative time								
Intracorporeal	25–60	40.89±6.84	53.363	0.001*	*P*1	0.952	*P*4	0.001*
Knot pusher	17–45	30.00±7.47			*P*2	0.001*	*P*5	0.444
Clip	25–45	31.08±6.29			*P*3	0.382	*P*6	0.001*
Hemo-o-lock	25–35	31.00±3.04						

**P*-value ≤ 0.05 is considered significant.

group C (*P*<0.001), and group D (*P*<0.001). The time of application in group D was statistically significantly shorter than in group A (*P*<0.001). The time of stump closure application in group D did not show statistically significant difference from the time of application in group C (*P*=0.570). The time of stump closure application in group B did not show statistically significant difference from the time of application in group C (*P*=0.426). Moreover, there was no statistically significant difference between group B and group D (*P*=0.178) in terms of the time of application.

The operative procedure time was found statistically significantly longer in group A than in group B (*P*<0.001), group C (*P*<0.001), and group D (*P*<0.001). No statistically significant difference was observed between group C and group D (*P*=0.952) and also between group C and group B (*P*=0.382). The operative procedure time in group D was found to be statistically significant shorter than group A (*P*<0.001) but did not show a statistically significant difference from group C (*P*=0.952). The operative procedure time in group D was shorter than group B but without statistically significant difference (*P*=0.444).

Operative abdominal drain insertion was done in 35 (32.4%) patients in group A, 12 (18.8%) patients in group B, 10 (20.8%) patients in group C, and eight (20%) patients in group D. There was no statistically significant difference among groups in terms of intra-abdominal drain application.

Superficial wound infection was recorded in each group as follows: eight (7.4%) patients in group A, four (6.3%) patients in group B, no patient in group C, and four (10.0%) patients in group D. No statistically

significant difference was found among groups concerning superficial wound infection.

Discussion

LA has improved the outcome of acute appendicitis, but it still requires laparoscopic skills of the surgical team [13]. The results of a meta-analysis concluded that LA is associated with a statistically significant lower incidence of postoperative complications, shorter postoperative hospital stay, better cosmetics, and early return to work [14].

There was no statistically significant difference among the groups concerning age or hospital stay length. Appendicular stump closure has been the issue of numerous research studies owing to a wide range of available techniques such as endoligature [including preformed suture loops (endo-loops) and intracorporeal sutures], Hemo-o-lock, bipolar coagulation, endoscopic linear cutting staplers, radiofrequency, ultrasonic vibrations, metal clips, or polymer clips [15].

All different techniques have their own advantages and disadvantages in terms of procedure price, gradient of learning curve, and both operative and application times [16]. The time of stump closure application and the operative time were significantly shorter in the Hemo-o-lock group than other groups. This can be explained by considering because of it is just necessary to introduce the instruments once, and the appendicular resection and its stump closure are performed in a single act, so the significantly shorter time of application (2.00 ± 00 min) also shortens surgical operative time itself.

Using either loop ligature with knot pusher or intracorporeal ligature for appendiceal stump closure is sometimes difficult in the area bordered by the iliac fossa and may lead to injuries to the surrounding structures. On the contrary, Hemo-o-lock and metallic clips application for stump closure can be done without any form of previous training skills or the risk of injuries to the neighboring organ [17].

Appendiceal stump closure can be done using either knot pusher or intracorporeal ligature. Many studies have shown these methods to be as safe as other methods [18,19]. Stump closure with sutures is a very cheap method with a disadvantage of prolonging the operation time [18].

For both metallic clips and Hemo-o-lock clip for stump closure, there is no difference between both regarding the application time and operative time [17]. The biocompatibility of metallic clip is better [18]; however, the drawback of metallic clip is that it cannot be easily removed from the base of the appendix if it was inadequately placed, whereas the Hemo-o-lock can be easily removed. A further superiority of Hem-o-lock is that during application, closing the Hem-o-lock clip is accompanied by a click sound, which facilitates its use, but there is no such sound accompanied by metallic clips. It is necessary to note that the opening of Hem-o-lock clips is larger, and this in turn makes its application in an enlarged, inflamed appendix easier.

Conclusion

Application of all four methods of stump closure is safe, reliable, and applicable and enhances the surgical hand skills. All techniques of appendix stump closure are comparable regarding postoperative complications. The intracorporeal ligature technique is significantly longer in terms of time of application.

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Conflicts of interest

There are no conflicts of interest.

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