

# Outcomes of Open and Laparoscopic Appendectomy With Single Endoloop Stump Closure

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## ABSTRACT

**Background and Objectives:** Although laparoscopic appendectomy (LA) has been used for 35 years, the open approach (OA) is preferred worldwide. Widespread access to instrumentation in a number of centers has reduced economic and logistical obstacles. The aim of this work is to compare the results for patients with suspected appendicitis treated using an OA versus patients treated using LA.

**Methods:** A retrospective study of all patients (N = 290) who underwent operation due to suspected appendicitis in the General Surgery Department from 2014 to 2017 was conducted. LA was performed in 91 patients, and OA was performed in 199 patients.

**Results:** Average surgery duration was 67.8 minutes in the LA group and 62.9 minutes in the OA group ( $P = .082$ ). It was necessary to perform 3 conversions (3.3%) from LA to OA. Wound infections occurred in 2.2% of patients in the LA group and in 12.6% of patients in the OA group ( $P = .007$ ). A reduced duration of hospitalization was noted in the LA group (3.3 days) compared with the OA group (4.7 days) ( $P < .001$ ).

**Conclusion:** The duration of LA is not considerably longer than that of OA. LA in patients with suspected appendicitis reduces the number of operation site infections compared with OA. LA with single endoloop stump clo-

sure is a safe method and may be recommended for wider applications.

**Key Words:** Appendicitis, Laparoscopic appendectomy, Appendectomy, Open approach, Instrumentation.

## INTRODUCTION

Although the laparoscopic approach has been used to treat acute conditions of the appendix for 35 years, this procedure fails to be a gold standard in surgery.<sup>1</sup> While surgeons are increasingly interested in minimally invasive methods, the open approach (OA) is preferred worldwide. Initially, the limitations for wider use of this technique were a consequence of surgeons' fear of intra-abdominal abscesses, longer operative time, and higher costs associated with laparoscopy.<sup>2</sup> However, popularization of minimally invasive techniques and access to instrumentation in a number of centers have removed economic and logistical obstacles.<sup>3</sup> Moreover, subsequent studies reported that operative times for the 2 approaches are similar for experienced surgeons.<sup>2,4</sup> Simultaneously, mortality rates and severe complications are not significantly different for the 2 groups. The major benefits of laparoscopic appendectomy (LA) include potential reductions in hospitalization time, wound infections, postoperative hernias, pain level, and perioperative trauma and improvements in cosmetic results.<sup>2,4,5</sup> Regarding LA, the best technique of appendiceal stump closure has not been determined to date. A critical point in the use of an endoloop is the manual fixation of ligature with the possibility of an insufficient closure and the danger of an appendiceal stump abscess. Therefore, most surgeons use 2 or 3 loops (leaving 2 on the stump) to close the appendiceal stump and to prevent leakage from the cut-off appendix.<sup>2,4</sup> The hypothesis of our study is that the use of a single endoloop for appendiceal stump closure may be sufficient and is an easy, safe, and cost-effective procedure. The aim of this work is to compare the results of patients with suspected appendicitis treated using an OA and LA with single endoloop stump closure.

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## MATERIALS AND METHODS

A retrospective study was conducted of all patients who underwent surgery due to suspected appendicitis in the General Surgery Department from January 2014 to December 2017. The analysis included 290 patients who were qualified for surgery due to suspected appendicitis based on history, clinical trials, blood test results, and medical imaging. The following data were collected: patient age, sex, time elapsed from the admission date to the surgery, surgery duration, intraoperative diagnosis, hospitalization time, occurrence of intra-abdominal abscesses, wound infections, and mortality. The Hospital Ethics Committee approved this study. Informed consent was required.

All laparoscopic surgeries (LA) were conducted by an experienced laparoscopic surgeon who was an operator or an assistant; the surgeries were performed according to the standard technique using 3 trocars. A pneumoperitoneum was created with the use of a Veress needle inserted at Palmer's point. Next, a 10-mm trocar with a shielded blade was inserted at the umbilicus. The first 5-mm trocar was placed at the umbilicus level on the right side at a 5-cm distance; another 5-mm trocar was inserted 2 cm above the pubic symphysis. Appendiceal mesentery and cutting of the appendiceal artery were performed after bipolar coagulation (BiClamp; ERBE, Marietta, GA, USA). Then, a single ENDOLOOP ligature (ETHICON; Bridgewater, NJ, USA) was placed at the base of the appendix and tied. Approximately 6 mm above the ligature, the appendix held (closing the lumen) with the other grasper was cut with scissors without coagulation and placed in an endobag such that the transection of the cut appendix did not contaminate the surrounding organs and the edge of the pouch. For patients with a purulent effusion or who had an abscess drained, the area and the pelvis minor were thoroughly irrigated, and a Redon drain was inserted through a lateral trocar. We did not perform any type of stump section coagulation to avoid energy accumulation at the level of a tied ligature, which might lead to burning and necrosis of the stump. The area of the cecum and the appendiceal stump was covered with the greater omentum (rotation of the table to the right and reverse Trendelenburg position make this maneuver easier). The specimen pouch and the excised appendix were removed through the umbilicus wound, which was closed with fascial sutures.

The OA was performed by 8 additional surgeons when it was not possible for an experienced laparoscopic surgeon to be involved with the operating team. For OA surgeries,

a longitudinal incision at McBurney's point was created, enabling visualization of the cecum base. When the surgeon was unable to completely access this area or when he was unable to identify the reason for pain, the incision was extended. After ligating the appendiceal mesentery, the ligature was placed around the appendix base and subsequently removed by cutting. The appendiceal stump was inverted into the cecum using a purse-string suture. When necessary, the peritoneal cavity was irrigated, and the drain was inserted through a separate incision. The fascia and peritoneum were closed by using slowly absorbable sutures.

All patients received prophylaxis with antibiotics (cefazolin) before surgery. When necessary, antibiotic treatment was prolonged with 2 doses after surgery. If an intra-abdominal abscess appeared, the antibiotic was changed (cefotaxime plus metronidazole).

The results were analyzed using the Student *t*-test to compare quantitative data, such as age, time elapsed before surgery, surgery time, and hospitalization time. Statistical significance for classified values, such as sex and the occurrence of complications, were determined by using the  $\chi^2$  test.  $P < .05$  was considered statistically significant.

## RESULTS

Laparoscopic surgery was performed in 91 patients, whereas the OA was performed in 199 patients. The 2 groups were compared with regard to demographics (sex and age), observation time in hospital before surgery, and intraoperative diagnoses (**Table 1**). No deaths after surgery occurred in the LA group, whereas 2 deaths occurred in the OA group. One death involved an 81-year-old man with advanced circulatory insufficiency who had cardiac arrest after the operation; another patient was diagnosed with advanced disseminated neoplastic process of the peritoneum and perforation of the small intestine with unknown origin. For 1 patient in each group, there was a need to perform another surgical intervention at a later time due to intra-abdominal abscesses; however, the result was not statistically significant. The average surgery duration was 67.8 minutes (40 to 140 minutes, SD 19.8 minutes) in the LA group and 62.9 minutes (30 to 155 minutes, SD 22.6 minutes) in the OA group; the difference was not statistically significant ( $P = .082$ ) (Table 1).

It was necessary to perform 3 (3.3%) conversions from LA to OA. In 1 case, the conversion was due to a perforation of the Meckel diverticulum and the need for partial resection of the small intestines. In 2 other cases, the reason for

**Table 1.**

Demographic and Clinical Data With Treatment Results From a Group of Patients Who Underwent Laparoscopic (n = 91) and Open (n = 199) Surgeries

	Laparoscopic Appendectomy	Open Approach	P
Average age (range) (years)	40.8 (16–86)	40.4 (15–97)	.758
<30/30–70/>70 years old	41/37/13	74/107/18	
Sex			.239
Male (%)	49/91 (53.8)	116/199 (58.3)	
Female (%)	42/91 (46.2)	83/199 (41.7)	
Observation time in hospital prior to surgery (range) (hours)	12.3 (4–32)	12.9 (4–42)	.588
Complicated appendicitis	33/91 (36.3)	69/199 (34.7)	.381
Appendiceal abscess	6/91 (6.6)	19/199 (9.5)	
Gangrenous/perforated with peritonitis	27/91 (29.7)	50/199 (25.1)	
Intraoperative diagnosis other than appendicitis	13/91 (14.3)	23/199 (11.6)	.173
Mesadenitis	6/91 (6.6)	10/199 (5.0)	
Gynecological conditions	1/91 (1.1)	5/199 (2.5)	
Other	6/91 (6.6)	8/199 (4.0)	
Average time of surgery (minutes)	67.8	62.9	.082
Average postoperative hospitalization time (days)	3.3	4.7	<.001
Mortality (%)	0/91 (0)	2/199 (1.0)	.017
Intra-abdominal abscess (%)	1/91 (1.1)	1/199 (0.5)	.062
Wound infection (%)	2/91 (2.2)	25/199 (12.6)	.007

conversion was that the appendix was located behind the cecum and it was difficult to separate the appendix from the large intestinal wall. Moreover, this situation occurred during the first 15 appendectomies performed in our center. In the LA group, wound infections occurred almost 6-fold less often compared with the OA group (2.2% versus 12.6%), and the difference was statistically significant ( $P = .007$ ). LA reduced the duration of hospitalization by approximately 1.5 days (3.3 versus 4.7 days), and the result was statistically significant ( $P < .001$ ).

## DISCUSSION

In some centers, LA slowly becomes a method of choice in the treatment of patients with suspected appendicitis. A laparoscopic approach allows the treatment of simple and complicated cases, such as patients with gangrenous appendicitis, perforations, appendiceal abscesses, or peritonitis. In the analyzed group, there were no differences in the number of complicated appendicitis cases between the groups. Other studies reported similar conclusions

with the number of complicated appendicitis ranging between 17.8% and 26.3%.<sup>6,7</sup>

Each time, the laparoscopic approach facilitated the determination of the cause of illness without the need to modify the number or the size of trocar ports; thus, the method was a sufficient diagnostic tool in cases with pain of the lower right hypogastrium and suspected appendicitis.

This method is especially recommended for obese patients as it avoids extensive wounds that are difficult to heal after the OA.<sup>8</sup> Similarly, minimizing trauma is especially beneficial for elderly patients. No differences in patients' age were noted between our groups; moreover, in the laparoscopic group, every seventh patient was older than 70 years. In a recent meta-analysis, Antoniou et al revealed that laparoscopic appendectomy had a 5.5-fold probability of offering a better treatment strategy compared with conventional appendectomy.<sup>9</sup> The reduced number of wound infections in the LA group results

from the lack of contamination of the body tissues, mainly subcutaneous tissue via appendiceal transection, fluid in the peritoneum, and surgeon's manipulations. In addition, the smaller length of the wound and its separation from the source of the illness via removal of the specimen through an incision below the umbilicus also contribute to the reduction in wounds. Moreover, removing the appendix in a specimen pouch limits the spread of an infection. This technique enabled a reduction in the number of infections at the operation site up by 6-fold to 2.2% compared with the OA group. Li et al reported a similar percentage of infections in laparoscopic surgeries based on a meta-analysis of 31 randomized studies.<sup>10</sup>

Contrary to concerns that it is not possible to close the appendiceal stump with additional inversion and a purse-string suture via the LA approach in contrast to the OA, differences in the number of serious complications and intra-abdominal abscesses were not evident. Single ligature with an endoscopic loop tie on the appendiceal stump allows for a firm closure of the appendiceal orifice at the cecum. Laparoscopic methods include the use of a stapler, clips, homemade loop with locking extracorporeal or intracorporeal knots, and electrothermal devices. However, limited and conflicting evidence exists regarding the most appropriate method for appendiceal stump closure during LA. The use of a stapler is safe and quick but is considerably more expensive compared with the use of endoloops. In a recent study, Escolino et al suggest that closing the appendiceal stump with an endoloop is associated with an increased number of postoperative intra-abdominal abscesses compared with the use of an endostapler (odds ratio 1.36).<sup>11</sup> These findings are in contrast to other studies that revealed no clinical difference in the number of postoperative complications between these 2 methods, even in complicated cases.<sup>12,13</sup> The authors of a recent meta-analysis claim that insufficient evidence is available at present to advocate omission of conventional ligature-based appendix stump closure in favor of any single type of mechanical device compared with another in uncomplicated appendicitis.<sup>12</sup> In a prospective randomized study, Colak et al did not demonstrate increased efficacy of polymeric clips compared with endoloop in terms of reducing complications after LA.<sup>14</sup> Of note, the operation time was reduced after clipping (64.7 versus 75.4 minutes). Gonenc et al compared laparoscopic intracorporeal knotting with clip ligation in 107 patients, demonstrating that both techniques are safe with comparable morbidity and mortality rates.<sup>15</sup>

In a published review, Mannu et al claimed that using a ligature on the appendiceal stump extends the surgery

duration by approximately 9 minutes.<sup>12</sup> However, the authors draw attention to the fact that a ligature is considerably less expensive than a stapler. We used ligatures mostly due to economic reasons. We did not report an increased duration of surgery compared with the OA. The duration of a surgery is reduced with experience; thus, even in more complicated cases, there exists a possibility to perform a safe surgery quickly.<sup>16</sup> According to recommendations of the European Association of Endoscopic Surgery, a surgeon should perform approximately 20 LAs during initial training.<sup>17</sup>

There is no doubt that another benefit of laparoscopic surgeries is the possibility to reduce the duration of hospitalization. This reduction results from a reduced number of complications, the more rapid return of peristalsis after postoperative paralytic ileus, and the opportunity for early rehabilitation and oral nutrition. Initially, patients were discharged home similar to OA cases; however, it was soon realized that patients might be safely discharged home earlier. Li et al noticed in a meta-analysis that, before 2000, the hospitalization time was reduced by 0.48 day on average. After 2000, when surgical centers were more experienced, the hospitalization time was reduced by 0.75 day.<sup>10</sup> In the analyzed group of patients who underwent laparoscopy, the duration of hospitalization was reduced by 1.4 days, from 4.7 to 3.3 days. Other authors report a similar advantage attributed to the laparoscopic method; however, the exact duration of postoperative observation in the hospital depends on the organizational method of a clinic. Pragacz et al report a 2-day reduction in the duration of hospitalization after LA.<sup>18</sup> Similar results were reported by Olmi et al with a hospital stay of 5.5 days in the OA appendectomy group and only 3.4 days in the LA group.<sup>19</sup> Although after LA patients do not typically require prolonged hospitalization, patients remained after surgery for an average of 3 days in our center. This result was attributed to 2 factors. First, the payer requires a 4-day hospitalization to refund the full amount of treatment. Second, a significant number of patients travel from locations a few dozen kilometers away from our facility, where access to outpatient surgical care is limited.

One of the biggest concerns of surgeons before LA is fear of intra-abdominal abscesses in the postoperative appendiceal bed. In our study, no significant differences were noted between the LA and OA groups. Similar data are reported in other studies, suggesting that this phenomenon does not currently constitute a problem in contrast to 10 to 20 years ago.<sup>20</sup> Applying the rules of good laparoscopic technique, such as careful dissection, use of the

tool only in the visual range, avoiding contact of the coagulation instrument's tip with intestinal serosa, irrigation only in the infected area without contamination of the entire peritoneal cavity, draining purulent focal sites, and use of drainage in cases of abundant effusions, minimizes the risk of abscesses. Simultaneously, a single ligature does not constitute a weak link, and the fear of leak is exaggerated. Minutolo et al report 1 intra-abdominal abscess in 139 LAs, which is similar to our results. In a recent study, Cao et al analyzed 6895 patients and concluded that laparoscopy itself is not an independent risk factor in performing appendectomies.<sup>20</sup>

One of the major impediments to the adoption of laparoscopic techniques remains the lack of surgeon training and surgeons' confidence in the LA. Gray et al demonstrated that patients operated on by surgeons trained in minimally invasive surgery had shorter operative times, fewer intraoperative adverse events, and reduced lengths of stay.<sup>21</sup> The Accreditation Council for Graduate Medical Education, which governs general surgery training programs in the United States, mandates the completion of 40 appendectomies before graduation, implying that this goal should be achieved by the end of residency training.<sup>22</sup> Authors concluded that for surgeons with no access to intensive laparoscopic training, adequate training for LA might not be attained at the end of the general surgery residency.<sup>21</sup>

## CONCLUSION

The duration of LA with single endoloop stump closure is not associated with a considerably longer operative time compared with an OA. LA in patients with suspected appendicitis reduces the number of infections at the operation site compared with the OA. LA with a single endoscopic loop tie may represent a safe alternative for other suture ligation techniques and does not increase stump leakage.

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