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Original Article General Surgery

Comparison of open and laparoscopic techniques in the surgical treatment of acute appendicitis

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ABSTRACT

OBJECTIVE: Acute appendicitis (AA) is the most common cause of acute abdomen and appendectomy is one of the most common surgical procedures. In this study, we aimed to compare open appendectomy (OA) and laparoscopic (LA) surgical techniques in the treatment of AA.

METHODS: The data of 236 patients treated with the diagnosis of AA in 2019–2020 were analyzed. Of these patients, 85 patients who received OA and 84 patients who received LA were included in the study. Then, the two groups were compared in terms of demographic, laboratory, clinical, and surgical treatments.

RESULTS: A total of 169 patients were included in the study. The mean age was 34.9 years (range 16–78), and the male-to-female ratio was 0.69. Statistical analysis revealed that the OA group had more leukocytosis, more female gender, and longer operation time than the LA group, but the LA group's complication rate was lower ($p<0.05$).

CONCLUSION: LA offers less morbidity, a shorter duration of hospital stay, and a fast return to normal activities compared to OA. In the surgical treatment of AA, LA can be applied as a routine and first-line treatment.

Keywords: Acute appendicitis; laparoscopic appendectomy; open appendectomy

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Appendicitis, which was first described by Dr. Fitz in 1886, is a global disease [1]. The average annual incidence of appendicitis in the past 15 years is reported to be ≤81–≥150 per 100,000 which varies by country. The incidence is 100/100,000 in North America and 160/100,000 in Turkiye [1]. In studies conducted in North America, it has been reported that the cumulative incidence rate for life is 9.0% and it is seen mostly in males (52.9%) with a mean age of 36.4 years in the white race. The peak age range has been found to be 15–19 [1, 2]. Non-perforated appendicitis is seen in 70% of patients [2]. According to recent studies in Turkiye, acute appendicitis (AA) is seen mostly in men (85.4%) and in the mean age of 28 years [3].

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Appendectomy has been accepted as the standard treatment method for AA although some authors suggest and argue the antibiotic treatment or percutaneous drainage recently [4]. Appendectomy can be performed as open appendectomy (OA) or laparoscopic appendectomy (LA) [5, 6]. Different surgical methods are used in the treatment of perforated and non-perforated appendicitis and there has not been a standard surgical method yet [2, 4]. Some studies have reported that LA is superior to OA in terms of shorter recovery time and faster regular diet toleration. However, in some studies, no such benefit has been reported and even traditional appendectomy has been preferred [7–9].

In this retrospective comparative study, unlike other studies, patients with LA and OA were extensively discussed in terms of pre-operative patient comorbidity degrees, clinical and laboratory characteristics of the patients, duration of surgery and complications, appendiceal histopathological results, and the surgical technique.

MATERIALS AND METHODS

We evaluated 236 patients who were operated for AA in 2019–2020. Our study was planned as a retrospective and cohort study. The data and the clinical outcomes of the patients were obtained from the hospital archives. Age under 16 years, pregnancy, incomplete or missing data, and concomitant additional surgical procedures to appendectomy were exclusion criteria. After the evaluation, 169 patients were included in the study. Informed consent was obtained from all patients for data use and surgical pictures. This study was approved by the local ethics committee with the registration number of 2018-18/223. The study was conducted in compliance with the principles included in the Declaration of Helsinki.

Groups and Clinical Features

The patients were divided into two groups: The OA group (n=85) and the LA group (n=84). Groups were compared in terms of age, gender, body mass index (BMI), and Charlson Comorbidity Index (CCI). Next, abdominal ultrasonography (USG) and abdominal computed tomography (CT) results were evaluated for radiological diagnosis. Leukocyte levels (normal range 4.6–10.2 × 10^3 μL), the presence of leukocytosis, and C-reactive protein (CRP) levels (normal range <0.5 mg/dL) were evaluated.

Highlight key points

- Acute appendicitis occurs in 8% of people during their lifetime.
- Appendicitis is treated with surgery, either through open (OA) or laparoscopic (LA) methods.
- LA has many advantages over OA, including high recovery rates, short hospital stays, and low complication rates.
- LA is ideal for surgery in patients without contraindications.
- LA has become the main approach to AA surgery in many centers.

Surgical Techniques

In the OA group, the abdomen was entered with a McBurney incision, and the appendix was found. The mesoappendix was dissected, and the vascular structures were ligated. Then, the appendix was tied and cut from the root, and the stump was buried. The operation area was controlled, and the abdominal layers including the peritoneum were closed in an anatomical fashion (Fig. 1).

In the LA group, three LA ports (10 mm, 10 mm, and 5 mm) were used to access the abdominal cavity. A 5 mm LigaSure™ (Covidien, Boulder, CO, USA) was used to dissect the mesentery of the appendix. Next, the root of the appendix was ligated with Vicryl Endoloop-0 suture in 80 patients, and Hem-o-lok clip XL (Weck Closure Systems, Research Triangle Park, NC, USA) in three patients. Then, it was cut 4–5 mm above the ligation site with the help of LigaSure. LA linear 45 mm stapler was used in only one patient because the appendix root and cecum surface were highly destructed. Then, the specimen was removed from the trocar using an endo bag (Fig. 2). Appendix specimens from both groups were sent for histopathological examination.

Histopathological Examination

Routine tissue follow-up, paraffin blocking, and serial sections with a thickness of 5 μm were performed on the appendix tissue, which was left to fixation in 10% formalin solution. The preparations were deparaffinized, stained with the hematoxylin-eosin (H-E) method, and evaluated under the light microscope. Evaluated appendix tissues were classified as catarrhal, gangrenous, and perforated appendicitis [2, 4].

Clinical Follow-up Process

Furthermore, the use of drainage during the surgery, operation time (minutes), complication status, time to

Figure 1. Open appendectomy; **(A)** Acute appendicitis, **(B)** Ligation, **(C)** Appendectomy specimen.

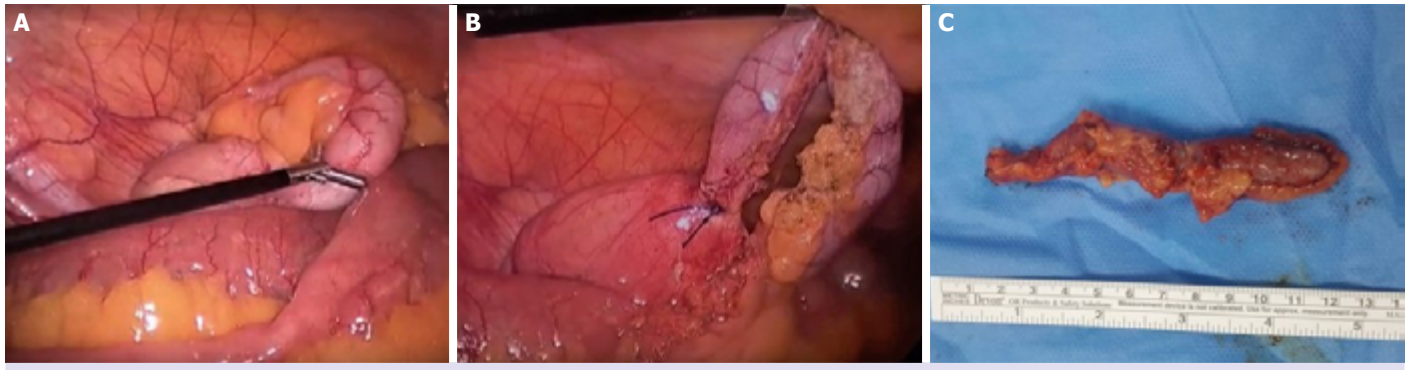

Figure 2. Laparoscopic appendectomy; **(A)** Acute appendicitis, **(B)** Ligation, **(C)** Appendectomy specimen.

toleration of regular diet (days), and the length of hospital stay (days) were evaluated. In both groups, closed aspiration drainage Jackson-Pratt (JP) with a 10 mm lumen diameter was used in the presence of an appendiceal abscess. All patients were operated on under general anesthesia, and pre-operative antibiotic prophylaxis (cefuroxime axetil 1 gr IV) was administered. According to the post-operative general condition of the patients, liquid foods were allowed after 24 h. Cefuroxime axetil was continued for patients with perforated appendicitis and/or plastron appendicitis during their stay in the hospital. Patients were discharged after 1–10 days depending on their clinical course.

The cost was not calculated in the present study, since most studies showed that LA was more costly than OA [2, 3].

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 21.0 software (IBM Corp., Armonk, NY, USA). The conformity of the data to the normal distribution was examined with the Shapiro–Wilk test. Two independent group comparisons of variables without normal distribution were made using the Mann–Whitney U test. The Chi-square test was applied for comparisons between categorical data. Descriptive statistics of categorical data were expressed as frequency (percentage), and descriptive statistics of numerical variables that did not show normal distribution were expressed as median (min–max). Results were evaluated at a 95% confidence interval and $p<0.05$ was considered statistically significant.

RESULTS

Demographic and Laboratory Evaluation

In our study, the median age is 34 (min: 16–max: 77) years, the female-to-male ratio is (1.01), and BMI median is 28.1 (min: 18.9–max: 37.6) kg/m^2 in the LA group which were higher than in the OA group. Compared to the OA group, the high ratio of male-to-female in the LA group was statistically significant ($p=0.006$). While CCI 0 and CCI 2 levels were higher in the OA group, CCI 3 and CCI 4 levels were higher in the LA group. Of the patients in the LA group,

Table 1. Demographic characteristics of patients undergoing laparoscopic appendectomy and open appendectomy

Demographic parameters	LA group (n=84)		OA group (n=85)		p
	n	%	n	%	
Age (years)	16–77 (mean 35.8)		16–78 (mean 33.9)		0.354*
Female/Male	1.04		0.44		**0.006****
BMI, kg/m^2	20.1–37.8 (mean 29.4)		18.9–32.8 (mean 28.6)		0.272*
CCI 0	76.2	64	80	68	
CCI 1	10.7	9	14.1	12	
CCI 2	8.3	7	2.4	2	0.451***
CCI 3	4.8	4	3.5	3	

*: Student's t-test; **: Chi-square test; ***: Mann–Whitney U test; CCI: Charlson Comorbidity Index; BMI: Body mass index; LA: Laparoscopic appendectomy; OA: Open appendectomy.

Table 2. Laboratory parameters of patients undergoing laparoscopic appendectomy and open appendectomy

Laboratory parameters	LA group (n=84)		OA group (n=85)		p
	n	%	n	%	
Presence of leukocytosis	82.1	69	94.1	80	**0.009****
C-reactive protein elevation	97.6	82	100	85	0.245**
Acute catarrhal appendicitis	72.6	61	78.8	67	
Gangrenous appendicitis	16.7	14	10.6	9	0.506*
Perforated appendicitis	10.7	9	10.6	9	

*: Chi-square test; **: Mann–Whitney U test; LA: Laparoscopic appendectomy; OA: Open appendectomy.

21.4% (n=18) were diagnosed with abdominal USG, and 78.6% (n=66) were diagnosed with CT. Of the patients in the OA group, 14.1% (n=12) were diagnosed with abdominal USG, and 85.9% (n=73) were diagnosed with CT (Table 1).

The leukocyte count of the patients in the LA group was found to be 2,500–24,000 (median 13,250) µL. Of these patients, 81% (n=68) demonstrated leukocytosis, 15.5% (n=13) demonstrated normal leukocyte levels (4.6-10.2 × 10^3 uL), and 2.4% (n=2) demonstrated leukopenia. The presence of leukocytosis in the OA group was statistically significant when compared with the LA group (p=0.009). The CRP range of the patients in the LA group was 0.1–31 mg/dL, and 97.6% (n=82) of the patients demonstrated high CRP levels. The CRP range in the OA group was 1–41 mg/dL and was high in all patients (Table 2).

Histopathological Findings

According to the sample pathologies, acute catarrhal appendicitis, gangrenous appendicitis, and perforated appendicitis were seen in 72.6% (n=61), 16.7% (n=14), and 10.7% (n=9) of the LA group, respectively. In the OA group, 78.8% (n=67), 10.6% (n=9), and 10.6% (n=9) demonstrated acute catarrhal appendicitis, gangrenous appendicitis, and perforated appendicitis, respectively, (Table 2).

Evaluating Surgical Procedures

During appendix root ligation in the LA group, Vicryl Endoloop-0 was used in 95.2% (n=80) of the patients, Hem-o-lok plastic clips were used in 3.6% (n=3), and Endo-GIA 45 mm was used in 1.2% (n=1). The base of the appendix was ligated with silk in all patients in the OA group. The operation time was 13–115 (medi-

Table 3. Surgical process parameters of patients undergoing laparoscopic appendectomy and open appendectomy

Surgical process parameters	LA group (n=84)		OA group (n=85)		p
	n	%	n	%	
Operation time (min)	13–115 (mean 59.4)		15–135 (mean 44.4)		**0.001****
Use of drain	4.8	4	4.7	4	1.000*
Presence of complications	5.95	5	9.41	8	**0.042***
Length of hospital stay (days)	1–6 (mean 2.1)		1–8 (mean 2.4)		0.073**

*: Chi-square test; **: Mann–Whitney U test; LA: Laparoscopic appendectomy; OA: Open appendectomy.

an 60) min in the LA group and 15–135 (median 45) min in the OA group, and this was statistically significant (p<0.001). During the operation, the JP drain was placed in 4.8% (n=4) of the patients in the LA group and 4.7% (n=4) of the patients in the OA group. In 3.6% (n=3) of the patients in the LA group, it was switched to OA due to technical reasons and the general condition of the patient. In addition, liquid food was started on the 1st post-operative day for all patients (Table 3).

Clinical Follow-up Evaluation

After surgery, trocar site infection (2.4%, n=2), subileus (1.2%, n=1), and intra-abdominal abscess (2.4%, n=2) were observed in the LA group. In the OA group, superficial wound infection (5.9%, n=5), ileus (2.35%, n=2), and intra-abdominal abscess (1.17%, n=1) were seen. Post-operative complication rates were 5.95% (n=5) in the LA group and 9.41% (n=8) in the OA group, which was statistically significant (p=0.042). In the treatment of complications, broad-spectrum antibiotic therapy, percutaneous drainage treatment with USG in a patient with appendectomy site abscess in the LA group, discontinuation of oral intake in patients with subileus, and parenteral fluid therapy were used. No surgery was required for the treatment of complications in both groups. The duration of hospital stay was 1–6 (mean 2.1) days in the LA group and 1–8 (mean 2.4) days in the OA group (Table 3).

DISCUSSION

AA is one of the most common abdominal emergencies with a lifetime risk of about 8% depending on the geographical and seasonal conditions [1, 10]. Genetic pre-disposition, low-fiber diet, fecalith, presence of foreign bodies, parasites, and obstructing tumors are reported to be effective in its etiology [10]. Epidemiological studies showed that it is frequently seen in the white race, males, and within the age range of 15–19 years [2, 10]. In studies conducted with adults, 53.7% of the patients have been reported to be male, and the mean age has been reported to be 39 years [11]. In the present study involving adults, 59.1% of the patients were male, and the median age was 34 years.

The first appendectomy for the treatment of appendicitis was performed by McBurney in 1864. Since then, this method has been accepted as the standard treatment for AA [12]. However, LA has become a new treatment standard for the last two decades [11, 12]. Today, 67% of complicated appendicitis cases are treated with LA [13]. Recent studies report that non-surgical medical treatment with antibiotics can also be performed in patients with high comorbidity [4, 14].

The LA technique is considered to be superior to OA in terms of technical aspects since the wound infection rate is lower, less pain occurs on the 1st post-operative day, and the length of hospital stay is shorter in LA [15]. Perhaps more importantly, it will allow the surgeon to examine the entire abdominal cavity. Therefore, it leads to less adhesion-induced ileus in the short- and long-term as well as detecting other causes mimicking appendicitis [16, 17]. Furthermore, LA has been shown to demonstrate significant benefits in obese patients (BMI>30) and patients with ASA scores III and IV, compared to OA [11, 18]. Conversely, OA also demonstrates some advantages: Lower intra-abdominal abscess development rate, shorter operation time, and cost-effectiveness [8, 19]. However, this may improve with the more widespread use of laparoscopy, the further increase in the learning curve, and the further development of the technique [8, 12]. In the present study, the operation time of the patients in the LA group was longer, but the compli-

cation rate was lower. Furthermore, LA has been successfully applied in patients with obesity and high CCI.

LA is widely used today in the treatment of non-complicated AA, but whereas some centers recommend OA in the treatment of complicated AA, some centers recommend LA [8, 20, 21]. The timing of the operation in patients with complicated appendicitis varies according to the clinical condition [2, 12]. Urgent appendectomy should be performed in severe cases with free perforation or generalized peritonitis [10, 12]. In stable patients with closed perforation, right lower quadrant periappendicular abscess, or phlegmon, preparation for surgery with percutaneous drainage should be performed as an initial treatment instead of surgical treatment to avoid surgical complications [12, 22]. In such cases, interval appendectomy can be performed following the regression of inflammation [14, 23]. In the present study, similar successful results were obtained both from LA and OA in patients with gangrenous and perforated appendicitis.

Considering the limitations of this study, the relatively small number of patients made it unable to form homogenous groups in terms of comorbidities such as obesity, diabetes mellitus, or pregnancy which may facilitate to make more accurate evaluation of different surgical approaches under different circumstances.

Conclusion

LA has become the main treatment strategy in the surgical treatment of AA due to its potential advantages from the nature of being a minimally invasive procedure such as demonstrating higher recovery rates, requiring a shorter hospital stay, presenting with lower complication rates, and providing an advantage in patients with high comorbidity such as obesity. LA can be planned first in appendectomy surgery in all patients who do not demonstrate contraindications for LA surgery.

Ethics Committee Approval: The Bezmialem Vakif University Clinical Research Ethics Committee granted approval for this study (date: 02.10.2018, number: 18/223).

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Authorship Contributions: Concept – SD, KCD; Design – SD, HKB; Supervision – EK, KCD; Fundings – SD, HK; Materials – SD, SY, AYT; Data collection and/or processing – SD, SY; Analysis and/or interpretation – HK, AYT; Literature review – SD, SY, VOG; Writing – SD, VOG; Critical review – HKB, EK.

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