



## Securing the appendiceal stump with the Gea extracorporeal sliding knot during laparoscopic appendectomy is safe and economical

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### Abstract

**Background:** Laparoscopic appendectomy (LA) has become very popular. One criticism of this approach is the high cost of the disposable equipment such as the linear stapler. An alternative would be suture ligation of the appendiceal base. To prove the safety of the Gea extracorporeal sliding knot (GESK) for closure of the stump after LA, a retrospective study was conducted.

**Methods:** For this study, 63 LA procedures performed by one surgeon using the Gea knot (group A) were reviewed and compared with 63 LA procedures performed by two other surgeons (group B) using the linear stapler. The GESK is created with 0-prolene in the manner already described. The main variable was the presence or absence of blowout, leak, or fistula from the appendiceal stump. The secondary variables were abdominal abscess, wound infection, and need for readmission or reoperation. The results were analyzed using the appropriate statistical methods.

**Results:** Both groups were similar in terms of age, gender, and pathologic diagnosis. No patient in group A or B experienced a colonic fistula, stump blowout, or leak. In group A, one patient experienced interloop abscesses. There were two wound infections. In group B, one patient experienced a wound infection, and another patient had a wound dehiscence of the umbilical port, which required reoperation. No statistical differences were noted between the two groups.

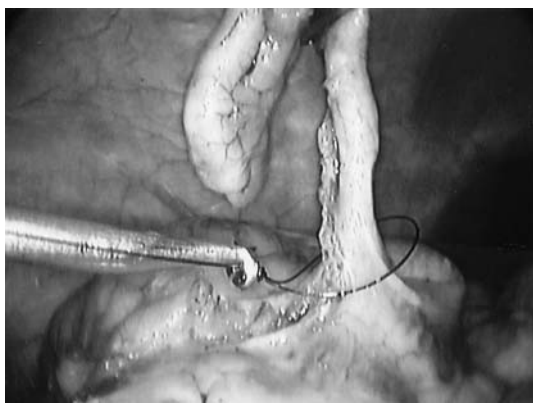
**Conclusions:** There are surgeons who routinely use sutures to secure the stump of the appendectomy. This study aimed to demonstrate that the GESK is as secure as the stapler for closure of the appendiceal stump. The GESK could be passed through a 5-mm trocar, potentially avoiding complications of a larger trocar site. The GESK seems to be an economic and safe alternative to the stapler.

**Key words:** Appendectomy — Appendicitis — Gea — Knot — Laparoscopic — Stump

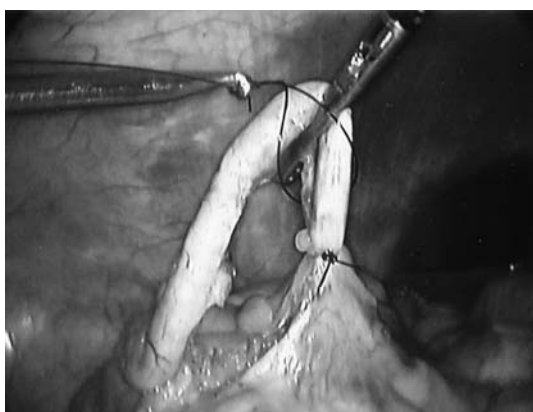
Appendicitis is the most common intraabdominal surgical emergency in the United States. The indications for an appendectomy fluctuate from the diagnostic uncertainty of acute appendicitis to interval appendectomy. Since its initial description, laparoscopic appendectomy (LA) [12] has gained popularity, although in some prospective trials, it has not clearly proven its superiority over the open procedure. We believe this trend may be attributable to surgeons' perception of a better visualization, a more precise dissection, and better hemostasis. There also may be an element of patient drive because lay individuals perceive "laser" surgery as less painful and easier on the body. It also is known that LA has a lower wound infection rate, less immediate postoperative pain, a subjective better quality of life score at 2 weeks, and a quicker recovery with consequent earlier return to work than the open procedure [2, 3, 5, 11].

One disadvantage of LA besides the longer operative time is its cost [5]. An important element that contributes largely to its elevated cost is the disposable equipment used during the procedure. The use of the Endo-GIA (United States Surgical Norwalk, CT) is common in LA. Because simple coagulation of the appendix stump generally is not recommended, an alternative to the expensive linear stapler would be suture ligation of the appendiceal base. This could be safely achieved by intracorporeal suturing, or even faster using an extracorporeal sliding knot such as the Gea extracorporeal sliding knot (GESK) described by Moreno M, et al. [8]. The virtues of the GESK are the fact that it takes only 19 s to be tied and secured, the low cost of a 0-prolene suture, and its capacity to be placed through a 5-mm trocar.

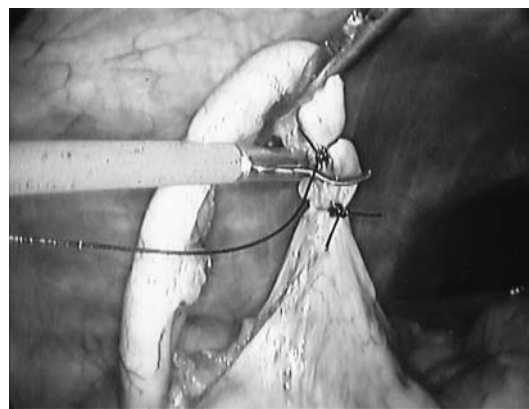
We firmly believe that using the Gea knot as described by the present authors is a safe method for closure of the appendiceal stump during LA. To prove



**Fig. 1.** The Gea knot has been formed extracorporeally and it is being tightened at the base.



**Fig. 2.** A second Gea knot is being applied approximately 1 cm apart from the previous one.



**Fig. 3.** The appendix is being severed in between the two Gea knots.

**Table 1.** Difference in costs of the disposable material used in laparoscopic appendectomy

Disposable material	Stapled appendectomy (\$)	Gea knot appendectomy (\$)
12-mm trocar	67.50	
11-mm trocar	± 67.50	67.50
5-mm trocar	51.00	102.00
Endo-GIA	266.54	
Endobag	90.10	
0-Prolene suture		1.24
Harmonic scalpel	355.50	
Endoshears		70.20
Endodissector	70.20	
Aspirator/irrigator	45.79	45.79
Total	1,014.13	286.73
Difference		727.40

this hypothesis, we carried out the following retrospective study.

## Materials and methods

The primary author has performed 63 consecutive LA procedures during the past 4 years. The surgical technique used included GESK. These procedures were performed in three different hospitals of Northeast Iowa. We designated this group of patients as group A. The GESK is created with a 0-prolene in the manner already described [8].

During the same period, two other surgeons performed 63 consecutive LA procedures. All these procedures took place in three hospitals of southern California. These surgeons used the Endo-GIA stapler instead of the GESK. This group was designated as group B.

To conduct this retrospective study, we reviewed the hospital records of all 126 patients and compared the information. Demographic data including age and gender were registered. The pathologic diagnosis of the appendix was classified as complicated, not complicated, or not pathologic. The complicated cases encompassed gangrenous transmural necrosis, both microperforated and perforated. On the other hand, the noncomplicated appendicitis included early, subacute, acute, and severe acute appendicitis; acute suppurative appendicitis; and ulcerating appendicitis.

The chart review included the variables of the presence or absence of stump leak and fistula from the appendiceal stump. The secondary variables were abdominal abscess, wound infection, and reoperation. Queries through the medical records departments of all six hospitals were run up to date in a search for admissions or visits to the emergency room of any of the patients for abdominal abscess, enterocutaneous fistula, or wound infection. The results were analyzed, and the

differences between the groups were compared with the chi-square, *t*-test, confidence intervals, and Mann-Whitney test.

For group A, the LA technique used one 11-mm and two 5-mm trocars. The mesoappendix was taken with bipolar forceps and endoshears. The base of the appendix was tied with a first throw of a 0-prolene GESK. A second 0-prolene GESK was used to tie the appendix a few millimeters away from the base knot. The GESK was performed according to the technique described by Moreno et al. [8] (Figs. 1–3).

The appendix and the sutures were severed with the endosissors. The appendix was placed in a manually made bag and retrieved through the 11-mm trocar site. In group B, there was a Hasson trocar, an 11-mm trocar, and a 5-mm trocar. The mesoappendix was taken by an Endo-GIA stapler with a vascular cartridge, occasionally reinforced with regular large clips. In the later group B cases, it was taken with a harmonic scalpel. At this point, the base of the appendix was divided by a linear stapler (Ethicon, Cincinnati, OH). The appendix was placed in a commercial bag and retrieved through the Hasson trocar site. The length of the procedure in both groups was defined by the surgery time written on the anesthesia record. The antibiotics used for each patient were the choice of the surgeon.

## Results

A total of 126 patients who underwent an LA were studied. The 63 LA patients in group A included 29 females (46%) and 34 males (54%) with an average age of 32.3 years. The average hospital stay was 2.78 days (range, 7 h to 15 days). The group average body mass index (BMI) was 26.47 kg/m<sup>2</sup>. The mean American

**Table 2.** Comparative characteristics, the statistical method and the significance between group A and B

	Gea knot appendectomy	Stapled appendectomy	Statistical method and significance
No. of patients	63	63	
Mean age (years)	32.3	33	
No. number of complications	13	11	Chi square, 0.206 ( $p = 0.650$ )
Appendicitis, median ASA	2	2	Mann-Whitney, 0.3234 ( $p > 0.05$ )
Median length of stay (h)	30	34	Mann-Whitney, 0.5948 ( $p > 0.05$ )
Mean BMI	26.47	26.01	T-test of difference, 0 ( $p = 0.642$ )
Median operating time (min)	77	50	Mann-Whitney, 0.000 ( $p < 0.05$ )
Median EBL	10	5	Mann-Whitney, 0.0095 ( $p < 0.05$ )

ASA, American Society of Anesthesiology; BMI, body mass index; EBL, estimated blood loss

Society of Anesthesiology (ASA) classification for preoperative risk was 1.84 (median, 2; range, 1–4). The average time required for the procedure was 81.26 min (range, 38–133 min). The median estimated blood loss was 10 ml (range, 5–150 ml; mode, 5 ml). The pathologic diagnoses of the specimens included complicated appendicitis in 13 cases (20.6%), no pathologic diagnosis in 10 cases (15.9%), and uncomplicated appendicitis in 40 cases (63.5%) (Table 1).

The recorded complications included two patients who had perforated appendicitis with proven pseudomonas peritonitis. The young male required a percutaneous drainage of interloop abscesses, which were remote from the cecum. The elderly female required a wound exploration for an organized abscess of one trocar site. The 15-year-old boy had a wound infection at the 11-mm trocar site.

In group A, the wound infection rate was (3.17%). There were no cases of stump blowout or cecal fistulae. The cost per procedure of the disposable material used for LA in group A was \$286.

Group B consisted of 31 females (49.2%) and 32 males (50.8%) with an average age of 33 years (range, 15–88 years). The average hospital stay was 2.14 days (range, 10 h to 8 days). The average BMI was 26 kg/m<sup>2</sup>. The median ASA classification for preoperative risk was 2 (range, 1–4; average, 1.69). The average time required for the procedure was 55.3 min (range, 20–217 min). The median estimated blood loss was 5 ml (range, 5–100 ml; mean, 12 ml; mode, 5 ml). The pathologic diagnoses of the specimens included complicated appendicitis for 11 patients (14.9%) and no pathologic diagnosis proper for 9 patients (14.9%). Of the 63 cases, 43 (68.25%) were classified as uncomplicated appendicitis.

No patients in group B experienced problems with the stump. One patient had a prolonged ileus. Although pneumatosis intestinalis was found on his CT scan, there was no evidence of intraabdominal abscess, stump leak, or fistula. Wound infection developed in one patient, representing 1.59% of this group. One patient had a wound dehiscence from her umbilical port site and underwent reoperation. The cost of the disposable equipment per procedure for LA in group B was \$1,014 (Table 2). The difference in median operative times and median blood losses between groups A and B reached statistical significance.

There was no mortality in this study. The queries through the health information departments of all six hospitals yielded no visits to the emergency room and no

admissions with a diagnosis of intraabdominal abscess, wound infection, stump blowout, or colonic fistula.

Three complications occurred in group A (wound infection, intraabdominal abscess and reoperation) and two occurred in group B. The difference was not statistically significant (Table 2).

## Discussion

Metaanalyses and randomized controlled trials (RCT) have shown less wound infection, less pain, earlier discharge, and earlier return to normal activities with LA than with open surgery [2, 3, 7, 9, 11]. The last RCT did not have the same results [5]. However, we firmly consider LA and open appendectomy to be at least equivalent.

In economic terms, there is an obvious difference between groups A and B. The use of an economic 0-prolene instead of the expensive stapler may represent up to \$727 in savings involving disposable material. With the use of one 11-mm trocar instead of one 12-mm and one 11-mm trocar, fewer wound complications may be incurred. This fact becomes evident by the reoperation seen in group B for a Hasson trocar-site wound dehiscence.

Although the operating room time is significantly different between groups A (81.26 min) and group B (51.3 min), there are many variables that could account for it including the trend toward a higher rate of complicated appendicitis in group A, the different technique for taking down the mesoappendix, and the surgeon's comparative experience and speed in performing the operation. We believe that as the surgeon masters the LA technique, the anesthesia and operating room times can be decreased.

Currently, LA is considered safe to perform, even for complicated or perforated appendicitis [4, 6]. Intraabdominal abscess, primarily responsible for deaths after LA, is reported to be lower for LA than for the open procedure [6, 10]. Our study had one case of intraabdominal abscess, which could be accounted for by pseudomonas peritonitis found during the operation that resulted in the development of interloop abscesses remote from the appendix, requiring percutaneous drainage. The rate of intraabdominal abscess was 1.6%, which is comparable with the rate obtained in larger studies [4, 6].

One limitation of this study was the small number of patients. As a result, definitive conclusions cannot be

drawn from the findings. However, few previous articles have demonstrated the efficacy of stump ligation without the consequence of higher complication rates than expected [1]. The absence of any stump blowout or fistula, or any communication between the stump and an abscess in either group speaks in favor of their comparability in securing the stump. The use of 0-prolene did not alter the outcome for the patients. Tying the gangrenous base of an appendix also did not cause problems. These results confirm what Beldi et al. [1] concluded. Beldi concluded that in minimally inflamed appendicitis, one endoloop was as safe as using two endoloops either do not part from the acceptable complication rate of open appendectomies.

## Conclusions

There is continued interest in the differences between open surgery and LA. Both approaches seem to be at least equivalent in outcomes. However, it seems that surgeons prefer performing the procedure laparoscopically. A main drawback of the laparoscopic approach is the cost. Previous studies have demonstrated that using suture to secure the appendiceal stump is safe. The current study, albeit small and retrospective, showed no statistical difference in the incidence of stump-related complications, abscess formation, or wound infection between LA and open surgery. This seems to support the notion that the GESK is as safe as the stapler for closing the appendiceal stump. The GESK requires only 19 s to be tied and secured. It uses a simple and economic 0-prolene suture, which can be passed through a 5-mm trocar. In this way, the costs of the disposable material can be kept to a minimum, and potential larger trocar-site complications can be avoided. The GESK seems to be a good alternative to the stapler and may help lower the costs of LA.

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## References

1. Beldi G, Muggli K, Helbling C (2004) Laparoscopic appendectomy using endoloops: a prospective, randomized clinical trial. *Surg Endosc* 18: 749–750
2. Chung RS, Rowland DY, Li P, Diaz J (1999) A metaanalysis of randomized controlled trials of laparoscopic versus conventional appendectomy. *Am J Surg* 177: 250–256
3. Garbutt JM, Soper NJ, Shannon WD, Botero A, Littenberg B (1999) Meta-analysis of randomized controlled trials comparing laparoscopic and open appendectomy. *Surg Laparosc Endosc* 9: 17–26
4. Katkhouda N, Friedlander MH, Grant SW, Achanta KK, Essani R, Paik Peter, Velmahos G, Campos G, Mason R, Mavor E (2000) Intraabdominal abscess rate after laparoscopic appendectomy. *Am J Surg* 180: 456–461
5. Katkhouda N, Mason RJ, Towfigh S (2005) Laparoscopic appendectomy versus open appendectomy: a prospective randomized double-blind study. *Ann Surg* 242: 439–450
6. Mancini GJ, Mancini ML, Nelson HS (2005) Efficacy of laparoscopic appendectomy in appendicitis with peritonitis. *Am Surg* 71: 1–5
7. Moberg F, Berndesen I, Palmquist U, Petersson T, Resh T, Montgomery A (2004) Randomized clinical trial of laparoscopic versus open appendectomy for confirmed appendicitis. *Br J Surg* 92: 298–304
8. Moreno M, Magos FJ, Arcovedo R, Olachea P, Palacios JA, Salazar A, Ramirez ME, Herrera JJ (2004) Comparison of the performance of the Gea extracorporeal knot with the Roeder extracorporeal knot and the classical knot. *Surg Endosc* 18: 157–160
9. Ortega AE, Hunter JG, Peters JH, Swamstrom LL, Schirmer B (1995) A prospective, randomized comparison of laparoscopic appendectomy with open appendectomy. *Am J Surg* 169: 208–213
10. Paik P, Towson BA, Anthone GJ, Ortega AE, Somons AJ, Beart RW Jr (1997) Intra-abdominal abscesses following laparoscopic and open appendectomies. *J Gastro Surg* 1: 188–193
11. Pedersen AG, Petersen OB, Wara P, Ronning H, Qvist N, Laurberg S (2001) Randomized clinical trial of laparoscopic versus open appendectomy. *Br J Surg* 88: 200–205
12. Semm K (1983) Endoscopic appendectomy. *Endoscopy* 15: 59–64