Application of different methods for stump closure in laparoscopic appendectomy

Ahmed Elshoura, Osama Hassan, Sherif Saber

Department of General Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt

Correspondence to Ahmed Abdel Fattah Elshoura, MD, PhD, GIT Unit, Department of General Surgery, Faculty of Medicine,Tanta University, Hassan Radwan 002, Tanta, Egypt; Tel: +02 01224580723; e-mail: ahmed.elshoura@med.tanta.edu.eg

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Background
Appendicular stump closure is the most critical event in laparoscopic appendectomy. The aim of the present study was to verify the effectiveness of stump closure using the endostapler, extracorporeal sliding knot, and intracorporeal suture in different stages of appendicitis.
Materials and methods
This prospective study was conducted from July 2014 to March 2016 and included 135 patients who underwent laparoscopic appendectomy. We reviewed patients' demography, operative time, hospital stay, and complications in different stump closure techniques.
Results
The stapler group consisted of 45 patients – 27 men and 18 women. The mean age was 33.5 years, mean operation time was 56.4 min, complication rate was 6.6%, and average hospital stay was 1.73 days. The extracorporeal sliding knot group consisted of 43 patients – 24 men and 19 women. The mean age was 36 years, mean operation time was 71.5 min, complication rate was 2.3%, and average hospital stay was 1.8 days. The intracorporeal suture group consisted of 47 patients – 21 men and 26 women. The mean age was 33.6 years, mean operation time was 84.3 min, complication rate was 4.2%, and average hospital stay was 2.3 days.
Conclusion
Laparoscopic staplers had the least hospital stay and the shortest operative time, inspite of the insignificant difference regarding the complication rates among the three groups. Although the application of the suture knot and the extracorporeal knot had the longest surgical procedure time, they were more suitable because of the economic conditions of our country.

Keywords:
extracorporeal knot, intracorporeal suture, laparoscopic appendectomy, staplers, stump closure

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Introduction

Open appendectomy (OA), inspite of being one of the early taught surgical skills, is not regularly performed by using a laparoscope, which is not a gold standard as laparoscopic cholecystectomy [1].

Laparoscopic appendectomy (LA) is first line of treatment in many vulnerable patients like females, obese patients, and elderly. It has an array of merits when compared with OA: minimized postoperative pain, hastened resuming of daily activity, shorter hospitalization period, and reduced incidence of wound infection. Nevertheless, some experts have reported a slightly higher rate of intra-abdominal abscesses, relatively longer duration, and exponential rise in the expenditures of the procedure when compared with traditional OA [2,3].

Closure of the appendicular stump is imperative to avoid adverse side effects [4]. This issue has led surgeons to search for the best technique for the closure of appendicular stump – the one that is safer, more feasible, simpler to use, and relatively economic.

There are several methods to secure appendicular stump closure, for instance, mechanical endostapler, endo ligature (endoloop), extracorporeal sliding knot, metal endoclips, polymeric endoclips, and intracorporeal suture and knot. The substitutes of appendical stump closure have their pros and cons, and yet there is an ongoing debate over the optimal technique [5–9].

The main objective of this study was to verify the safety and effectiveness of appendicular stump closure using endoscopic stapler, extracorporeal sliding knot, and intracorporeal suture in different stages of acute appendicitis carried out laparoscopically.

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Materials and methods

This randomized clinical trial was conducted during the period from July 2014 to March 2016. The study included 135 patients who were admitted to Tanta University Hospitals, General Surgery Department, during the period of study and fulfilled the inclusion criteria. Patients were prospectively evaluated to undergo LA for clinically suspected acute appendicitis.

Exclusion criteria included any of the following: pregnancy, patient classified as grade IV according to the American Society of Anesthesiologists classification, patients diagnosed intraoperative with different pathology, and previous lower abdominal operation.

History, physical examination, laboratory, and advanced radiological methods (when needed) were used for the diagnosis of acute appendicitis. Patients were randomly allocated into three study groups using the simple randomization method.

Depending on the appendicular stump closure technique, our patients were divided into three groups: group A (endoscopic staplers), group B (pretied sliding extracorporeal knot), and group C (intercorporeal suture knot).

An ethical approval was obtained from the ethics committee of Tanta University Hospitals, Egypt, before the enrollment of patients started. All patients signed an informed consent.

Three senior surgeons participated in the procedure. General anesthesia was applied for all patients. NSAIDs were used for analgesia. Intraoperative antibiotic therapy was given according to the severity of the inflammation: it comprises third-generation cephalosporins (ceftriaxone) and metronidazol (for anaerobic bacteria). This therapy was given for 5–10 days according to the clinical sequel.

The three-port technique was used in LA, during which the patient was in the supine position. The main surgeon and his assistant were standing on the left side and the laparoscopy unit was placed on the right side of the patient.

First, a Veress needle was used for pneumoperitoneum, an essential step in laparoscopy, after which a 10 mm trocar was inserted in the umbilicus and used as an introducer for the telescope. Second, a 5 mm trocar was inserted in the midline of the suprapubic region, and then, a third trocar with a diameter of 10 or 12 mm (for stapler) was introduced in the lower-left quadrant. Finally, a 15° Trendelenburg with a slight tilt to the left was used to enhance the surgical field view. After visualization of the abdominal organ and confirmation of the current diagnosis, the appendix was positioned using a hand tool introduced through the 5 mm trocar. Meanwhile, the mesoappendix was separated using electrocautery. It is worth mentioning that a harmonic scalpel was used in few cases for the same purpose, taking into consideration the downsizing the specimen's size by close dissection to the mesoappendix and avoiding the problem of extraction of the resected appendix.

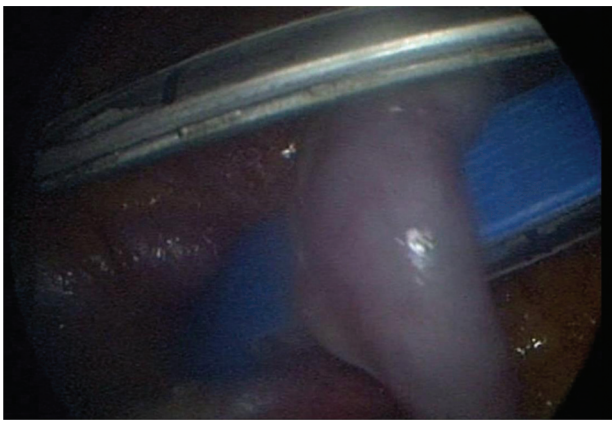
Three different methods of closing the appendicular stump were carried out in the three groups. In group A, we used endo-GIA staplers (Fig. 1).

In group B, the appendicular stump closure was carried out by applying two sliding extracorporeal knots using Vicryl 2-0 (Ethicon; VICRYL Johnson & Johnson ETHICON (USA)) in a healthy tissue next to the cecum wall (Fig. 2). In group C, the appendicular stump closure was associated with the use of the suture knot on the base (Fig. 3).

The abdominal cavity was irrigated with warm saline; in complicated cases suctioning was used to dry the cavity. After resection of the appendix, histopathological study was ordered for all specimens, and when necessary, a retrovesical drain tube was inserted.

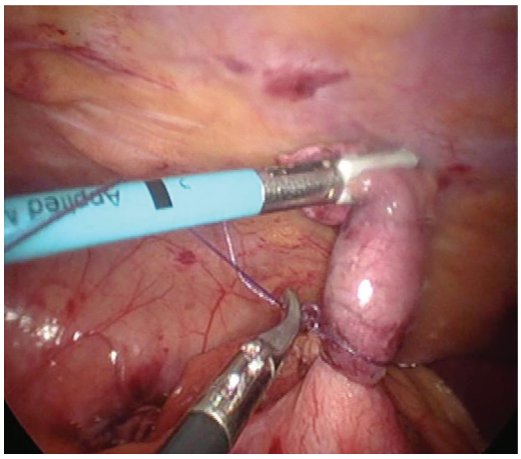
We reviewed patients' data including age and sex, presence of intraoperative and postoperative complications, duration of surgical procedure, length of hospital stay, mortality, and histopathologic diagnosis. Patients were followed-up by phone calls at 1 week, 2 weeks, and 1 month after surgery.

Figure 1



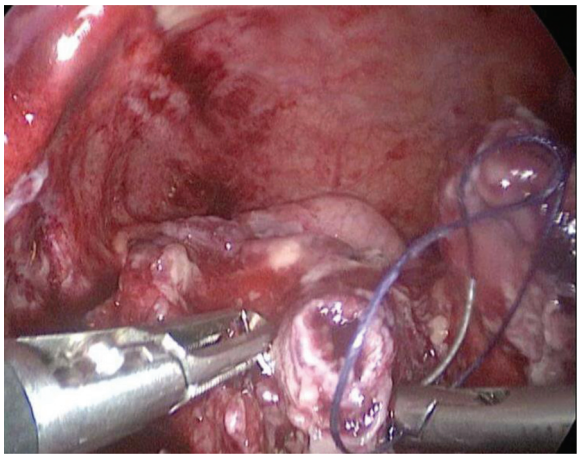
Stump closure by using endo-GIA staplers.

Figure 2



Stump closure by sliding the pretied extracorporeal knot.

Figure 3



Stump closure by using the intercorporeal suture.

The statistical analysis was carried out using statistical package for the social science (SPSS, v. 23; SPSS Inc., Chicago, Illinois, USA). Quantitative data were presented as mean and SD and analyzed using the one-way analysis of variance. The Kruskal–Wallis test was used for nonparametric data. Whereas qualitative data presented as number and percentage were analyzed by using the χ^2-test. The level of significance was adopted at P less than 0.05.

Results

Totally, 139 patients were enrolled into this prospective clinical study. Four patients were excluded because of different pathology (three cases were of right adnexal pathology and one case had a sealed perforated duodenal ulcer that was identified as the cause of symptoms). Totally, 72 patients were men and 63 were women; their ages ranged from 10 to 63 years, with a mean age of 34.3±14 years.

In group B, the intended closure of the appendicular stump with the extracorporeal knot failed in two cases because of appendicular base necrosis, and then a suture knot was done instead.

There were 45 patients in group A – 27 (60%) men and 18 (40%) women. Their mean age was 33.5±13.6 years (range: 10–62 years).

There were 43 patients in group B – 24 (55.8%) men and 19 (44.2%) women. Their mean age was 36 years (range: 11–58 years). There were 47 patients in group C – 21 (44.7%) men and 26 (55.3%) women. Their mean age was 33.6±14.5 years (range: 13–63 years).

There was no statistically significant difference between the groups in terms of age and sex distribution. Mean operating time of all operations was 70.9 min (range: 30–125 min). There was a statistically significant difference as regards mean operation time between the three groups ($P<0.05$): in group A, the mean operation time was 56.4 min (range: 30–85 min), in group B it was 71.5 min (range: 40–90 min), and in group C it was 84.3 min (range: 45–125 min), as shown in Table 1.

The post-hoc test results showed statistically significant differences as regards operation time between the groups: between group A (stapler) and group B (extracorporeal knot), the P-value was 0.01; between group A (staplers) and group C (suture knot), the P-value was 0.02; and between group B (extracorporeal knot) and group C (suture knot), the P-value was 0.004.

In our study, there were no intraoperative complications, no cases were converted to open approach, and there was no mortality.

The total rate of postoperative complications was 4.4%. In group A the complication rate was 6.6% (three cases: one intra-abdominal abscess, one wound infection, and one ileus). In group B the complication rate was 2.3% (one relaparoscopy because of intra-abdominal abscess). And in group C the complication rate was 4.2% (two cases: one wound infection and one intra-abdominal abscess).

All complications occurred in the complicated appendicitis. Two patients who developed intra-abdominal abscess were treated by the placement of ultrasound-guided percutaneous tube drain into the

Table 1 Statistical analysis of operative times

Groups	*P*-value for compared variables, operative time ANOVA: *N*=135; *F* ratio=80.7; *P*=0.001		
	A (stapler)	B (extracorporeal knot)	C (suture knot)
Group A (stapler)	–	0.01	0.002
Group B (extracorporeal knot)	0.01	–	0.004
Group C (suture knot)	0.02	0.004	–

ANOVA, analysis of variance.

Table 2 Statistical analysis of hospital stay

Groups	*P*-value for compared variables, operative time Kruskal–Wallis test: *N*=135; χ^2=21.5; *P*=0.0002		
	A (stapler)	B (extracorporeal knot)	C (suture knot)
Group A (stapler)	–	0.6	0.002
Group B (extracorporeal knot)	0.6	–	0.003
Group C (sutures)	0.002	0.003	–

abscess under the cover of parental antibiotic regimen. The third patient who developed intra-abdominal abscess underwent relaparoscopy because of failure of sonar-guided drainage; for this patient slipped ligature was found and a suture knot was performed.

The two patients who developed wound infection were managed with regular wound care and antibiotics.

One patient experienced a prolonged intestinal ileus, which resolved under conservative treatment (nasogastric tube, nothing per month, intravenous fluids, and bowel stimulants).

The χ^2-test showed no statistically significant association between the type (operative technique) of operation and the postoperative complication rates (*P*=0.3).

As per clinical findings, in group A simple appendicitis was found in 26 (57.8%) patients, complicated appendicitis in 14 (31.1%), and no macroscopic signs of inflammation (normal) in five (11.1%); in group B, simple appendicitis was found in 32 (74.4%) patients, complicated appendicitis in eight (18.6%), and no macroscopic signs of inflammation (normal) in three (7%); and in group C, simple appendicitis was found in 28 (59.6%) patients, complicated appendicitis in 13 (27.6%), and no macroscopic signs of inflammation (normal) in six (12.8%). In the case of macroscopic noninflamed appendix and no other obvious abdominal pathology explaining right-lower quadrant pain, we still removed the appendix. Histological examination showed acute appendicitis in 127 (94.1%) out of 135 patients. There was no statistically significant difference between the three groups regarding the type of appendicitis (*P*=0.81).

The mean length of hospital stay was 1.94 days (range: 1–12 days): in group A the average hospital stay was 1.73 days (range: 1–7 days); in group B it was 1.8 days (range: 1–12 days); and in group C it was 2.3 days (range: 1–5 days). The nonparametric Kruskal–Wallis test and post-hoc tests were used for the statistical analyses of variances to compare the results in the three groups. They showed significant differences in the mean hospital stay between the groups (*P*=0.0002): there was a significant difference between group A (staplers) and C (suture) (*P*=0.002) and between group B (clips) and group C (sutures) (*P*=0.003), whereas there was no significant difference between group A and group B (*P*=0.6), as shown in Table 2.

A 30 days' follow-up was done for 119 (88.1%) patients through telephone interviews for any complaints encountered.

Discussion

LA is anticipated to get more popular in the near future, and has become the benchmark treatment of acute appendicitis [10]. LA involves several approaches within the maneuver, including not only the position of the trocar but also the closure of the appendicular stump. Nevertheless, the most considering issue is the securing of the appendicular stump [11].

There is little doubt that effective closure of the appendicular stump in LA is crucial to prevent numerous perioperative complications (e.g. intra-operative appendicle's content spill or postoperative leak from the stump). It is worth mentioning that the more the safety and the less special skills required, the more preferable the approach to be adopted [12].

In the present study, patients' demographic data (e.g. sex and age) were insignificant among the studied groups. The mean duration of the procedure in groups A, B, and C were 56.4, 71.5, and 84.3 min, respectively. Interestingly, group C, in which suture knot was used, had significantly longer duration compared with the other groups, which can be attributed to the fact that this method seems to be the most technically demanding. The average operative time in all procedures was 70 min, which might be attributed to the upslope of our learning curve (which was the primary reason), to the fact that acute appendicitis of different stages was included, and that the included complicated cases had an increased difficulty of the procedures due to advanced inflammatory processes. However, the time recorded in our study was comparable with those of other published literature [13–15].

No cases of mortality or intraoperative complications were reported in our study, although an array of factors were standing behind laparotomy, which had variable frequency, like adhesions, localized perforation, diffuse peritonitis, appendix base necrosis, bleeding, and iatrogenic lesions [16]. Among the 135 studied patients, no patients needed laparotomy, which can be attributed to the fact that in group B, only two patients had necrosis at the level of appendicular base that could not be managed by extracorporal knot, and thus they were relocated to group C to be treated by using a suture knot. Interestingly, necrosis of the appendicle's base was the leading cause of the failure of the procedure in group B.

In our study, the procedure used for group C was technically difficult: it had the longest hospitalization stay, as patients needed a longer observation period. Needless to say, the hospital stay varied in the literature according to the country in which the study was carried out. The centers in the USA had the least hospital stay, with patients discharged after 1 day of the surgery. The average length of hospitalization in recent studies was from 2 to 5.9 days, showing no statistically significant difference among the various approaches of appendix stump closure [15,17,18].

In the present study, the reported postoperative complication was six out of 135 (4.44%) patients, with no statistically significant difference between the three groups. The postoperative complication rates observed in our study were similar to that in other reports [4,15,17]. It is noteworthy that only patients with complicated appendicitis had reported postoperative complications. Another issue to add is that the low incidence of infected surgical site denotes the relative safety of all studied techniques of appendicular stump closure.

According to this study perspective, the decreased incidence of intra-abdominal abscess formation was due to the thorough peritoneal irrigation, suctioning, fragments removal, using drains whenever needed, and proper antibiotic administration. Therefore, these complications are probably not results of the technique *per se*, but may reflect the difficult situation of the complicated appendicitis.

On the basis of the histology of the appendices, it was found that in all types of appendicitis, the suture knot and the endostapler can be used, whereas the extracorporeal knot works for all types of appendicitis except appendicular base necrosis, which plays a significant role in failure of the technique.The rate of negative appendectomies in our study was low (5.9%) compared with the data in the literature [7,17].

Despite the usage of several approaches for appendicular stump closure, the highest priority should be directed to identifying the severity of inflammation in the base of the appendix as well as the required expenditures.

Staplers, inspite of being safe and fast, are expensive to use when compared with the extracorporeal knot and suture knot, which are more cost effective regardless the high technical skills required and the longer time consumed. Furthermore, the detached stapler clips are the root cause of peritoneal adhesion, which could lead to small intestinal obstruction and, hence, an ileus [7,19,20].

Recently, it was published that because of the lack of evidence of technical superiority, the surgeon should choose the suitable maneuver for him and for the patient [21].

The optimal technique should be safe with the least complication and should be cost effective.

The limitation of this study was that the complication rate in LA was low, and therefore a larger number of patients should be included to reach good statistical power with this endpoint.

Conclusion

There is no global agreement on any technique for appendicular stump closure. In our study laparoscopic

staplers had the least hospital stay and the shortest operative time. Whereas the application of the suture knot and extecorporeal knot is economically cheaper and enhances the surgical hand skills.

The final decision on the method depends on the surgeon's training and experience, the availability of equipments, costs, and the severity of appendix inflammation.

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Conflicts of interest
There are no conflicts of interest.

References

1 Li X, Zhang J, Sang L, Zhang W, Chu Z, Li X, *et al.* Laparoscopic versus conventional appendectomy – a meta-analysis of randomized controlled trials. BMC Gastroenterol 2010; 10:129.

2 Krisher SL, Browne A, Dibbins A, Tkacz N, Curci M. Intra-abdominal abscess after laparoscopic appendectomy for perforated appendicitis. Arch Surg 2001; 136:438–441.

3 Sporn E, Petroski GF, Mancini GJ, Astudillo JA, Miedema BW, Thaler K. Laparoscopic appendectomy – is it worth the cost? Trend analysis in the US from 2000 to 2005. J Am Coll Surg 2009; 208:179–185.

4 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; 8:35.

5 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; 19:11–15.

6 Costa-Navarro D, Jiménez-Fuertes M, Illán-Riquelme A. Laparoscopic appendectomy: quality care and cost-effectiveness for today's economy. World J Emerg Surg 2013; 8:45.

7 Partecke LI, Kessler W, von Bernstorff W, Diedrich S, Heidecke CD, Patrzyk M. Laparoscopic appendectomy using a single polymeric clip to close the appendicular stump. Langenbecks Arch Surg 2010; 395: 1077–1082.

8 Delibegovic S, Matovic E. Hem-o-lok plastic clips in securing of the base of the appendix during laparoscopic appendectomy. Surg Endosc 2009; 23:2851–2854.

9 Gonenc M, Gemici E, Kalayci MU, Karabulut M, Turhan AN, Alis H. Intracorporeal knotting versus metal endoclip application for the closure of the appendiceal stump during laparoscopic appendectomy in uncomplicated appendicitis. J Laparoendosc Adv Surg Tech A 2012; 8:231–235.

10 Gomes CA, Nunes TA, Fonseca Chebli JM, Junior CS, Gomes CC. Laparoscopy grading system of acute appendicitis: new insight for future trials. Surg Laparosc Endosc Percutan Tech 2012; 22:463–466.

11 Hue CS, Kim JS, Kim KH, Nam S-H., Kim KW. The usefulness and safety of Hem-o-lok clips for the closure of appendicular stump during laparoscopic appendectomy. J Korean Surg Soc 2013; 84:27–32.

12 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; 20:1473–1476.

13 Ates M, Dirican A, Ince V, Ara C, Isik B, Yilmaz S. Comparison of intracorporeal knot-tying suture (polyglactin) and titanium endoclips in laparoscopicappendiceal stump closure: a prospective randomized study. Surg Laparosc Endosc Percutan Tech 2012; 22:226–231.

14 Bali İ, Karateke F, Özyazıcı S, Kuvvetli A, Oruç C, Menekşe E, *et al.* Comparison of intracorporeal knotting and endoloop for stump closure in laparoscopic appendectomy. Ulus Travma Acil Cerrahi Derg 2015; 21:446–449.

15 Strzałka M, Matyja M, Rembiasz K. Comparison of the results of laparoscopic appendectomies with application of different techniques for closure of the appendicular stump. World J Emerg Surg 2016; 11:4.

16 Moberg AC, Ahlberg G, Leijonmarck CE, Montgomery A, Reiertsen O, Rosseland AR, Stoerksson R. Diagnostic laparoscopy in 1043 patients with suspected acute appendicitis. Eur J Surg 1998; 164:833–840.

17 Rickert A, Colin MK, Runkel N, Kuthe A, Köninger J, Jansen-Winkeln B, *et al.* The TICAP-study (titanium clips for appendicular stump closure): a prospective multicentre observational study on appendicular stump closure with an innovative titanium clip. BMC Surg 2015; 15:85.

18 Swank HA, van Rossem CC, van Geloven AW, in't Hof KH, Kazemier G, Meijerink WJHJ. Endostapler or endoloops for securing the appendiceal stump in laparoscopic appendectomy: a retrospective cohort study. Surg Endosc 2013; 28:576–583.

19 Kuehnel F, Marusch F, Koch A, Gastinger I. Retained loose linear cutter staples after laparoscopic appendectomy as the cause of mechanical small bowel obstruction. Int J Colorectal Dis 2007; 22:717–718.

20 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; 93:1390–1393.

21 Gorter RR, Heij HA, Eker HH, Kazemier G. Laparoscopic appendectomy: state of the art. Tailored approach to the application of laparoscopic appendectomy? Best Pract Res Clin Gastroenterol 2014; 28:211–224.