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Surgical outcomes of emergency open appendectomy for acute appendicitis: an audit of 2268 patients in a single center

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ABSTRACT

Although conservative treatment and laparoscopic surgery are becoming increasingly popular for acute appendicitis, emergency open appendectomy is still performed in many situations. The purpose of this study was to examine the surgical outcomes of emergency open appendectomy for acute appendicitis. Between July 2008 and August 2022, 2,268 patients who underwent emergency open appendectomy for acute appendicitis were enrolled in this study. Of these patients, 417 (18.4%) had complicated appendicitis (CA), and 1,851 (81.6%) had uncomplicated appendicitis (UA). Clinical characteristics and both surgical and postoperative outcomes were compared between the groups. The percentage of CA patients increased after 2020, and by age, the proportion was greater for those aged 50 and older. In the CA group, patients were older (55.5 vs 30.0 years, p<0.001) and had more comorbidities (34% vs 12%, p<0.001). Additionally, in the CA group, the operation time was longer (86 vs 55 min, p<0.001), and the rate of postoperative complications was greater (16% vs 3.0%, p<0.001). There was one mortality in the CA group due to postoperative cerebral infarction. The postoperative hospital stay was significantly longer in the CA group (9 vs 5 days, p<0.001). In conclusion, in the CA group, the patients were older and had more comorbidities. Patients who underwent emergency open appendectomy for CA had longer operation times and more complications. This large single-center study provides insights into emergency open appendectomy for acute appendicitis and useful information in terms of comparisons with other treatment modalities, such as laparoscopic appendectomy and elective appendectomy.

Keywords: emergency surgery, open appendectomy, surgical outcome, complication

Abbreviations:
CA: complicated appendicitis
UA: uncomplicated appendicitis

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INTRODUCTION

Acute appendicitis is one of the most common causes of acute abdominal pain, with a reported lifetime risk of 7–8%.[1] Therefore, local core hospitals play an important role in the treatment of acute appendicitis. Appendicitis can be divided into two groups: complicated appendicitis (CA), which includes perforated or abscessed cases; and uncomplicated appendicitis (UA), which includes catarrhal, phlegmonous, and gangrenous cases. As patient characteristics and treatment outcomes differ among the groups, it is important to consider these factors when developing a treatment strategy.

Although emergency surgery was once the gold standard for treating acute appendicitis, research on conservative therapy or interval appendectomy has progressed. The effectiveness of conservative treatment has been reported mainly for UA, but Salminen et al reported that 27.3% of patients experienced recurrence within 1 year and 39.1% within 5 years, indicating a high recurrence rate.[2,3] In addition, a randomized controlled trial reported that patients' quality of life decreased with conservative treatment, suggesting that surgery is still important.[4]

Laparoscopic appendectomy has become a popular surgical approach and is considered more useful than laparotomy, mainly in terms of reducing postoperative pain, shortening the length of hospital stay, and reducing wound infection. However, problems such as the extension of operation time and increased medical expenses have also been noted.[5,6] Furthermore, in a retrospective nationwide study,[7] 45.5% of CA patients and 36% of UA patients underwent open surgery, indicating that open appendectomy is still a widely performed surgical procedure. Therefore, it is necessary to select an appropriate surgical method based on the patient's background, the degree of inflammation, and the situation at each facility. It is also important to obtain data on open surgery for comparison with laparoscopic surgery. Although there are national reports using nationwide databases[8] and reviews,[9] large-scale data from single-centre community hospitals are inadequate.

The purpose of this study was to examine the demographics of patients and surgical outcomes of emergency open appendectomy at a single institution, separately, for UA and CA patients.

MATERIALS AND METHODS

This study protocol was approved by the Ethics Review Board of Ogaki Municipal Hospital (20200924-7) and in accordance with the 1964 Helsinki declaration and its later amendments. All participants were given the opportunity to opt-out of this study, and patient anonymity was preserved.

Between July 2008 and August 2022, a total of 2,282 patients underwent emergency open appendectomy with a preoperative diagnosis of acute appendicitis at Ogaki Municipal Hospital, Gifu, Japan. The exclusion criteria included patients for whom the diagnosis of acute appendicitis was not confirmed during intraoperative evaluation (n=11) and patients who underwent appendectomy by laparoscopy (n=3). The remaining 2,268 patients were included in this study. Among these patients, 1,851 had UA (catarrhalis, n=242; phlegmonosa, n=1330; gangrenous, n=279), and 417 had CA (abscess formation, n=25; perforation, n=355; both, n=189).

At our institution, when acute appendicitis was suspected based on clinical findings and/or laboratory data, a definitive diagnosis was made using computed tomography (CT) scans and/or ultrasonography. After a definitive diagnosis was made, an emergency open appendectomy was performed. However, if patients with simple appendicitis prefer conservative treatment, antibiotics are prescribed.[10]

The degree of inflammation was determined by surgical findings and gross findings of the resected appendix. Pathological examination was performed only if other diseases or malignancies were suspected.

We retrospectively collected medical records and compared the clinical characteristics and surgical outcomes between the UA group and the CA group. The Clavien–Dindo (CD) classification was used to classify postoperative complications.[11] Additionally, patients were analysed by age and chronological age stratified by the degree of inflammation.

Surgical procedure

In most cases, a McBurney incision was made under spinal anaesthesia. For patients aged less than 15 years, general anaesthesia was chosen. After identification of the appendix, the appendicular vessels were ligated at the root. We resected the appendix after ligation at the root and buried it with purse-string sutures. When CA was suspected preoperatively, a pararectal, transrectal or lower midline incision was made under general anaesthesia. If the ileocecal area was lumped together due to inflammation or if the root of the appendix was considered difficult to process, we performed caecal resection or ileocecal resection. One or two silicon drainage tubes were placed into the abdominal cavity as necessary.

Statistical analyses

Continuous data are expressed as medians and ranges and were compared using the Mann–Whitney U test. Statistical analyses for categorical variables were performed using Fisher's exact probability tests. A value of $p < 0.05$ was considered to indicate statistical significance. All the statistical analyses were performed using EZR, a graphical user interface for R (The R Foundation for Statistical Computing, version 2.13.0).[12]

RESULTS

The distribution of the degree of inflammation by year is shown in Figure 1. Between 2008 and 2019, the percentage of CA patients ranged from 11.3% to 22.4%, but after 2020, the

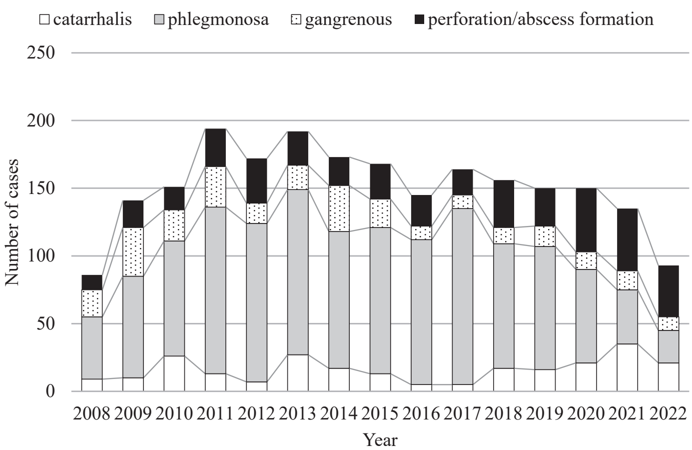

Fig. 1 Distribution of degree of inflammation by year
After 2020, the percentage of CA (perforation/abscess formation) patients increased.
CA: complicated appendicitis

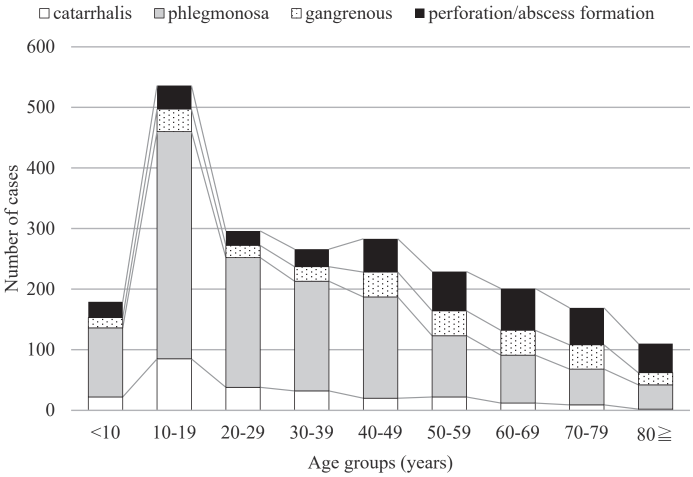

Fig. 2 Distribution of degree of inflammation by age
Teenagers composed the largest group of patients with appendicitis. UA (catarrhalis, phlegmonosa, gangrenous) was more common in younger patients, but the proportion of CA (perforation/abscess formation) increased with age.
UA: uncomplicated appendicitis
CA: complicated appendicitis

percentage increased from 31.3% to 40.9%. The distribution of the degree of inflammation by age is shown in Figure 2. Teenagers composed the largest group of patients with appendicitis, accounting for 23.6% of all patients. UA was more common in younger patients, but the proportion of CA increased with age, and 43.6% of patients aged 80 and older had CA.

The clinical characteristics are shown in Table 1. In the CA group, the median age and body mass index (BMI) were greater, and more patients had comorbidities.

Table 1 Clinical characteristics

	UA (n=1851)	CA (n=417)	P
Age (years)	30 (4–95)	55.5 (3–96)	<0.001
Sex (male)	1044 (56)	192 (46)	0.37
BMI (kg/m^2)	20.9 (9.3–43.9)	21.6 (3.7–34.6)	0.0012
Comorbidity	213 (12)	141 (34)	<0.001
Hypertension	88 (4.7)	61 (15)	<0.001
Diabetes	46 (2.6)	43 (10)	<0.001
Heart disease	56 (3.0)	34 (8.2)	<0.001
Cerebrovascular disease	29 (1.6)	33 (7.9)	<0.001
Pulmonary disease	31 (1.7)	14 (3.4)	0.041
Renal disease	14 (0.8)	16 (3.8)	<0.001
Anti-coagulant therapy	40 (2.2)	31 (7.5)	<0.001

Data are shown as number of patients (%) or median (range).
BMI: body mass index
UA: uncomplicated appendicitis
CA: complicated appendicitis

Table 2 Surgical outcomes

	UA (n=1851)	CA (n=417)	P
Operation time (min)	55 (16–220)	86 (25–268)	<0.001
Blood loss (mL)	5 (1–65)	10 (1–900)	<0.001
Anesthesia			<0.001
General	732 (40)	370 (89)	
Spinal	1119 (60)	47 (11)	
Procedure			<0.001
Appendectomy	1846 (99.7)	344 (82)	
Cecal resection	2 (0.1)	8 (1.9)	
Ileocecal resection	3 (0.2)	65 (16)	
Skin incision			<0.001
McBurney	1682 (91)	121 (29)	
Pararectal	161 (8.7)	241 (58)	
Midline	8 (0.4)	53 (13)	
Transrectal	0	2 (0.5)	
Drain	166 (9.0)	370 (89)	<0.001

Data are shown as number of patients (%) or median (range).
UA: uncomplicated appendicitis
CA: complicated appendicitis

The surgical outcomes are summarized in Table 2. In the CA group, the operation time was significantly longer (86 vs 55 min, p<0.001), and the estimated blood loss was significantly greater (10 vs 5 mL). Ileocecal resection was performed in 3 (0.2%) and 65 (16%) patients in the UA and CA groups, respectively. In the UA group, two patients underwent ileal resection because of preoperative suspicion of tumor and one because of injury at the end of the ileum.

Postoperative outcomes are presented in Table 3. The postoperative complication rate was significantly greater in the CA group (16% vs 3.0%, p<0.001). The most common complication was wound infection (12% vs 2.9%, p<0.001). Reoperations were required for 3 (0.2%) and 5 (1.2%) patients in the UA and CA groups, respectively. Table 4 shows the details of the reoperations. In Patient 2, ileocecal resection was performed because of an adhesive bowel obstruction. After reoperation, anastomotic leakage occurred, and an enterocutaneous fistula developed. Patient 6 was obese and had a BMI of 28.8 kg/m^2. Although the operative field was poor, open appendectomy was performed via a McBurney incision. The appendix was ruptured, and the appendix tip was left behind unnoticed. On postoperative Day 8, laparoscopic resection of the ruptured appendix tip left behind was performed.

There was one mortality in the CA group due to postoperative cerebral infarction. The postoperative hospital stay was significantly longer in the CA group (9 vs 5 days, p<0.001).

Table 3 Postoperative outcomes

	UA (n=1851)	CA (n=417)	P
Complication*	56 (3.0)	65 (16)	<0.001
Wound infection	53 (2.9)	52 (12)	<0.001
Abdominal abscess	12 (0.6)	29 (7.0)	<0.001
Paralytic ileus	4 (0.2)	26 (6.2)	<0.001
Cecal fistula	0	4 (1.0)	<0.001
Anastomotic leakage	0	1 (0.2)	0.41
Pneumonia	1 (0.05)	6 (1.4)	<0.001
Brain disease	1 (0.05)	1 (0.2)	0.81
Reoperation	3 (0.2)	5 (1.2)	0.005
Mortality	0	1 (0.2)	0.183
Postoperative hospital stays, (median, range)	5 (2–51)	9 (3–146)	<0.001

Data are shown as number of patients (%).
UA: uncomplicated appendicitis
CA: complicated appendicitis
*Grade II and higher according to the Clavien–Dindo classification.

Table 4 Reoperation cases

Case	Year	Age	Sex	Group	Duration* (days)	Cause of reoperation	Procedure	Complications	Postreoperative hospital stay (days)
1	2011	14	Male	UA	8	Retroperitoneal haematoma	Open hemostasis	None	8
2	2013	44	Male	CA	21	Adhesive bowel obstruction	Ileocecal resection	Leakage	125
3	2018	5	Female	CA	7	Abdominal abscess	Open drainage	None	9
4	2018	72	Male	CA	8	Wound dehiscence	Wound closure	Wound infection	38
5	2018	86	Female	CA	30	Abdominal abscess	Open drainage	None	11
6	2018	50	Male	UA	4	Ruptured appendix tip left behind	Resection of appendix tip	None	8
7	2021	46	Male	CA	80	Stump appendicitis	Resection	None	6
8	2022	51	Male	UA	25	Wound dehiscence	Wound closure	None	26

UA: uncomplicated appendicitis
CA: complicated appendicitis
* Duration from appendectomy to reoperation (days).

DISCUSSION

In this study, we divided patients who underwent emergency open appendectomy into a UA group and a CA group and examined patient backgrounds and surgical outcomes. Patients in the CA group were older, had longer operation time, and had more complications.

To date, although there have been many reports on acute appendicitis, most of these reports involve surgical outcomes combined with open and laparoscopic outcomes and multicentre reports.[3,6,7,13,14] This was a large study of emergency open appendectomy performed at a single institution.

In the present study, the operation time in the CA group was significantly longer than that in the UA group, and the estimated blood loss was significantly greater (10 vs 5 mL). These findings are consistent with previous reports.[7] Although most patients underwent appendectomy, ileocecal resection was performed in 65 (16%) patients in the CA group. A randomized controlled trial by Mentula et al reported that a 10% risk for bowel resection in patients with appendiceal abscess must be taken into consideration.[13]

Postoperative complications occurred in 3.0% of patients in the UA group and 16% of patients in the CA group. According to a retrospective nationwide study,[7] the incidence of CD grade II or higher complications was 3.5% in UA patients and 10.7% in CA patients. This difference may be attributed to the fact that we performed all emergency open appendectomies, whereas a retrospective nationwide study performed only half of the open appendectomies. However, in the UA group, the postoperative complication rates were similar. Previous studies have shown that laparoscopic appendectomy is associated with increased rates of intestinal injury, readmission, and postoperative abdominal abscess.[14,15] Moreover, a randomized, double-blind study showed that laparoscopic appendectomy does not offer significant advantages over open appendectomy[16] and that laparoscopic appendectomy was associated with more postoperative abdominal abscesses.[17] Conversely, a nonrandomized study concluded that laparoscopic appendectomy was associated with a shorter postoperative hospital stay, fewer complications[18] and a shorter duration of bowel obstruction.[19] A recent meta-analysis showed that laparoscopic appendectomy for CA is associated with reduced mortality, total morbidity, wound infection, respiratory complications, and ileus without a higher incidence of postoperative abdominal abscess.[20] Our study showed that the rates of complications, including wound infection, abdominal abscess, ileus, and pneumonia, were greater in the CA group. If these procedures were performed laparoscopically, whether these complications could have been prevented is an ongoing debate. However, among the patients who required reoperation, ruptured appendix tip left behind in Patient 6, and wound dehiscence in Patients 4 and 8 could have been prevented.

The total proportion of appendectomy cases for the entire study period was 81.6% for UA and 18.4% for CA. The distribution of inflammation by year revealed that the percentage of CA ranged from 11.3% to 22.4% through 2019, but after 2020, the percentage of CA increased from 31.3% to 40.9%. There are two possible reasons for this increase. One possibility is the aging of the population due to chronological age. The median age after 2020 was significantly higher than through 2019 (45 vs 32.5 years, $p<0.001$). Another possibility is the impact of the COVID-19 pandemic. Several studies have reported increased rates of CA during the pandemic period, attributed to patients avoiding contact with the virus and delaying hospital visits.[21,22] Consistent with these previous studies, our study also showed an increase in the incidence of CA after the pandemic.

This study has several limitations. First, as a single-centre retrospective study, there may be biases in patient selection and treatment interventions that may not be generalizable to other patient populations in different settings. Second, the study did not include patients who received antibiotic therapy, and the data from these patients might have affected the overall results. Additionally, the determination of the degree of inflammation might be inaccurate because inflammation is assessed preoperatively and intraoperatively by the attending physician, and no histopathological examination is routinely performed. However, this study had the largest sample size (n=2268) for reports on surgical outcomes of emergency open appendectomy for acute appendicitis, and the results of this study are helpful in terms of comparison with other treatment modalities, such as laparoscopic appendectomy and elective appendectomy.

CONCLUSIONS

This study demonstrated that, in the CA group, patients were older and had more comorbidities. Patients who underwent emergency open appendectomy for CA had longer operation times and more complications. This large single-center study provides useful information in terms of comparisons with other treatment modalities, such as laparoscopic appendectomy and elective appendectomy.

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REFERENCES

1 Stewart B, Khanduri P, McCord C, et al. Global disease burden of conditions requiring emergency surgery. *Br J Surg*. 2014;101(1):e9-e22. doi:10.1002/bjs.9329
2 Salminen P, Paajanen H, Rautio T, et al. Antibiotic Therapy vs Appendectomy for Treatment of Uncomplicated Acute Appendicitis: The APPAC Randomized Clinical Trial. *JAMA*. 2015;313(23):2340–2348. doi:10.1001/jama.2015.6154
3 Salminen P, Tuominen R, Paajanen H, et al. Five-Year Follow-up of Antibiotic Therapy for Uncomplicated Acute Appendicitis in the APPAC Randomized Clinical Trial. *JAMA*. 2018;320(12):1259–1265. doi:10.1001/jama.2018.13201
4 O'Leary DP, Walsh SM, Bolger J, et al. A Randomized Clinical Trial Evaluating the Efficacy and Quality of Life of Antibiotic-only Treatment of Acute Uncomplicated Appendicitis: Results of the COMMA Trial. *Ann Surg*. 2021;274(2):240–247. doi:10.1097/SLA.0000000000004785
5 Athanasiou CD, Robinson J, Yiasemidou M, Lockwood S, Markides GA. Laparoscopic vs open approach for transverse colon cancer. A systematic review and meta-analysis of short and long term outcomes. *Int J Surg*. 2017;41:78–85. doi:10.1016/j.ijsu.2017.03.050
6 Li X, Zhang J, Sang L, et al. Laparoscopic versus conventional appendectomy – a meta-analysis of randomized controlled trials. *BMC Gastroenterol*. 2010;10:129. doi:10.1186/1471-230X-10-129
7 Yamada T, Endo H, Hasegawa H, et al. Risk of emergency surgery for complicated appendicitis: Japanese nationwide study. *Ann Gastroenterol Surg*. 2020;5(2):236–242. doi:10.1002/ags3.12408
8 Oba T, Yamada T, Matsuda A, et al. Patient backgrounds and short-term outcomes of complicated appendicitis differ from those of uncomplicated appendicitis. *Ann Gastroenterol Surg*. 2021;6(2):273–281. doi:10.1002/ags3.12523
9 Moris D, Paulson EK, Pappas TN. Diagnosis and Management of Acute Appendicitis in Adults: A Review. *JAMA*. 2021;326(22):2299–2311. doi:10.1001/jama.2021.20502
10 Takayama Y, Kaneoka Y, Maeda A, Fukami Y, Takahashi T, Uji M. Etiologies and outcomes of emergency surgery for acute abdominal pain: an audit of 1456 cases in a single center. *Eur J Trauma Emerg Surg*. 2020;46(2):363–369. doi:10.1007/s00068-018-1051-3
11 Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evalua-

tion in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240(2):205–213. doi:10.1097/01.sla.0000133083.54934.ae

12 Kanda Y. Investigation of the freely available easy-to-use software 'EZR' for medical statistics. *Bone Marrow Transplant*. 2013;48(3):452–458. doi:10.1038/bmt.2012.244

13 Mentula P, Sammalkorpi H, Leppäniemi A. Laparoscopic Surgery or Conservative Treatment for Appendiceal Abscess in Adults? A Randomized Controlled Trial. *Ann Surg*. 2015;262(2):237–242. doi:10.1097/SLA.0000000000001200

14 Andersson RE. Short-term complications and long-term morbidity of laparoscopic and open appendicectomy in a national cohort. *Br J Surg*. 2014;101(9):1135–1142. doi:10.1002/bjs.9552

15 van Rossem CC, Schreinemacher MH, Treskes K, van Hogezand RM, van Geloven AA. Duration of antibiotic treatment after appendicectomy for acute complicated appendicitis. *Br J Surg*. 2014;101(6):715–719. doi:10.1002/bjs.9481

16 Katkhouda N, Mason RJ, Towfigh S, Gevorgyan A, Essani R. Laparoscopic versus open appendectomy: a prospective randomized double-blind study. *Ann Surg*. 2005;242(3):439–448;discussion 448–450. doi:10.1097/01.sla.0000179648.75373.2f

17 Pedersen AG, Petersen OB, Wara P, Rønning H, Qvist N, Laurberg S. Randomized clinical trial of laparoscopic versus open appendicectomy. *Br J Surg*. 2001;88(2):200–205. doi:10.1046/j.1365-2168.2001.01652.x

18 Guller U, Hervey S, Purves H, et al. Laparoscopic versus open appendectomy: outcomes comparison based on a large administrative database. *Ann Surg*. 2004;239(1):43–52. doi:10.1097/01.sla.0000103071.35986.c1

19 Leung TT, Dixon E, Gill M, et al. Bowel obstruction following appendectomy: what is the true incidence? *Ann Surg.* 2009;250(1):51–53. doi:10.1097/SLA.0b013e3181ad64a7

20 Quah GS, Eslick GD, Cox MR. Laparoscopic appendicectomy is superior to open surgery for complicated appendicitis. *Surg Endosc*. 2019;33(7):2072–2082. doi:10.1007/s00464-019-06746-6

21 Orthopoulos G, Santone E, Izzo F, et al. Increasing incidence of complicated appendicitis during COVID-19 pandemic. *Am J Surg*. 2021;221(5):1056–1060. doi:10.1016/j.amjsurg.2020.09.026

22 Kariya A, Krutsri C, Singhatas P, et al. Incidence of complicated appendicitis during the COVID-19 pandemic: A systematic review and meta-analysis. *Int J Surg Open*. 2022;45:100512. doi:10.1016/j.ijso.2022.100512