

PROCEEDINGS

HAS LAPAROSCOPIC APPENDECTOMY BECOME THE GOLD STANDARD?

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ABSTRACT

INTRODUCTION: Appendicitis is one of the most common surgical emergencies. It is traditionally treated by conventional surgery. However, with the advent of minimally invasive surgery, laparoscopic appendectomy is gaining popularity due to faster recovery and less postoperative pain.

AIM: Retrospective study of perioperative data and postoperative results in patients with acute appendicitis operated on at the Clinic of Hepatobiliary, Pancreatic and General Surgery at Acibadem City Clinic Tokuda University Hospital and analysis of the information obtained have been conducted.

MATERIALS AND METHODS: For the period 01.01.2008–31.12.2024, a total of 1,091 patients with clinical, laboratory and imaging findings of acute appendicitis.

Study Design: single-center, retrospective

METHODS:

- 1/ anamnestic-diagnostic data, including accompanying documentation;
- 2/ surgical methods—laparotomy and laparoscopy;
- 3/ follow-up in the early and late postoperative period (patient follow-up in the GammaCode Master hospital system).

RESULTS: The study included 1,091 patients who underwent appendectomy for acute appendicitis. Of these, 653 (59.9%) underwent laparoscopy, 41 underwent laparoscopy followed by conversion (3.8%), and 396 (36.3%) underwent various types of laparotomy. Complications were diagnosed in 21.6% of all patients. The distribution in terms of the stage of inflammation was as follows: catarrhal—13.5%, phlegmonous—46.6%, gangrenous appendicitis—18.5%, gangrenous appendicitis with abscess and perforation—8.9%, chronic and chronic exacerbated—10.9%, and appendiceal tumors (NET, carcinoid, adenocarcinoma, mucinous neoplasm, metastasis)—1.7%. In 473 (43.35%) patients, the appendicular stump was closed using only a tightening Endoloop ligature; an endo-stapler was used in 132 cases or 12.3%.

CONCLUSIONS: Since 2017, laparoscopic appendectomy has been the gold standard even in complicated cases of acute appendicitis. In a larger sample of patients, one or two self-tightening ligatures at the base of the appendix are sufficient. Patients who undergo intraoperative conversion are considered a subgroup with an increased risk of morbidity.

Keywords: acute appendicitis, laparoscopy, appendicular hammer

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INTRODUCTION

Appendicitis is one of the most common surgical emergencies. It is traditionally treated by conventional surgery. However, with the advent of minimally invasive surgery, laparoscopic appendectomy is gaining popularity due to faster recovery and less postoperative pain. Over the past 10 years, laparoscopic appendectomy has become the first choice even in cases of complicated appendicitis, with its frequency reaching over 95% of cases in some reports. Often, making the correct diagnosis is a challenge. Laparoscopy has many advantages in the treatment of this disease. In addition to the fact that the operation is performed through three small ports and no incision is made in the abdominal wall, the possibility of diagnostic examination of the entire abdomen is particularly valuable. Concomitant pathology, evidence of peritonitis, and gynecological inflammation can be successfully treated during laparoscopic surgery. Appendicitis is called the first American surgical disease, and appendectomy holds a prominent and storied position in surgical history. Charles McBurney published his report on the surgical management of appendicitis in 1895. He described the potential consequences of undrained purulent appendicitis, the disadvantages of the classical midline laparotomy, and exploratory needle puncture. Finally, he described a novel surgical approach and exposure, introducing consecutive lateral incisions through the external oblique aponeurosis, internal oblique, and transversus abdominis muscles rather than midline laparotomy. Despite a significant change in managing acute appendicitis with primary antibiotic therapy, the primary option for treating acute appendicitis remains a surgical approach.

AIM

Retrospective study of perioperative data and postoperative results in patients with acute appendicitis operated on at the Clinic of Hepatobiliary, Pancreatic and General Surgery at Acibadem City Clinic Tokuda University Hospital and analysis of the information obtained have been conducted.

MATERIALS AND METHODS

For the period 01.01.2008–31.12.2024, a total of 1,091 patients with clinical, laboratory, and imaging findings of acute appendicitis have undergone differ-

ent types of surgery in our clinic. The study design was single-center, retrospective, with the use of different methods: 1/ anamnestic-diagnostic data, including accompanying documentation; 2/ surgical methods—laparotomy and laparoscopy; 3/ follow-up in the early and late postoperative period (patient follow-up in the GammaCode Master hospital system). All patients had preoperative laboratory results, including imaging tests in cases of suspected diagnosis; consultation with a gynecologist for women with unclear clinical picture and the necessary consultation with a cardiologist and anesthesiologist as required by the National Health Insurance Fund. Laparoscopies were performed using a typical three-port technique, with an optical port supraumbilically, a 5mm working port supra-pubically, and a 12mm working port along the left mid-clavicular line. In some cases of complicated appendicitis, a 5mm working port was also placed on the right along the right axillary line, for placing drainage tube behind the cecum.

RESULTS

The study included 1,091 patients who underwent appendectomy for acute appendicitis. The average age of the patients was 36.96 ± 14.69 years (3–94 years). The gender distribution was 536 men (49.2%) and 554 women (50.8%). In terms of comorbidity, slightly more than half of the patients, 710 individuals (65.1%) reported no accompanying diseases, 239 (21.9%) had one accompanying disease, 78 (7.2%) had two, and 27 (2.5%) had three. More than four comorbidities were reported in only 15 (1.4%) patients. Twenty patients (1.8%) were pregnant at the time of surgery or had given birth within the previous eight months. Preoperative computed tomography (CT) was performed in 383 (34.6%) of cases. The following values were defined for two of the laboratory markers of inflammation, leukocytes, and CRP. The mean preoperative leukocyte count was 13.42 ± 4.71 ($1-32.74$ g/L), and the mean CRP was 75.02 ± 91.26 ($<0.5-665.60$). In the correlation analysis, both values showed no statistical relationship with the type of inflammation. (Table 1, Table 2).

Of the different types of operations, 653 (59.9%) were laparoscopies, 41 were laparoscopies followed by conversion (3.8%), and 396 (36.3%) were various types of laparotomy (Table 3).

Table 1

Correlations				
			Preoperative CRP	Type of Inflammation
Kendall's tau_b	Preoperative CRP	Correlation Coefficient	1.000	.159**
		Sig. (2-tailed)	.	.000
		N	1090	1090
	Type of inflammation	Correlation Coefficient	.159**	1.000
		Sig. (2-tailed)	.000	.
		N	1090	1090
Spearman's rho	Preoperative CRP	Correlation Coefficient	1.000	.204**
		Sig. (2-tailed)	.	.000
		N	1090	1090
	Type of inflammation	Correlation Coefficient	.204**	1.000
		Sig. (2-tailed)	.000	.
		N	1090	1090

** . Correlation is significant at the 0.01 level (2-tailed).

Table 2

Correlations				
			Type of Inflammation	Preoperative Leu
Kendall's tau_b	Type of inflammation	Correlation Coefficient	1.000	.056*
		Sig. (2-tailed)	.	.013
		N	1090	1090
	Preoperative Leu	Correlation Coefficient	.056*	1.000
		Sig. (2-tailed)	.013	.
		N	1090	1090
Spearman's rho	Type of inflammation	Correlation Coefficient	1.000	.071*
		Sig. (2-tailed)	.	.019
		N	1090	1090
	Preoperative Leu	Correlation Coefficient	.071*	1.000
		Sig. (2-tailed)	.019	.
		N	1090	1090

*. Correlation is significant at the 0.05 level (2-tailed).

Complications were diagnosed in 21.6% (235) of all patients. A very small percentage of these were surgical complications, as shown in Table 4.

The distribution of complications was mainly for non-surgical cases, with the most frequent complications being surgical wound complications in 89

(8%), followed by postoperative fever in 58 (5.2%), and functional disorders of the gastrointestinal tract in 42 (3.8%). Severe systemic complications affecting the respiratory and cardiovascular systems account for a relatively small percentage of 0.5% and 0.6%. A severe but fortunately isolated case of postoperative

Table 3. Type of surgery.

Type of Surgery		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Laparotomy Davis	120	10.8	11.0%	11.0
	Laparotomy Roux	52	4.7	4.8%	15.8
	Laparotomy McBurney	148	13.4	13.6%	29.4
	Laparotomy Lenander	29	2.6	2.7%	32.0
	Median laparotomy	47	4.2	4.3%	36.3
	Laparoscopy	653	59.0	59.9%	96.2
	Laparoscopy, subsequently conversion	41	3.7	3.8%	100.0
	Total	1090	98.5	100.0	
Missing	System	17	1.5		
Total		1107	100.0		

Table 4. Surgical complications.

Surgical Complications		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1049	94.8	96.3	96.3
	Ventral hernia	15	1.4	1.4	97.7
	Abscess—intra-abdominal, in abdominal wall	14	1.3	1.3	99.0
	Bowel obstruction	3	.3	.3	99.3
	Port bleeding	4	.4	.4	99.6
	Wound dehiscent	3	.3	.3	99.9
	Appendicular stump necrosis	1	.1	.1	100.0
	Total	1089	98.4	100.0	
Missing	System	18	1.6		
Total		1107	100.0		

residual relaxation from the muscle relaxant Musckoblock required treatment in the intensive care unit. The complication was recorded during the COVID lockdown, when there were known difficulties in the availability of certain anesthetic drugs (Table 5).

In terms of complications related to the type of laparoscopic intervention performed, there were 40% ventral hernias (6 out of 15 ventral hernias) and 85.7% (12 out of 14 abscesses) intra-abdominal abscesses. All 4 cases of hemorrhage were recorded in the laparoscopy group. Overall, surgical complications during laparoscopy occurred in 2.62% (17 out

of 653 cases). In comparison, the percentage of surgical complications during laparotomy according to McBurney was 3.38% (5 out of 148 cases). In terms of non-operative complications, 74.1% (43 out of 58 cases) had postoperative fever up to 38°C, and 27% (24 out of 89 cases) had SSI, which is close to the percentage for McBurney laparotomy, 25.8% (23 out of 89 cases). Laparoscopy accounted for all cases of thrombophlebitis, 75% of cases of hemorrhage (6 out of 8 cases), and 73.8% of cases of functional intestinal disorders (31 out of 42 cases). Overall, non-operative complications in the laparoscopy group were 17.76%

Table 5. Non-surgical complications.

Nonsurgical Complications				
		Responses		Percent of Cases
		N	Percent	
	No	876	79.0%	80.4%
	Postoperative fever up to 38C	58	5.2%	5.3%
	SSI	89	8.0%	8.2%
	Superficial trombophlebitis	3	0.3%	0.3%
	Bleeding—from port, from abdominal tube	8	0.7%	0.7%
	Functional disorders—diarrhea, paralysis of bowel	42	3.8%	3.9%
	Urological—infections, globus	5	0.5%	0.5%
	Virus and candida infections	4	0.4%	0.4%
	Skin dehiscent	4	0.4%	0.4%
	RS- acute respiratory failure, LTE, pneumonia	6	0.5%	0.6%
	Acute cholecystitis	1	0.1%	0.1%
	Paracecal abscess	1	0.1%	0.1%
	Rash	3	0.3%	0.3%
	CVS- AH, hypotension, AMI	7	0.6%	0.6%
	Postoperative residual relaxation	1	0.1%	0.1%
Total		1109	100.0%	101.7%

Table 6. Types of inflammation.

Type of Inflammation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Catarrhal	147	13.3	13.5	13.5
	Phlegmonous	508	45.9	46.6	60.1
	Gangrenous	202	18.2	18.5	78.6
	Gangrenous with perforation	50	4.5	4.6	83.2
	Gangrenous with abscess	47	4.2	4.3	87.5
	Chronic	48	4.3	4.4	91.9
	Chronic, acute	71	6.4	6.5	98.4
	Carcinoid, mucinous neoplasm	6	.5	.6	99.0
	NET	6	.5	.6	99.5
	AdenoCa of appendix	4	.4	.4	99.9
	Metastasis	1	.1	.1	100.0
	Total	1090	98.5	100.0	
Missing	System	17	1.5		
Total		1107	100.0		

Table 7. Closing of the appendicular stump.

Closing of the Appendicular Stump					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Circular suture	407	36.8	37.3	37.3
	EndoLoop 1pc	360	32.5	33.0	70.4
	EndoLoop 2pc	113	10.2	10.3	80.7
	HaemoLock polymer clips	47	4.2	4.3	85.0
	EndoGIA 45\60mm	132	11.9	12.3	97.2
	Linear stapler GIA 80mm/75mm	16	1.4	1.5	98.6
	ECA	15	1.4	1.4	100.0
	Total	1090	98.5	100.0	
Total		1107	100.0		

Table 8.

Symmetric Measures			
Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
.080	.034	2.651	.008 ^c
.063	.032	2.068	.039 ^c
1089			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

(125 out of 653). In comparison, non-operative complications in McBurney laparotomy were 22.97% (34 out of 148 cases).

The distribution in terms of the stage of inflammation was as follows: catarrhal—13.5%, phlegmonous—46.6%, gangrenous appendicitis—18.5%, gangrenous appendicitis with abscess and perforation—8.9%, chronic and chronic, acute—10.9%, appendiceal tumors (NET, carcinoid, adenocarcinoma, mucinous neoplasm, metastasis)—1.7% (Table 6).

Table 9. Correlations; type of surgery.

Correlations				
			Type of Surgery	Type of Inflammation
Kendall's tau_b	Type of surgery	Correlation Coefficient	1.000	.064 [*]
		Sig. (2-tailed)	.	.012
		N	1090	1090
	Type of inflammation	Correlation Coefficient	.064 [*]	1.000
		Sig. (2-tailed)	.012	.
		N	1090	1090
Spearman's rho	Type of surgery	Correlation Coefficient	1.000	.078 ^{**}
		Sig. (2-tailed)	.	.010
		N	1090	1090
	Type of inflammation	Correlation Coefficient	.078 ^{**}	1.000
		Sig. (2-tailed)	.010	.
		N	1090	1090

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

In 473 (43.35%) patients, the appendicular stump was closed with a self-gripping EndoLoop ligature; an endosuture device was used in 132 cases, or 12.3%.

During the statistical analysis, there was no statistical correlation between the method of closing the appendicular stump and the presence of surgical complications (Table 8). Ventral hernias were most common when using a running suture (53.3%), followed by laparoscopic endostapler, and endolum 1 with equal percentages. For intra-abdominal abscesses, there was a 20% difference in the use of one or two EndoLoop ligatures—42.9% vs. 21.4%.

The results were similar for non-surgical complications. Postoperative fever was most common with the use of EndoLoop (25.9%), followed by the running suture (24.1%), and the laparoscopic EndoGIA (22.4%). Regarding wound infection (SSI), which was the most common complication after appendectomy, it occurred in 59.6% of cases when a purse-string suture was used. In laparoscopic approaches, it was most common with the endoluminal stapler (12.4%) and the laparoscopic endoscopic stapler (7.9%).

There was no statistical correlation between the type of inflammation and the type of surgical intervention.

DISCUSSION

Acute appendicitis is one of the most common emergency surgical procedures. It is traditionally treated by performing classic open surgery. However, with the advent of minimally invasive surgery, laparoscopic appendectomy is gaining popularity. Laparoscopic appendectomy has several advantages over open appendectomy, such as faster recovery, less postoperative pain, lower incidence of infections, and fewer adhesions [1]. Our experience shows that about 60% of appendectomies are performed laparoscopically, including in cases of complicated appendicitis, which is in line with global trends, and a lower incidence of complications compared to McBurney laparotomy. With regard to the most common non-surgical complication, wound infection, our sample shows a relatively equal frequency between laparoscopy and McBurney laparotomy, with a difference of 2%, but when considered in relation to the different types of laparotomy, the percentage is significantly

lower. In the past, laparoscopic appendectomy was not as popular as cholecystectomy due to the higher risk of postoperative intra-abdominal abscesses. In addition, the methods for closing the appendicular stump were expensive, unreliable, or required specific technology [2]. Since then, numerous studies have proven the safety and reliability of laparoscopic appendectomy [3,4], and it is recommended as the gold standard for the management of acute appendicitis. Various techniques are used to interrupt the appendicular hammer, some of which are relatively expensive, such as endoscopic linear staplers (EndoGIA), and others much more affordable, such as factory-made loop ligatures (EndoLoop 2/0). Some studies have also described metal and polymer clips as an option for interrupting the appendix, but some surgeons still have concerns about their safety, with the main limiting factor for their use being the appropriate size to secure the appendicular hammer, according to Rickert et al. [5]. In conclusion, intracorporeal ligation with an EndoLoop or the use of clips is sufficiently effective to secure the appendicular hammer. The only limitation to the use of clips is the wider diameter of the appendicular base, in which case the EndoLoop is a more than adequate and relatively inexpensive alternative [2]. In our sample, the percentage of EndoLoop use significantly exceeds other possible methods of intracorporeal appendectomy. The relatively low incidence of complications proves its reliability in the presence of a healthy appendicular base. In complicated appendicitis, with compromise of the base, the safest method for intracorporeal interruption remains the laparoscopic endostapler (EndoGIA). In some more recent studies, over 97% of appendectomies were performed laparoscopically, with 86% of them using a stapler to cut the appendix. According to Schildberg et al., since 2017, laparoscopic appendectomy has been the gold standard even for complicated forms of acute appendicitis, reaching an impressive 95% on an annual basis [6]. In our sample, laparoscopies account for 59.9%, showing impressive growth over the last 5–10 years. A downward trend has been observed during the years of the COVID pandemic due to the ban on laparoscopies for COVID-positive patients and the increase in total peritonitis of appendicular origin due to patients' fear of going to a hospital. The conversion rate is 3.8%, ranging from 5.9% to 1.9% in the world

literature; after 2015, between 1.9% and 3.2%. The results of Schildberg et al. show 4% surgical complications, with a rate of 17.3% in the laparotomy group and only 3% in the laparoscopy group [6]. Our results show a similar frequency of surgical complications in laparoscopy (2.62%), while in open surgery there are several subgroups and the percentage is significantly lower—3.38% in McBurney laparotomy.

When comparing our results with the publications of other groups, the situation is not so clear. Thompson et al. report an open surgery rate of 4.8% in 3,019 patients studied, which is 2.5 times higher than our group [7]. In another publication with over 65,000 patients from 2013, the proportion of laparoscopic procedures is only 33.8% [8]. All these results show that our study demonstrates an almost complete transition to laparoscopic surgery, especially after 2015. This development took several decades. This is not surprising, as there are already theories about the introduction and spread of technologies in this context. The spread of innovation involves five phases: adoption by innovators, followed by early followers, the early majority, the late majority, and finally the laggards [9]. Furthermore, good ideas must be communicated through conversation. The critical point in favor of surgical technology in this case is an average of 20% acceptance of the procedure by users (e.g., surgeons). This clearly shows why it takes so long for a procedure to become widespread [10–13]. According to our study, it took 45 years from the first laparoscopic appendectomy in 1980 to achieve an increasing frequency of laparoscopic appendectomy in Bulgaria, at the Tokuda Hospital for Active Treatment, and reach a rate of 59.9%.

CONCLUSION

Since 2017, laparoscopic appendectomy has been the gold standard even in complicated cases of acute appendicitis. In a larger sample of patients, one or two self-ligating ligatures at the base of the appendix are sufficient. Patients who undergo intraoperative conversion are considered a subgroup with an increased risk of morbidity. The various methods of closing the appendicular stump are sufficiently reliable and relatively accessible. In cases of compromised appendicular base, the main tool of choice is the endoscopic linear stapler.

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