

# Analysis of stapling *versus* endoloops in appendiceal stump closure

G. Beldi<sup>1</sup>, S. A. Vorburger<sup>1</sup>, L. E. Bruegger<sup>1</sup>, T. Kocher<sup>2</sup>, D. Inderbitzin<sup>1</sup> and D. Candinas<sup>1</sup>, for the Swiss Association of Laparoscopic and Thoracoscopic Surgery Study Group

<sup>1</sup>Department of Visceral and Transplant Surgery, University Hospital Bern, Bern, <sup>2</sup>Department of Surgery, Kantonsspital Baden, Baden, Switzerland  
Correspondence to: Dr G. Beldi, Department of Visceral and Transplant Surgery, University Hospital Bern, CH-3010 Bern, Switzerland  
(e-mail: guido.beldi@insel.ch)

**Background:** The effectiveness of various appendiceal stump closure methods has not been evaluated systematically. The aim of this study was to compare the morbidity of stump closure by stapling or use of endoloops.

**Methods:** A non-concurrent cohort study of prospectively acquired data was performed. The primary outcome variable was the rate of intra-abdominal surgical-site infection. Secondary outcome measures were complications, duration of intervention, hospital stay, rate of readmission to hospital and the difference in direct costs of the operation.

**Results:** Staples were used in 60.5 per cent and endoloops in 39.5 per cent of 6486 patients operated on for suspected appendicitis between January 1995 and December 2003. Among 4489 patients with acute appendicitis the rate of intra-abdominal surgical-site infection was 0.7 per cent in the stapler group and 1.7 per cent in the endoloop group ( $P = 0.004$ ). The rate of readmission to hospital was 0.9 and 2.1 per cent respectively ( $P = 0.001$ ).

**Conclusion:** Application of a stapler for transection and closure of the appendiceal stump in patients with acute appendicitis lowered the risk of postoperative intra-abdominal surgical-site infection and the need for readmission to hospital.

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## Introduction

The laparoscopic approach for the treatment of appendicitis has gained wide clinical acceptance. Laparoscopic appendicectomy offers fewer wound infections, faster recovery and an earlier return to work in comparison to open surgery<sup>1,2</sup>. Although the technique of laparoscopic appendicectomy was first described more than 20 years ago, the technical details are still being modified<sup>3</sup> and improvements can be measured in terms of complications and cost<sup>4</sup>.

The base of the appendix is most frequently closed using staplers or endoloop ligatures<sup>5-7</sup>. Staplers have the advantage of relatively easy handling and a possible reduction in the incidence of leakage in advanced appendicitis owing to closure with a double row of staples<sup>8</sup>. However, rare complications, such as small bowel

obstruction, have been attributed directly to the stapling device<sup>9</sup>. An advantage of endoloops is that they are six to 12 times cheaper than stapling devices. To date, there has not been a systematic comparison of the efficacy of the two methods for treatment of the appendiceal stump. The aim of this study was to compare the overall incidence and specific intraoperative and postoperative complications after application of a stapler *versus* endoloops for stump closure in laparoscopic appendicectomy.

## Patients and methods

The Swiss Association for Laparoscopic and Thoracoscopic Surgery database was used for this investigation. Data were collected prospectively, starting in 1995, from patients undergoing various laparoscopic procedures at institutions in Switzerland that perform general surgery

**Table 1** Demographic data and intraoperative findings

	Stapler (n = 3921)	Endoloop (n = 2565)	P
Age (years)*	30 (21–45)	28 (20–40)	< 0.001‡
Bodyweight (kg)*	69 (59–79)	69 (59–79)	0.943‡
ASA grade			0.136§
I	2466 (62.9)	1558 (60.7)	
II	1259 (32.1)	881 (34.3)	
III	183 (4.7)	112 (4.4)	
IV	13 (0.3)	14 (0.5)	
Intraoperative findings			
Acute appendicitis	2683 (68.4)	1806 (70.4)	0.096§
Perforated appendicitis	598 (15.3)	268 (10.4)	< 0.001§
Other pathology	81 (2.1)	68 (2.7)	0.146§
No pathology	559 (14.3)	423 (16.5)	0.015§

Values in parentheses are percentages unless indicated otherwise; \*values are median (interquartile range). ASA, American Society of Anesthesiologists. ‡Student's *t* test; § $\chi^2$  test.

(university, county and district hospitals, and surgeons in private practice). A total of 7143 laparoscopic appendicectomies performed for suspected appendicitis between January 1995 and December 2003 were analysed. Exclusion criteria were application of a clip for stump closure (77 patients) and lack of notification of the closure technique (580 patients). Data were grouped according to the stump closure technique, with either a stapler (3921 patients; 60.5 per cent) or endoloops (2565 patients; 39.5 per cent). Patient data are summarized in *Table 1*.

### Outcome measures

The primary outcome measure was the rate of intra-abdominal surgical-site infection, defined as postoperative intra-abdominal abscess and peritonitis. Secondary outcome variables were intraoperative and postoperative complications, duration of operation, hospital stay, rate of readmission to hospital, and the difference in direct costs of the operation. Intraoperative complications included access-related complications, such as lesions caused by a Veress needle or by limited open access, organ lesions and bleeding (intraperitoneal and into the abdominal wall). Postoperative complications included bleeding (intraperitoneal and into the abdominal wall), superficial surgical-site infection, postoperative ileus, small bowel obstruction and stay in the intensive care unit (ICU).

The price of a stapler was set at €306 (Multifire Endo-GIA™ 30, 3.5 mm; Tyco Healthcare Switzerland, Wollerau, Switzerland) and the price of two endoloops at €16 each (PDS-Endoloop® 2-0; Ethicon, Johnson & Johnson Medical, Spreitenbach, Switzerland) for assessment of the difference in direct costs of the operation.

The cost of operating time was calculated as €14.5 per min for a Swiss university hospital.

### Statistical analysis

Data on age, bodyweight and duration of operation are given as median (interquartile range, i.q.r.).  $\chi^2$  and Fisher's exact test were used to analyse intergroup differences for proportional data. Data were analysed with NCSS® software (NCSS, Kaysville, Utah, USA). *P* < 0.050 was considered statistically significant.

### Results

There were no significant differences between the two groups in overall intraoperative and postoperative complication rates (*Table 2*). Readmission to hospital was significantly more frequent in the endoloop group. The main reason for readmission was postoperative intra-abdominal abscess formation (*Table 3*). The rate of conversion to open surgery and frequency of postoperative ICU stay was significantly higher among patients who had stapled stump closure.

Among 4489 patients with acute appendicitis there was a significantly higher rate of intra-abdominal surgical-site infection and readmission to hospital in the endoloop group (*Table 4*). There were no significant differences in the rate of intra-abdominal surgical-site infection, reoperation or readmission to hospital among 866 patients with perforated appendicitis, but the frequency of admission to the ICU was significantly higher in the stapler group.

Overall, the median (i.q.r.) duration of operation was 51.7 (39.3–69.0) min when a stapler was used compared

**Table 2** Intraoperative and postoperative complications

	Stapler (n = 3921)	Endoloop (n = 2565)	P*
Conversion to open surgery	68 (1.7)	25 (1.0)	0.016
Intraoperative complication	52 (1.3)	28 (1.1)	0.470
Bleeding	43 (1.1)	23 (0.9)	0.511
Organ lesion	4 (0.1)	4 (0.2)	0.808
Access related	5 (0.1)	1 (0.0)	0.466
Postoperative complication	231 (5.9)	136 (5.3)	0.343
Intra-abdominal surgical-site infection	45 (1.1)	41 (1.6)	0.150
Bleeding	42 (1.1)	23 (0.9)	0.574
Superficial surgical-site infection	26 (0.7)	12 (0.5)	0.400
Postoperative ileus	29 (0.7)	12 (0.5)	0.234
ICU stay	26 (0.7)	5 (0.2)	0.013
Small bowel obstruction	7 (0.2)	2 (0.1)	0.470
Other	21 (0.5)	20 (0.8)	0.292
Reoperation	82 (2.1)	40 (1.6)	0.148
Readmission to hospital	47 (1.2)	57 (2.2)	0.002

Values in parentheses are percentages. ICU, intensive care unit. \* $\chi^2$  test.

**Table 3** Reasons for readmission to hospital

	Stapler (n = 47)	Endoloop (n = 57)	P*
Intra-abdominal surgical-site infection	21 (45)	39 (68)	0.018
Superficial surgical-site infection	5 (11)	6 (11)	1.000
Bleeding	3 (6)	4 (7)	1.000
Diarrhoea, colitis	3 (6)	2 (4)	0.656
Cardiopulmonary	3 (6)	1 (2)	0.326
Pain	2 (4)	2 (4)	1.000
Tumour	0 (0)	2 (4)	0.500
Fever	2 (4)	1 (2)	0.588
Small bowel obstruction	2 (4)	1 (2)	0.588
Hernia	1 (2)	1 (2)	1.000
Not specified	5 (11)	1 (2)	0.089

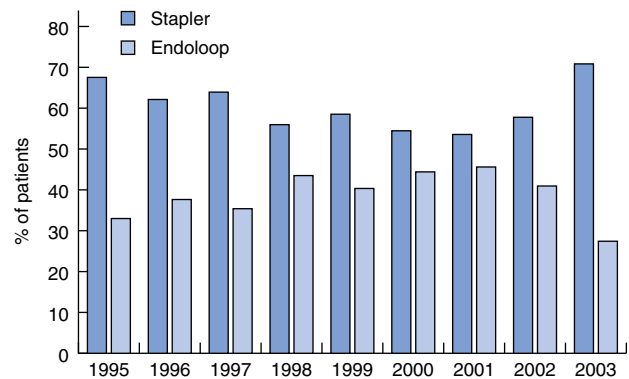
Values in parentheses are percentages. \*Fisher's exact test.

with 53.4 (40.5–72.5) min for endoloops ( $P = 0.001$ ). The conversion rate was significantly lower in the endoloop group ( $P = 0.016$ ) (Table 2). The median hospital stay was 5.9 days for the stapler group and 5.4 days for the endoloop group ( $P = 0.001$ ).

Changes in the use of staplers and endoloops over the study period are shown in Fig. 1. A progressive increase in the use of staplers was noted after 2001.

The relative risk for readmission to hospital in the stapler group was 0.54, representing a relative risk reduction for readmission of 46 per cent with use of the stapler. The absolute risk reduction was 1.02 per cent. Thus, the number of patients that needed to be treated (NNT) using a stapler instead of endoloops to prevent one readmission to hospital was 98. For patients with acute appendicitis the NNT to prevent one readmission or one intra-abdominal surgical-site infection was 80 and 102 respectively.

The median duration of operation was 1.7 min shorter when a stapler was used. In combination with other material costs, this resulted in increased direct operative costs of a

**Fig. 1** Changes in the use of staplers and endoloops over the course of the study

median of €248 when a stapler was used for appendiceal stump closure compared with endoloops.

## Discussion

In patients with acute non-perforated appendicitis, intra-abdominal surgical-site infections were significantly more common after stump closure with endoloops. Treatment of the appendiceal stump with endoloops involves the application of one or two proximal ligatures and one distal ligature around the base of the appendix, which results in extraversion of the appendiceal stump mucosa, as opposed to the inversion of the mucosa with stapling devices<sup>7</sup>. The higher rate of abscess formation after endoloop closure might be explained by insufficient closure of the stump or exposure of the remaining contaminated mucosa to the abdominal cavity. Mucosal necrosis with loosening of the ligature could be postulated as another mechanism of leakage. An advantage of use of a stapler for stump treatment appears to be the tight closure and prevention of protruding mucosa.

**Table 4** Complications of patients with acute and perforated appendicitis, and those without appendicitis

	Acute appendicitis			Perforated appendicitis			Other intra-abdominal or no pathology		
	Stapler (n = 2683)	Endoloop (n = 1806)	P*	Stapler (n = 598)	Endoloop (n = 268)	P*	Stapler (n = 640)	Endoloop (n = 491)	P*
Conversion	31 (1.2)	11 (0.6)	0.088	31 (5.2)	12 (4.5)	0.737	6 (0.9)	2 (0.4)	0.478
Intraoperative bleeding	33 (1.2)	19 (1.1)	0.686	8 (1.3)	1 (0.4)	0.288	2 (0.3)	3 (0.6)	0.658
Postoperative bleeding	26 (1.0)	17 (0.9)	0.925	13 (2.2)	3 (1.1)	0.415	3 (0.5)	3 (0.6)	1.000
Superficial surgical-site infection	14 (0.5)	8 (0.4)	0.878	9 (1.5)	3 (1.1)	0.764	3 (0.5)	1 (0.2)	0.637
Intra-abdominal surgical-site infection	20 (0.7)	31 (1.7)	0.004	23 (3.8)	8 (3.0)	0.693	2 (0.3)	2 (0.4)	1.000
ICU stay	9 (0.3)	4 (0.2)	0.679	15 (2.5)	0 (0)	0.008	2 (0.3)	1 (0.2)	1.000
Reoperation	43 (1.6)	22 (1.2)	0.352	36 (6.0)	13 (4.9)	0.529	3 (0.5)	5 (1.0)	0.304
Readmission	23 (0.9)	38 (2.1)	0.001	21 (3.5)	6 (2.2)	0.400	3 (0.5)	13 (2.6)	0.004

Values in parentheses are percentages. ICU, intensive care unit. \* $\chi^2$  test.

This study was based on a database that used standardized forms, so miscoding and under-reporting cannot be excluded. However, because the sample size was large, miscoding of diagnoses and complications was likely to be random and unlikely to influence the observed endpoints significantly. Likewise, complications, such as surgical-site infections, bowel paralysis and bleeding, could have been coded differently. However, one of the major findings of this study, the reduced rate of hospital admission, was based on objective data.

The decision to use a stapler or endoloops and how to extract the appendix was based on the preference of the surgeon and institution. Therefore, the two groups were not randomly assigned. An allocation bias is unlikely to be responsible for the increased rate of abscess formation, as subgroup analysis of main factors involved in surgical-site infections (perforation, patient age, length of hospital stay) showed a tendency for use of a stapler in older patients with more advanced disease. The greater extent of patients with perforated appendicitis in the stapler group possibly represents operations with increased difficulty and may explain the higher conversion rate, the increased frequency of ICU admission and the longer hospital stay in this group. These factors combined represent a negative selection bias for patients in the stapler group and suggest that they comprised a higher-risk population. Nevertheless, the use of a stapler decreased the rate of intra-abdominal surgical site infection and readmission to hospital.

The time course shown in *Fig. 1* indicates a recent decrease in the use of endoloops in laparoscopic appendectomy. This decrease might reflect personal experience with infectious complications with use of endoloops.

The overall cost of a laparoscopic appendectomy is the same or less than that for an open appendectomy in European countries and the USA<sup>10,11</sup>. The present study showed that use of a stapler cost €248 more than the use of endoloops. Multiplying the difference in cost by the number needed to prevent one readmission to hospital by stapling (NNT 80 for patients with acute appendicitis) revealed that overall costs of readmission of more than €19 840 rendered stapling more cost effective than application of endoloops. However, to obtain accurate cost-effectiveness data indirect and intangible costs should

be acquired prospectively. The sample size for such a prospective study would be 4786 patients ( $\alpha = 0.05$ ,  $\beta = 0.2$ ). In the light of the reduced rate of surgical-site infection and readmission to hospital, it seems unethical to perform such a prospective randomized trial.

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