Evaluation of intracorporeal knotting and metallic clipping of the appendicular stump in laparoscopic appendicectomy

Hady S. Abou Ashour

General Surgery Department, Faculty of Medicine, Minoufiya University, Shibin Al Kom, Egypt

Correspondence to Hady Saleh Abou Ashour, MD, MRCS. (Eng.), Faculty of Medicine, Minoufiya University, Shibin Al Kom, Egypt
Tel: +201000630111;
e-mail: aboashour_hady@yahoo.com

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Background
Laparoscopic appendicectomy has gained popularity, especially among laparoscopic surgeons, due to the advantages of minimal-access surgery and the simplicity of the technique. Together with endoloop, various techniques have been tried to secure the base of the appendix. Some laparoscopic surgeons apply ligature or clips owing to its lower cost and feasibility. In this study, we applied intracorporeal ligature (knotting) or metallic clips for secure closure of the base of the appendix during laparoscopic appendicectomy.

Aim
The aim of this work was to evaluate the application of both techniques, together with recording of any specific complications related to each.

Patients and methods
During the period from February 2010 to November 2013, in Minoufiya University Hospital and other private hospitals, 200 laparoscopic appendicectomy patients were included in this prospective study. In total, 117 patients were female and the overall average age was 27.4 years. Patients were divided into two equal groups (group A and group B): group A underwent intracorporeal knotting of the base and the metallic clip closure technique was the alternative in group B.

Results
The mean operative time was 45 min in group A and 37 min in group B ($P < 0.05$). The mean hospital stay was 2.07 days in group A and 2 days in group B, and this was not significant ($P > 0.05$). Complications varied between port-site wound infection and delayed intestinal sounds, and there were no significant differences or major complications.

Conclusion
In our study, both intracorporeal knotting and the metallic clip closure technique were successful, feasible, and economic in securing the appendicular stump, except for a wide, severely edematous, or gangrenous base, wherein the metallic clip closure technique was not appropriate.

Keywords:
clipping of appendicular stump, knotting, knotting and metallic clipping of the appendicular stump

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Introduction

Historically, the right lower quadrant incision of open appendicectomy (OA) has persisted essentially unchanged since it was pioneered by McBurney in the 19th century [1,2].

Laparoscopic appendicectomy (LA) has become a frequently used alternative in the treatment of acute appendicitis. In 1983, LA was first described by Semm, a German surgeon, and in 1987, Schreiber carried out the first LA for acute appendicitis. For long time, LA has not gained the same widespread popularity and enthusiasm as has laparoscopic cholecystectomy [3], but reports [3,4] have documented the feasibility and the safety of LA, suggesting that it is the new 'gold standard'.

Several studies have compared LA with the conventional open procedure, regarding the surgical time, the hospital stay, return of the patient to normal life, and complications [3,5].

Various techniques have been used for the ligation of the appendicular stump, such as preformed suture loops (endoloops) and endoscopic linear cutting staplers (endo-GIA), and sealing of appendiceal vessels was performed by the Liga-Sure System, the Harmonic scalpel [6,7], bipolar coagulation [8], and base control was further tried by polymeric clips [9,10], ligature by polyglactin suture [11], and endorings [12]. In this study, the evaluation of both techniques was performed regarding their safety and cost, and any expected specific complications were reported.

Patients and methods

During the period from February 2010 to November 2013, in Minoufiya University Hospital and other

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private hospitals, 200 LA patients were included in this prospective study. The study was approved by the local ethics and research committee of the Minoufiya Faculty of Medicine and its university hospitals. In total, 117 patients were female and 83 were male. Patients were divided into two equal groups (group A and group B). Group A included patients who underwent intracorporeal knotting (ICK) of the appendicular stump and the metal clip closure technique (MCC) was the alternative option in group B.

The primary objective of this study was to evaluate both techniques regarding their safety and to report any complications specific to each technique.

Other secondary objectives included the following:

(1) The cost effectiveness of both techniques.
(2) The simplicity of the techniques for trainees.

Difficulty or insecure knotting or clipping of the appendicular stump due to any cause was reported as failure of the technique and no cross-over plan was decided. All patients were subjected to full history taking, clinical evaluation, abdominal ultrasound, and routine laboratory investigations. Informed consent was taken and patients with any criteria that interfere with laparoscopic surgery were excluded from the study, for example, pregnancy, previous lower abdominal surgery and hostile abdomen, age less than 5 years or more than 65 years, and concomitant morbidities that interfere with laparoscopic surgery, for example, patients with ASA III physical status.

Before surgery, all the patients received standard intravenous antibiotics (1.2 g of amoxicillin and clavulanic acid and 500 mg of metronidazole); the criteria of discharge were absence of fever, audible intestinal sounds, oral fluid tolerance, and the ability to walk around. The appendix was sent for histopathological evaluation, and the postoperative analgesia and antibiotic was continued for 5–7 days.

Patients were followed up for 6 months to report any early or late postoperative complications.

Surgical procedure

The surgeon stood to the left side of the patient, looking toward his/her caudal direction. Then, three ports were used: the first one was located in the periumbilical region to introduce a 0–30° Karl Storz optic telescope, two more working ports (5 mm) were inserted in the right lower quadrant at the McBurney point, and a 10 mm port in the left lower quadrant just above the pubic hair line lateral to the border of the rectus sheath; this port can also be used for the telescope, using the periumbilical port as a working port for the right hand and the right one as a working port for the left hand (this was an alternative option for standard port uses).

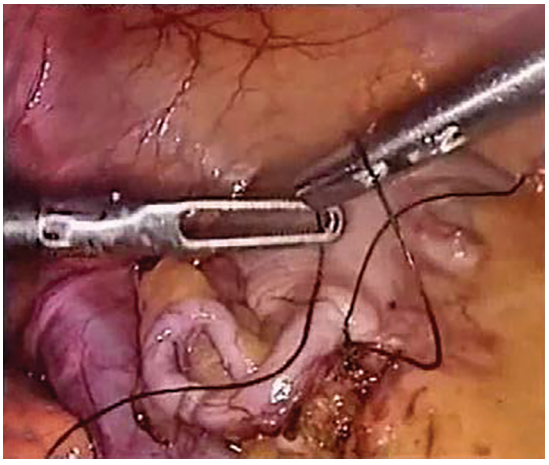
The patient was then positioned in the Trendelenburg with a mild-left tilt, to facilitate the exposure of the appendix. Any pus collection was aspirated, and then, dissection of the appendix and control of the appendicular artery by clips or ligation was performed. The appendiceal stump closure was secured by applying an ICK by polyglactin suture 2-0 or 3-0 in group A (Figs. 1–3). In group B, the stump was secured by two or three large titanium endoclips on the healthy firm tissue next to the cecum wall. A distal clip (spaced 10 mm from the proximal one) was applied to permit a cut in between (Figs. 4 and 5). It was noticed that the appendix base becomes wider in its attachment to the cecum, and the clip cannot secure 100% of the stump diameter (Fig. 6), and so it was better to clip 0.75 cm away from the cecum to achieve proper occlusion. After sectioning of the appendix, the extraverted appendiceal mucosa was coagulated and the abdominal cavity was reassessed for any local or remote fluid collection or bleeding, and irrigation with warm saline solution and suction under visualization was performed.

This was followed by routine histopathology of the removed appendix. A non suction drain was inserted in 15 patients with complicated appendix or infected collection.

The overall average cost was calculated for each technique after each operation.

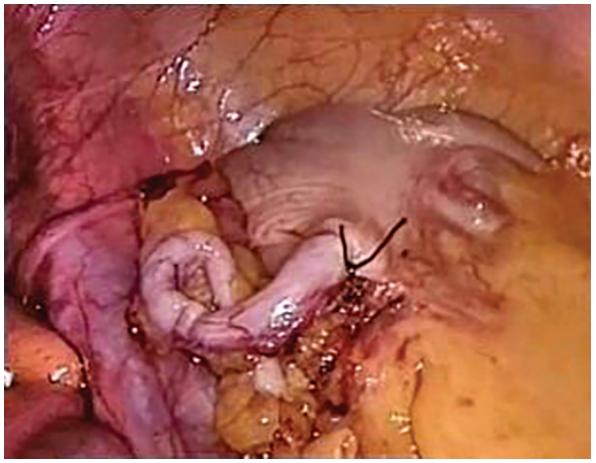
Diagnoses of operative complications were defined and reported as bleeding, iatrogenic injury, endoclip escape or blow out, small-bowel obstruction, or enteric leak.

Figure 1



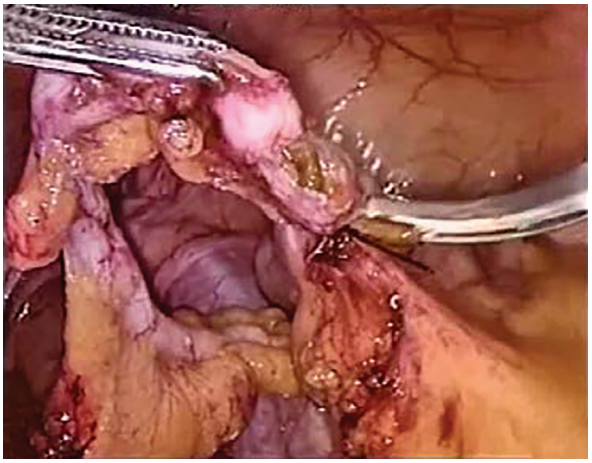
Intracorporeal knotting.

Figure 2



Secure knote.

Figure 3



Cutting distal to the knote.

Figure 4

Metal clip closure technique.

Figure 5

Metal clip closure technique, distal clip.

Figure 6

Metal clip closure technique, mucosal coagulation.

Results

The mean age was 29.3 years in group A and 25.5 years in group B. The mean operative time was 45 min in group A and 37 min in group B ($P < 0.05$). The mean hospital stay was 2.07 days in group A and 2 days in group B ($P > 0.05$). The ICK technique was successful to close the appendix base safely in 94% of the patients in group A and in 83% of the patients in group B ($P < 0.05$). There were no statistically significant differences detected between the two groups in terms of the distribution of age, sex, the appendix location, and the histopathologic diagnosis ($P > 0.05$). There were no intraoperative complications such as bleeding or intestinal injury. No statistically significant differences were detected between the groups in terms of the hospital stay, the follow-up time, and operative or postoperative complications ($P > 0.05$). The average overall cost of patients in groups A and B were $465.5 and $473.6, respectively.

Postoperative complications in group A were as follows: two (2%) patients had port-site skin infection; one (1%) patient showed delayed intestinal sounds for 72 h and improved by medications. In group B, one (1%) patient had port-site skin infection and one patient was readmitted after 4 days due to fever (38.1°) and lower abdominal pain and tenderness; the patient was admitted for 24 h; there was mild leukocytosis, and an abdominopelvic ultrasound denoted no collection,

and so blow out and leak were excluded; antibiotic and antipyretic were given to this patient with rapid improvement and discharge. There were no specific early or late complications related to both techniques, and the conversion to open technique was not needed in either of them.

It was noticed in this study that the condition of the base of the appendix, and not the distal part of the appendix, affected the applicability of both techniques, as gangrene of the tip only did not affect clipping or ligation, but severe friability or necrosis of the base made the application of both techniques impossible and risky. The quality of the base of the appendix varied as follows:

(1) Normal.
(2) Hyperemic.
(3) Severely edematous.
(4) Edematous and friable.
(5) Gangrenous necrotic.

The outcomes are shown in Table 1 and complications in Table 2.

Discussion

The acceptance of LA among surgeons is increasing [13]. LA has been shown to be advantageous compared with OA with regard to early postoperative parameters such as postoperative pain and recovery of bowel function. LA is also associated with a lower wound infection rate [14,15].

Despite the lack of a clear outcome of the cost benefit of LA, most cost studies have confirmed a substantially higher cost of LA compared with OA, due to the expensive disposable equipment used during the procedure [16,17]. The appendiceal stump has been secured by different ways during LA, including the use of mechanical endostapler, [18] endoligature (Endoloop) [19–21], metal endoclips [22–24], polymeric endoclips [25], and intracorporeal suture [26].

The previous alternatives have advantages and disadvantages for the different clinical stages of acute appendicitis, but endoloops and endostaplers are used most frequently [15,18–28].

Sahm *et al.* [13] and Billingham and Basterield [17] in their studies reported that intracorporeal suturing is a safe alternative to the expensive linear stapler or to the less expensive endoloop and showed no significant difference in efficacy and safety [13].

Kiudelis *et al.* [29] and Billingham and Basterield [17] reported that intracorporeal ligation is lower in cost and €80 cheaper than the endoloop technique. Compared with laparoscopic staplers, endolpoops have an advantage as they are 6–12 times cheaper than stapling devices [30], and intracorporeal suture is even cheaper than endoloops [29].

As commercially available titanium and absorbable clips can sustain a high degree of intraluminal pressure and cannot be displaced by a pressure of 300 mgHg [31] and are low cost, their use is acceptable for secure closure of the appendiceal stump similar to that of cystic duct closure. Rickert *et al.* [27] used a titanium double-shanked clip in their study. It has the ability to secure appendix stumps with a diameter of up to 20 mm safely. Despite being an easy and safe technique, the disadvantage is the need for a 12.5-mm trocar for introducing the clip applicator.

Table 1 Characteristics and outcomes of both techniques

	Group A (ICK)	Group B (MCC)	*P* value
Age (years)	29.3 (range 18–41)	25.5 (range 13–44)	
Sex (female)	52	65	
Condition of the stump			
Normal	6	7	
Hyperemia and mild edema	75	77	
Severe edema and thickening of the stump	15	11 (1 wide)	
Friability of the stump	3 (2 wide)	2 (1 wide)	
Base necrosis	1	3 (1 wide)	
Total no.	100	100	
Wide base>10 mm	9	7	
Intraoperative complications	0	0	
Operation time (min)	45 (range 40–65)	37 (range 32–50)	
Simplicity of the technique for the trainee	+++	+++++	
Hospital stay (days)	2.07 (range 1.3–2.4)	2	>0.05
Mean appendix diameter (mm)	10 (range 5–15)	10 (range 5–15)	

ICK, intracorporeal knotting; MCC, metal clip closure technique; +, increasing numbers of +, mean more simple.

Table 2 Complications of both techniques in the early period and over 6 months

	Group A (ICK)	Group B (MCC)	*P* value
Bleeding	0	0	
Iatrogenic intestinal injury	0	0	
Small-bowel obstruction	0	0	
Conversion rate	0	0	
Stump blow out or enteric leak	0	0	
Abdominal abscess	0	0	
Postoperative delay of intestinal sounds	0	1	
Wound infection	2	1	
Failure of the technique	6	17	<0.01
Readmission	0	1	
Reoperation	0	0	
Average overall cost	$465.5	$473.6	>0.05

ICK, intracorporeal knotting; MCC, metal clip closure technique.

We agreed with some authors' study results [11,22,23] that using a titanium endoclip for appendiceal stump closure is safe and associated with a shorter operation time in LA. It also simplifies the procedure and provides a useful alternative to ICK for appendiceal stump closure.

The only disadvantage of the titanium clip closure technique is the presence of appendiceal base necrosis, which was the most important factor responsible for procedure failure during the treatment of complicated appendicitis; one more reason for failure is an appendix with a wide base of more than 10 mm during MCC as clips do not close all diameters of the appendix. The use of mechanical stapler can circumvent the problem; however, it was not used in our study and management was performed successfully by ICK and base invagination by burse string sutures. In this study, the metal clip closure success rate was 83%, and the 17% failure was due to either a wide caliber base or the presence of advanced cecum–appendiceal inflammatory edema or proximal third necrosis or gangrene. ICK succeeded to securing 94% of the appendiceal stump, and the failure was due to friability, base necrosis or tissue break down in cases of severe stump edema. In our study, severely inflamed or more than 10-mm wide appendiceal base could not be secured by the MCC technique (group B), but it was successful in only 83 (83%) patients; the other 16 patients had wide and friable bases. Some bases with severe edema and thickening needed more care during securing because forcible firing of clips or tight ligation led to tissue break down.

In both techniques, failure of securing the stump was managed by gentle ligation at the most firm viable point close to the cecum, and then reinforced by burse string sutures and base invagination.

Rakić *et al.* [32] reported that the cost of the endostapler was set at €378.50 (Endopath-Endocutter ATG45; Ethicon Endo-Surgery Inc., Cincinnati, Ohio, USA) and the cost of the endoloop was set at €32.80 (Vicryl-Endoloop 0; Ethicon Endo-Surgery Inc.). In our study, the overall cost of the procedure in group A (ICK) was $465.5 and in group B (MCC) was $473.5 ($P$>0.05). The cost of titanium clips was $6.7 (about €5.2) and that of the polygalactin suture was $4.8 (about €4), which is very low compared with endoloops or endostaplers. From our study, the application of both techniques was found to be safe and cost effective, and there were no significant differences regarding complications: only one case in group B had a delay in bowel sounds, which was not related to the technique used; also, the incidence of port-site skin infection was low in both techniques (P > 0.05). There were no reported specific complications related to either techniques such as intestinal leak, blow out, or intestinal obstruction. There was no significant difference of cost or hospital stay for both techniques, but both were noticeably cheaper than those performed by staplers or endoloops.

Both techniques were feasible and cost effective, especially in developing countries, and MCC was much easier for trainees than the ICK technique and could be considered a preliminary step in teaching hospitals for closure of small-caliber noncomplicated appendix.

Conclusion

Both ICK and metallic clip closure techniques were safe and economic in securing the appendiceal stump, except for wide, severely edematous or gangrenous base, wherein the metallic clip closure technique was not appropriate and was inferior to knotting.

Acknowledgements

Conflicts of interest

None declared.

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