Surg Endosc (2006) 20: 1473–1476
DOI: 10.1007/s00464-005-0525-7

SURGICAL ENDOSCOPY
and Other Interventional Techniques

Securing the appendiceal stump in laparoscopic appendectomy: evidence for routine stapling?

G. Kazemier,[1] K. H. in't Hof,[1] S. Saad,[2] H. J. Bonjer,[1] S. Sauerland[3]

[1] Department of Surgery, Erasmus Medical Centre Rotterdam, Dr Molewaterplein 40, 3015 GD, Rotterdam, The Netherlands
[2] Department of Abdominal, Vascular and Transplantation Surgery, Merheim Hospital, University of Witten-Herdecke, Cologne, Germany
[3] Biochemical and Experimental Division, Medical Faculty, Cologne University, Cologne, Germany

Received: 20 July 2005/Accepted: 6 March 2006/Online publication: 3 July 2006

Abstract
Background: This metaanalysis aimed to compare endoscopic linear stapling and loop ligatures used to secure the base of the appendix.
Methods: Randomized controlled trials on appendix stump closure during laparoscopic appendectomy were systematically searched and critically appraised. The results in terms of complication rates, operating time, and hospital stay were pooled by standard metaanalytic techniques.
Results: Data on 427 patients from four studies were included. The operative time was 9 min longer when loops were used ($p = 0.04$). Superficial wound infections (odds ratio [OR], 0.21; 95% confidence interval (CI), 0.06–0.71; $p = 0.01$) and postoperative ileus (OR, 0.36; 95% CI, 0.14–0.89; $p = 0.03$) were significantly less frequent when the appendix stump was secured with staples instead of loops. Of 10 intraoperative ruptures of the appendix, 7 occurred in loop-treated patients ($p = 0.46$). Hospital stay and frequency of postoperative intraabdominal abscess also were comparable in loop-treated and staple-treated patients.
Conclusions: The clinical evidence on stump closure methods in laparoscopic appendectomy favors the routine use of endoscopic staplers.

Key words: Appendectomy — Appendicitis — Laparoscopy — Stapling

Laparoscopic appendectomy (LA) is progressively accepted as the treatment of choice for acute appendicitis. Numerous randomized trials and metaanalyses have shown less postoperative pain, reduced wound infections, faster recovery, and shorter hospital stay after laparoscopic appendectomy [2, 7, 10, 19, 21, 22, 27].

Correspondence to: G. Kazemier

Although the surgical technique of laparoscopic appendectomy has been well established, controversy exists regarding closure of the appendiceal stump. In the early days of LA, the stump was closed with preknotted loops (Roeder loops or endoloops) [1, 8, 26]. After the introduction of laparoscopic linear staplers, it became "en vogue" to apply these in LA, particularly for difficult cases such as perforation at the appendiceal base [4, 5, 11]. Currently, some authors advise the routine use of linear staplers during LA to avoid leakage from the appendiceal stump [24].

Findings have shown both techniques to be safe, but both entail potential drawbacks. Linear staplers are expensive and require a 12-mm port for their introduction. Leaving metal staples on the stump and in the abdominal cavity can cause adhesion-related short bowel obstruction or formation of pseudopolyps in the cecum [15, 16, 20].

On the other hand, loops are associated with more manipulation of the stump. Moreover, they can slip, which can potentially lead to more postoperative infections. Loops are not safe for closure of the cecum when the base of the appendix is perforated if the inflammation of the appendix has involved the cecum as well [18]. If loops are too tight, they also can cut into the tissue or cause local necrosis, predisposing to stump leakage.

Complications attributable to stump closure are rare, which means that large studies are required to show the superiority of either method. Pooling data from the literature is potentially helpful in overcoming this sample size problem [23]. This study aimed to determine the optimal technique for securing the appendiceal stump in LA using data available in the current literature.

Materials and methods

For this study, only the data of patients who underwent laparoscopic surgery were assessed. All randomized controlled trials comparing

Table 1. Quality assessment of the included studies[a]

Author, year	Concealment of random allocation	Blinding of patients or study staff	Intention-to-treat-analysis	Total score (0–6)
Ortega et al., 1995 [17]	2 Telephone randomizations	2 Patients and nurses blinded	0 Five crossover patients[b]	4
Klima et al., 1998 [12, 13]	1 Methods unclear	0 No blinding mentioned	1 No conversions mentioned	2
Lange et al., 1993 [14]	1 Methods unclear	0 No blinding mentioned	0 Methods unclear, abstract only	1
Shalaby et al., 2001 [25]	2 Envelope randomization[c]	0 No blinding	1 No conversions mentioned	3
Beldi et al., 2004 [3]	0 Quasi-randomization	0 No blinding	0 Over 20% excluded	0

[a] According to Jadad et al. [9]
[b] For five patients assigned to stapled appendectomy, the stapler was unavailable. These cases were treated using loops and analyzed within the loop group
[c] Personal written communication with Dr. Rafik Yousef Shalaby (October 2001)

different closing techniques of the appendiceal stump during laparoscopic appendectomy for acute appendicitis were included. Trials that allocated patients depending on the availability of staff or instruments were excluded. The aims of the surgical interventions under investigation were to remove an inflamed or uninflamed appendix and to close the appendiceal stump with stapler or loops. The methods used to achieve these aims were LA with stapler and LA with loops.

To be as comprehensive as possible, the following search strategies were used to identify all relevant studies regardless of language after the year 1983. The Cochrane Library (Version IV/2004), Medline, Embase, SciSearch, and Biosis were searched electronically. All searches were repeated until January 31, 2005. Reference lists were checked, and authors of relevant articles and known international experts in the field of laparoscopic surgery were contacted to obtain information on any past, present, or future studies. Abstracts presented to the international scientific societies with a focus on endoscopic surgery were searched for by hand, and the authors were asked to provide full information on their study.

All studies were assessed by two reviewers (K.H.H. and S.S.), who checked the main criteria of the study design and analysis, the method of randomization and allocation concealment, the blinding of outcome assessment, and how the study dealt with protocol violations. These three aspects of quality were scored using a scale of 0 to 2, as proposed by Jadad et al. [9].

For dichotomous variables, risk differences with their 95% confidence intervals (CI) were calculated. Because the study dealt with rare events, the Peto odds ratio (OR) also was calculated. For continuous variables, means with their corresponding standard deviations (SDs) are generally needed to calculate the mean differences and 95% confidence intervals. If a study did not report the SD for a mean value, we estimated the SD to be equal to the mean. The effect measures were pooled within a random effects model. Heterogeneity was quantified by the I^2 statistics, which range from 0% (no heterogeneity) to 100% (maximum heterogeneity).

Results

The five studies included in the review contributed to the results in the following way. One study compared double and single loops at the base of the appendix [3], without showing major differences. The patients from this study were not included in the final analysis. Four studies compared LA using staplers and LA using loops [12, 14, 17, 25]. Three of these studies had a three-armed design randomizing patients to laparoscopic appendectomy with loops, staplers, or a third procedure. The third procedure was open appendectomy [17], extracorporeal stump ligation [25], or additional sinking of the appendix stump [12]. One trial was performed with children [25].

The quality of all the included studies was moderate to poor (Table 1). Typical shortcomings were a lack of blinding and various types of protocol violations, which made complete intention-to-treat analysis impossible. No study described the actual accrual rate of patients with suspected acute appendicitis during the study period, nor did any include a longer follow-up period to detect intraabdominal adhesions and similar problems.

Table 2 summarizes the therapeutic effects from the four aforementioned studies. The findings based on 427 patients show that the operative time was 9 min shorter ($p = 0.04$) if a stapler was used. The results on operative time, however, were heterogeneous ($I^2 = 73\%$). Rupture of the appendix occurred with similar frequency in the two groups ($p = 0.46$). Figure 1 shows that wound infections were significantly less likely if a stapler was used (OR, 0.21; 95% CI, 0.06–0.71; $p = 0.01$). Figure 2 shows that postoperative ileus was significantly less common in the staple group (OR, 0.36; 95% CI, 0.14–0.89; $p = 0.03$). Both outcomes were homogeneous. Intraabdominal abscesses were seen at similar rates in the two groups (OR, 0.62; 95% CI, 0.20–1.94). The hospital stay was apparently unaffected by the stump closure technique. However, the results on hospital stay were heterogeneous ($I^2 = 67\%$). No study assessed costs in detail.

Discussion

Reduction of surgical trauma and prevention of postoperative morbidity are the pillars to the provision of patient safety. The laparoscopic approach to appendicitis has improved the outcome of appendectomy, but requires laparoscopic skills of the surgical team [22]. Appendectomy is performed by surgical teams with varying experience in laparoscopic surgery. The routine use of staplers to secure the appendiceal stump during laparoscopic appendectomy can contribute to a reduction in the complexity of the procedure. This was confirmed by the current study, which showed a decrease in operating time when the appendiceal stump was closed with a stapling device. The 9-min reduction in operating time in the staple group almost compensated for the average 12 min longer operating time for laparoscopic appendectomy, as compared with the open approach [22].

This study also shows that the routine use of staplers contributes to patient safety. It reduces the number of wound infections and the frequency of postoperative ileus. However, the clinical impact from wound infec-

Table 2. Results of randomized controlled trials comparing loop ligature and stapling used to secure the basis of the appendiceal stump

Author, year	Treatment groups (*n*)	Operative time (min)	Intraoperative rupture of appendix	Intraabdominal abscesses	Superficial wound infection	Postoperative ileus	Length of hospital stay (days)
Lange et al., 1993 [14]	Endoloop[a] (*n* = 50)	57.3[b]	NA	7/50			4.5[b]
	Stapler (*n* = 50)	48.7[b]	NA	6/50			3.7[b]
Ortega et al., 1995 [17]	Two endoloops[c] (*n* = 84)	68 ± 25	4/89	4/89	4/89	14/89	2.98 ± 2.7
	Stapler[c] (*n* = 83)	66 ± 24	2/78	2/78	0/78	5/78	2.16 ± 3.2
Klima et al., 1998 [12]	Two endoloops with stump sinking (*n* = 50)	59[b]	1/50	0/50	1/50	0/50	NA
	Two endoloops without stump sinking (*n* = 50)	54[b]	2/50	4/50	2/50	1/50	NA
	Stapler (*n* = 50)	48.5[b]	1/50	2/50	1/50	0/50	NA
Shalaby et al., 2001 [25]	Endoloop[a] (*n* = 40)	38.5 ± 4.4	NA	1/40	3/40	1/40	1.48 ± 0.68
	Stapler (*n* = 60)	23.9 ± 3.0	NA	0/60	0/60	0/60	1.73 ± 0.80
Metaanalysis: OR (95% CI)		−9 min (0 to −18)	0.61 (0.17–2.22)	0.62 (0.20–1.94)	0.21 (0.06–0.71)	0.36 (0.14–0.89)	−0.3 days (−1.2–0.6)

NA, not available; OR, odds ratio; CI, confidence interval
[a] The trials do not make clear whether one or two loops were applied
[b] Data on standard deviation are not reported. Standard deviation was estimated as equal to the reported mean
[c] In five patients assigned to stapled appendectomy, the stapler was unavailable. These cases were treated using loops and analyzed within the loop group

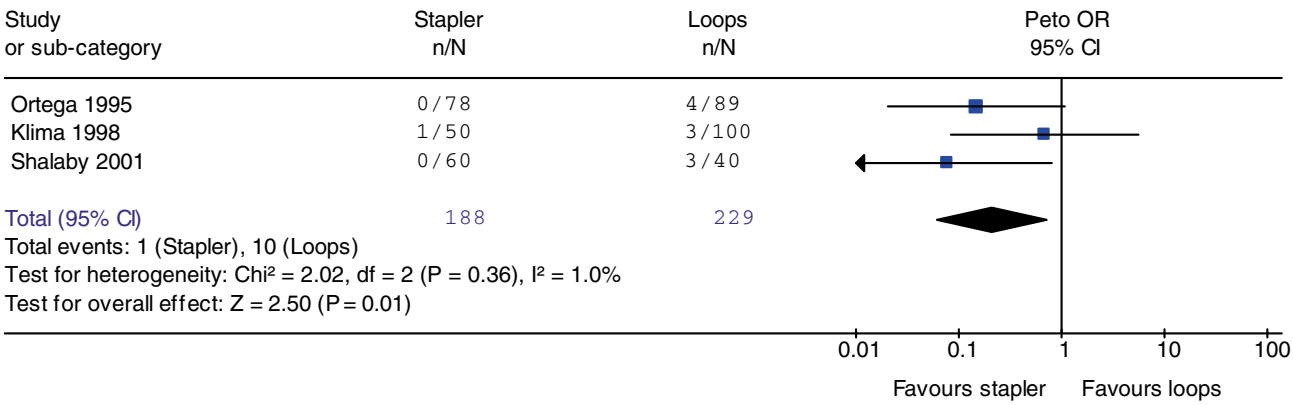

Fig. 1. Superficial wound infection rates in randomized controlled trials comparing loop ligature and stapling used to secure the base of the appendiceal stump.

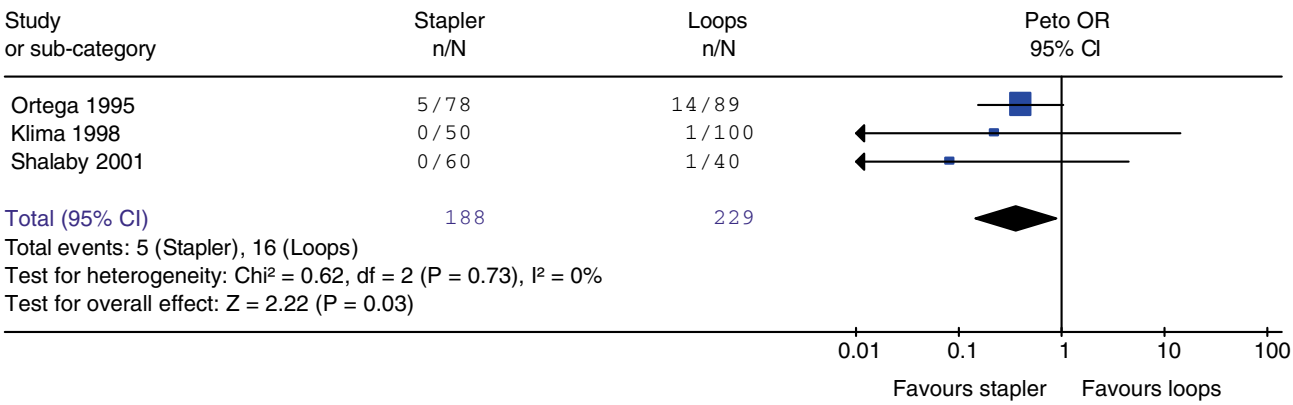

Fig. 2. Postoperative ileus rates in randomized controlled trials comparing loop ligature and stapling used to secure the base of the appendiceal stump.

tions of trocar wounds 1 cm or less in diameter should not be overestimated.

Optimization of the technique applied to close the appendiceal stump with loops was not the subject of this trial. However, techniques of loop placement play an important role in the final performance of this closure technique. One concern with the use of a loop is partial transsection of the stump followed by leakage. Tightening the loop knot with due force requires experience, particularly when the stump of the appendix is fragile, as in cases of severe or long-standing inflammation. Placement of two loops on the appendiceal stump to provide more secure closure of the appendiceal stump has been suggested, although this will not avoid transsection per se [6]. Oversewing of the appendiceal stump possibly prevents complications, but requires considerable expertise in laparoscopic suturing techniques [12]. The observation that the numbers of intraabdominal abscesses were comparable in the two groups and that the hospital stays did not differ can possibly be attributed to the sample size in this study, although all currently available data from the literature were pooled.

If staplers were as cheap as loops, the routine use of staplers in laparoscopic appendectomy would arguably be the better option. However, considerable differences in costs between the two methods exist. In the European Union, a 300-€ increase in direct costs is to be expected for every laparoscopic appendectomy. This represents more than half of the total costs for operating material (550 €).

Further studies are necessary to establish the costs of abdominal infections and postoperative ileus after appendectomy. Consequently, a future comparative trial should assess all types of local infection as the primary outcome measure. According to current data, superficial infection occurs in 3.5% and intraabdominal infection in 1.5% of cases. Because some of the trials used a stapler whereas others excluded perforated cases, the true infection rate probably amounts to about 8%. Thus, the trial to test the hypothesis that the routine use of staplers to secure the appendiceal stump reduces this 8% rate to 4% would require 600 patients per group. Until such a trial is completed, the routine use of staplers during laparoscopic appendectomy appears to be preferable, but at high direct costs.

References

1. al Fallouji M (1993) Making loops in laparoscopic surgery: state of the art. Surg Laparosc Endosc 3: 477–481
2. Attwood SE, Hill AD, Murphy PG, Thornton J, Stephens RB (1992) A prospective randomized trial of laparoscopic versus open appendectomy. Surgery 112: 497–501
3. Beldi G, Muggli K, Helbling C, Schlumpf R (2004) Laparoscopic appendectomy using endoloops: a prospective, randomized clinical trial. Surg Endosc 18: 749–750
4. Cristalli BG, Izard V, Jacob D, Levardon M (1991) Laparoscopic appendectomy using a clip applier. Surg Endosc 5: 176–178
5. Daniell JF, Gurley LD, Kurtz BR, Chambers JF (1991) The use of an automatic stapling device for laparoscopic appendectomy. Obstet Gynecol 78: 721–723
6. Guillem P, Mulliez E, Proye C, Pattou F (2004) Retained appendicolith after laparoscopic appendectomy: the need for systematic double ligature of the appendiceal base. Surg Endosc 18: 717–718
7. Heikkinen TJ, Haukipuro K, Hulkko A (1998) Cost-effective appendectomy: open or laparoscopic? A prospective randomized study. Surg Endosc 12: 1204–1208
8. Houben F, Willmen HR (1998) Vereinfachte Appendektomie ohne Stumpfversenkung: Erfahrungen aus 20-jähriger konventioneller und 5-jähriger laparoskopischer Anwendung. Chirurg 69: 66–71
9. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, McQuay HJ (1996) Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 17: 1–12
10. Kazemier G, de Zeeuw GR, Lange JF, Hop WCJ, Bonjer HJ (1997) Laparoscopic vs open appendectomy: a randomized clinical trial. Surg Endosc 11: 336–340
11. Klaiber C, Wagner M, Metzger A (1994) Various stapling techniques in laparoscopic appendectomy: 40 consecutive cases. Surg Laparosc Endosc 4: 205–209
12. Klima S (1998) Bedeutung der Appendixstumpfversorgung bei der laparoskopischen Appendektomie. Zentralbl Chir 123(Suppl 4): 90–93
13. Klima S, Schyra B (1996) Technik und Bedeutung der Stumpfversorgung für das Ergebnis der laparoskopischen Appendektomie. Langenbecks Arch Chir Suppl Kongressbd 113: 556–558
14. Lange J, Zünd MR, Nägeli J (1993) Prospektiv randomisierte Studie: Roederschlinge versus Endo-GIA bei der laparoskopischen Appendektomie [abstract]. Min Invas Chir 2(Suppl 1): 8
15. Lörken M, Marnitz U, Schumpelick V (1999) Freier intraperitonealer Clip als Ursache eines mechanischen Dünndarmileus. Chirurg 70: 1492–1493
16. Nottingham JM (2002) Mechanical small bowel obstruction from a loose linear cutter staple after laparoscopic appendectomy. Surg Laparosc Endosc Percutan Tech 12: 289–290
17. Ortega AE, Hunter JG, Peters JH, Swanstrom LL, Schirmer B, Laparoscopic Appendectomy Study Group (1995) A prospective, randomized comparison of laparoscopic appendectomy with open appendectomy. Am J Surg 169: 208–213
18. Paik PS, Towson JA, Anthone GJ, Ortega AE, Simons AJ, Beart RW Jr (1997) Intraabdominal abscesses following laparoscopic and open appendectomies. J Gastrointest Surg 1: 188–193
19. Pedersen AG, Petersen OB, Wara P, Ronning H, Qvist N, Laurberg S (2001) Randomized clinical trial of laparoscopic versus open appendicectomy. Br J Surg 88: 200–205
20. Petrocelli P, Corsale I, Giannessi S, Cerone M, Colugnat D, Matocci GC (2003) Complicanze da suture meccaniche in chirurgia laparoscopica: occlusione intestinale da clip: Segnalazione di un caso clinico e revisione della letteratura. Minerva Chir 58: 591–594
21. Sauerland S, Lefering R, Holthausen U, Neugebauer EAM (1998) Laparoscopic vs conventional appendectomy: a metaanalysis of randomised controlled trials. Langenbeck's Arch Surg 383: 289–295
22. Sauerland S, Lefering R, Neugebauer E (2004) Laparoscopic versus open surgery for suspected appendicitis (Cochrane Review). In: The Cochrane Collaboration (ed) The Cochrane Database of Systematic Reviews, Vol. IV/2004 (CD-ROM). Update Software, Oxford, UK
23. Sauerland S, Seiler CM (2005) Role of systematic reviews and meta-analysis in evidence-based medicine. World J Surg 29: 582–587
24. Schäfer M, Krähenbühl L, Frei E, Büchler MW (2000) Laparoscopic appendectomy in Switzerland: a prospective audit of 2,179 cases. Dig Surg 17: 497–502
25. Shalaby R, Arnos A, Desoky A, Samaha AH (2001) Laparoscopic appendectomy in children: evaluation of different techniques. Surg Laparosc Endosc Percutan Tech 11: 22–27
26. Shimi SM, Lirici M, Vander Velpen G, Cuschieri A (1994) Comparative study of the holding strength of slipknots using absorbable and nonabsorbable ligature materials. Surg Endosc 8: 1285–1291
27. Temple LK, Litwin DE, McLeod RS (1999) A metaanalysis of laparoscopic versus open appendectomy in patients suspected of having acute appendicitis. Can J Surg 42: 377–383