ORIGINAL

Preoperative predictors of extended resection in patients with complicated acute appendicitis undergoing surgery

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Abstract : Background : Appendectomy can be challenging and occasionally converted to extensive resection for complicated appendicitis. However, optimal treatment strategies can be developed using preoperative risk assessment. Thus, we aimed to investigate the preoperative predictors of extensive resection in complicated appendicitis patients undergoing surgery. Materials and methods : In total, 173 complicated appendicitis patients undergoing surgery between 2014 and 2019 were classified into the appendectomy (n = 153) or extensive resection (n = 20) groups. Clinicopathological factors and surgical outcomes were compared between groups. Results : Extensive resection was performed in 20 of 173 complicated appendicitis patients (11.5%). The rates of having defects in the wall structure at the appendix root on computed tomography images were significantly higher, and the duration from onset to surgery was significantly longer in the extensive resection group. Significant differences were found in operative duration, blood loss and postoperative hospitalization, but none in the incidence of postoperative complications between groups. Multivariate analyses showed that defects in the wall structure at the appendix root and five days or longer from onset were identified as independent predictors of extensive resection. Conclusions : Defects in the wall structure at the appendix root and five days or longer from onset predict extensive resection performance in complicated appendicitis patients. J. Med. Invest. 68 : 334-341, August, 2021

Keywords **:** *complicated acute appendicitis, extensive resection, predictive factors, days from onset, surgery*

INTRODUCTION

Complicated appendicitis is defined as appendix perforation with an abdominal abscess or peritonitis (1). Acute appendicitis with delayed detection frequently results in complicated appendicitis (2, 3). Although surgery has been considered the most effective treatment for complicated appendicitis for several decades, conservative treatment strategies, including antibiotic drugs with or without percutaneous drainage of abdominal abscess, are the preferred treatment of choice for complicated appendicitis according to the guidelines for appendicitis in the European Association of Endoscopic Surgery (EAES) (1) or the first choice of treatment according to the World Society of Emergency Surgery (WSES) (4). Furthermore, conservative treatment was successful in 93% of complicated appendicitis patients (2). Despite the high success rate of conservative treatment, recurrent appendicitis occurs in 5–27% of cases (2, 5-7). Therefore, optimal treatment is still controversial in complicated appendicitis patients.

Appendectomy is considered a gold standard for the treatment of appendicitis patients. In complicated appendicitis patients, appendectomy can be technically challenging and occasionally converted to extensive resection, such as an ileocecal resection or right hemicolectomy in the presence of an abdominal abscess (8). ER has been reported to be performed on approximately 3–30% of appendicitis patients with abscess and is associated with more technical demands and higher rates of morbidity than appendectomy (9, 10). Recently, several studies have reported that interval/delayed appendectomy not only reduces morbidity rates but also avoids recurrent appendicitis and extensive resection (11). Thus, preoperative risk assessment for extensive resection can be used to develop an optimal treatment strategy for surgery for complicated appendicitis. However, little is known about the preoperative predictors of extensive resection in complicated appendicitis patients. Therefore, this study aimed to investigate the preoperative predictors of extensive resection in complicated appendicitis patients treated with surgery.

Received for publication May 10, 2021 ; accepted August 5, 2021.

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MATERIALS AND METHODS

Patients

A total of 423 acute appendicitis patients who underwent surgery at our institute between January 2014 and December 2019 were included in the study. All patients were diagnosed with acute appendicitis using computed tomography (CT). Complicated appendicitis was defined as either gangrenous inflammation with or without perforation, and with abdominal abscess or inflammatory mass according to WSES guidelines (4). Among them, 173 patients (40.9%) diagnosed with complicated appendicitis using CT records reviewed by at least two radiologists were selected. In patients diagnosed with complicated appendicitis preoperatively, surgery was basically the first choice. However, conservative treatment was sometimes given depending on patient's wishes and condition. Finally, 173 complicated appendicitis patients who underwent surgery were included in this study. Of these, 153 underwent appendectomy and 20 underwent extensive resection (Fig. 1). This study was approved by the institutional review board of our hospital (02-46). Informed consent was waived by the ethical committee due to the retrospective nature of the study.

CT imaging and evaluation

All preoperative multidetector-row CT images were acquired using a multidetector-row scanner (Siemens Healthineers, Erlangen, Germany). An intravenous contrast scan was obtained following the injection of nonionic iodinated agents using an automated injector, unless contraindicated. CT images were reviewed and reported by at least two radiologists.

Factors analyzed

Clinicopathological data, including those on age, sex, body mass index, operative history, Charlson comorbidity index (12), comorbidities (heart disease ; history of heart failure, angina, myocardial infarction and arrhythmia, cerebrovascular disease : history of cerebral infarction, subarachnoid hemorrhage, cerebral hemorrhage, hypertension with medical treatment, and diabetes mellitus with medical treatment), steroid use, American Society of Anesthesiology Physical Status (ASA-PS), days from onset to surgery, treatment, use of preoperative percutaneous drainage, and pathological findings were collected from all patients. Data on preoperative radiologic findings suggestive of gangrenous/perforated appendix, abdominal abscess, appendicolith, and defects in partial or complete wall structures at the appendix root (Fig. 2) were also collected from the CT records. Results of preoperative laboratory examination, including white blood cell count and C-reactive protein level, were collected. Surgical outcomes included surgical approach (open or laparoscopic surgery, or conversion to open surgery), intraoperative findings, duration of operation, amount of blood loss, length of postoperative hospitalization, rate of readmission within less than 30 days, and postoperative complications according to the Clavien-Dindo classification (13). Moreover, intraoperative findings of the patients with uncomplicated appendicitis were reviewed to determine the diagnostic accuracy of CT for detecting complicated appendicitis.

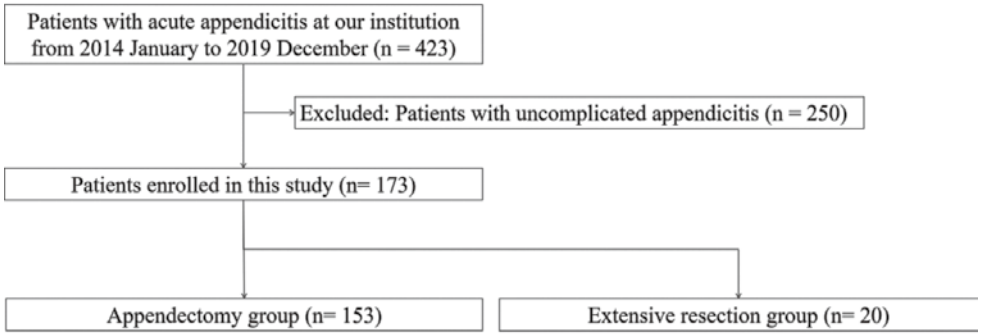

Fig 1. Flowchart of the study population.

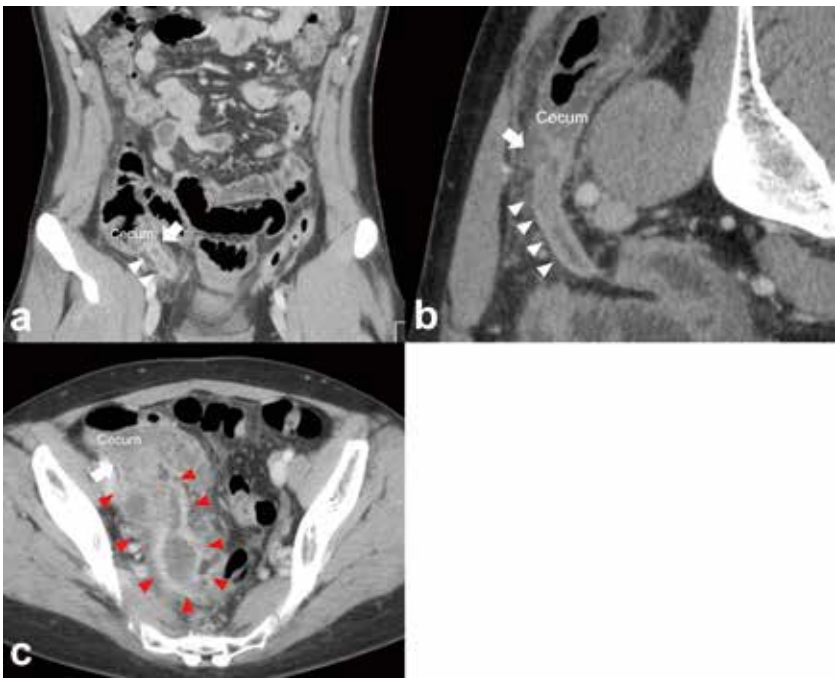

Fig 2. CT images of wall structure defects at the appendix root. (a) Coronal and (b) multi-planar reconstruction contrast-enhanced CT images showing partial wall structure defects at the appendix root (white arrow) and normal appendix wall at the appendix tip (white arrowhead). (c) Axial contrast CT image showing large pelvic abscess (red arrowhead) with an incomplete appendiceal wall structure (white arrow).

Statistical analyses

All statistical analyses were performed using the R version 4.0.0 software package (R Foundation for Statistical Computing, Vienna, Austria). Continuous data are presented as medians (interquartile ranges), and continuous variables were nonparametrically analyzed using the Mann-Whitney test. Categorical variables were compared using Fisher's exact test. The sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy of CT for complicated appendicitis were calculated using intraoperative findings as the gold standard. All variables with p-values <0.05, in the univariate analyses, were included and analyzed in the multivariate logistic regression analysis. Statistical significance was set at $p < 0.05$.

RESULTS

Patients' characteristics and clinicopathological findings

Patient characteristics and clinicopathological findings were compared between groups (Table 1). Extensive resection was performed in 20 of 173 (11.5%) patients with complicated

Table 1. Patients' characteristics and clinicopathological findings

Variables	Appendectomy (n = 153)	Extensive resection (n = 20)	p-value
Age [years ; median (IQR)]	61.0 (46.0–73.0)	65.5 (52.3–78.3)	0.131
Age ≥ 65 years, n (%)	80 (52.3)	13(65.0)	0.345
Sex, n (%)			0.153
Male	89 (58.2)	8 (40.0)	
Female	64 (41.8)	12 (60.0)	
BMI [kg/m^2 ; median (IQR)]	22.3 (20.2–25.0)	21.8 (20.4–23.4)	0.494
Charlson comorbidity index [median (IQR)]	0 (0–1)	1 (0–1)	0.507
Comorbidity, yes, n (%)			
Cardiovascular disease	15 (9.8)	3 (15.0)	0.422
Cerebral infarction	6 (3.9)	2 (10.0)	0.233
Hypertension	31 (20.3)	6 (30.0)	0.383
Diabetes mellitus	15 (9.8)	1 (5.0)	0.698
Steroid use, yes, n (%)	1 (0.6)	0 (0)	1.000
ASA-PS, n (%)			0.755
1	39 (25.5)	1 (5.0)	
2	84 (54.9)	12 (60.0)	
3	27 (17.6)	6 (30.0)	
4	3 (2.0)	1 (5.0)	
History of operation, n (%)	18 (11.8)	4 (20.0)	0.291
Received preoperative abdominal ultrasonography, n (%)	5 (3.3)	0 (0.0)	1.000
Diagnosis of CT images, n (%)			0.851
Perforation	112 (73.2)	15 (75.0)	1.000
Intra-abdominal abscess	104 (68.0)	16 (80.0)	0.315
Appendicolith	68 (44.4)	8 (40.0)	0.813
Defects in the wall structure at the appendix root	31 (20.3)	11 (55.0)	0.001*
Preoperative WBC, [/uL ; median (IQR)]	12360 (10020–14680)	12980 (10420–16100)	0.482
Preoperative CRP, [mg/L ; median (IQR)]	13.6 (7.66–21.9)	14.0 (11.9–24.0)	0.295
Days from onset to surgery, [median (IQR)]	3 (2.0–7.0)	8 (3.8–11.3)	0.010*
Treatment, n (%)			0.168
Emergent surgery	133 (86.9)	16 (80.0)	
Unplanned surgery due to conservative treatment failure or recurrent appendicitis	12 (7.8)	4 (20.0)	
Elective surgery after conservative treatment	8 (5.2)	0 (0.0)	
Preoperative percutaneous drainage, n (%)	2 (1.3)	0 (0)	1.000
Pathological findings, n (%)			0.078
Catarrhal or phlegmonous appendicitis	37 (24.2)	2 (10.0)	
Gangrenous appendicitis	105 (68.6)	15 (75.0)	
Chronic appendicitis or fibrosis	8 (5.2)	1 (5.0)	
Low-grade pseudomyxoma	3 (2.0)	1 (5.0)	
Adenocarcinoma	0 (0)	1 (5.0)	

IQR, interquartile range ; ASA-PS, the American Society of Anesthesiology performance status ; BMI, body mass index ; CT, computed tomography ; WBC, white blood cell count ; CRP, C-reactive protein. *Statistically significant.

appendicitis. The median age was comparable between the two groups. Charlson comorbidity index, the preoperative comorbidity rates, and the ASA-PS were not significantly different between the two groups. Although the CT diagnostic rates of perforation, intra-abdominal abscess, and appendicolith were not different between the two groups, the rate of defects in the wall structure at the appendix root was higher in the extensive resection group (appendectomy group : 20.3% vs. extensive resection group : 55.0%, p = 0.001). Days from onset were significantly longer in the extensive resection group (median, appendectomy group : 3 days vs. extensive resection group : 8 days, p = 0.010). Conservative treatment was intended in 24 (13.9%) of 173 patients with complicated appendicitis. Among these patients, 16 (66.7%) patients underwent unplanned surgery due to conservative treatment failure or recurrent appendicitis. Only one patient had appendiceal adenocarcinoma in the extensive resection group. The other patient characteristics, clinical findings, and hematologic examinations were not significantly different between the two groups.

Surgical outcomes and postoperative complications

The surgical outcomes were compared between the two groups (Table 2). Fifteen patients in the appendectomy group were diagnosed with uncomplicated appendicitis intraoperatively. The duration of operation, amount of blood loss, and postoperative hospitalization were significantly different between the two groups. The postoperative complications were compared between the two groups (Table 3). The incidence of postoperative complications according to Clavien-Dindo classification grade II or higher was not significantly different between the two groups (appendectomy group, 18.3% ; extensive resection group, 20.0% ; p = 0.768). No surgery-related deaths were observed in this study.

Cutoff point of days from onset to surgery

Receiver operating characteristic curves were plotted to select the cutoff value of the days from onset to surgery (area under the curve : 0.675, 95% confidence interval [CI] : 0.567-0784) (Fig. 3). The optimal cutoff values were selected based on Youden's index {the maximum value of (sensitivity + specificity - 1)} in relation to the outcome of the extensive resection procedure (14). Accordingly, the cutoff value of days from onset to surgery was calculated as 5 (sensitivity : 0.70, specificity : 0.65).

Diagnostic accuracy of CT for detecting complicated appendicitis

Preoperative CT reported that there were 40.9% (173/423) patients who had complicated appendicitis and 59.1% (250/423) patients had uncomplicated appendicitis. However, intraoperative findings showed 46.8% (198/423) patients had complicated appendicitis and 53.2% (225/423) patients had uncomplicated appendicitis. The sensitivity, specificity, positive and negative predictive values, and the accuracy of CT for detecting complicated appendicitis, were 79.8%, 93.3%, 91.3%, 84.0%, and 87.0% respectively (Table 4).

Table 2. Surgical outcomes

Variables	Appendectomy (n = 153)	Extensive resection (n = 20)	p-value
Surgical approach, n (%)			1.000
Open	95 (62.1)	13 (65.0)	
Laparoscopic	58 (37.9)	7 (35.0)	
Conversion to open surgery	0 (0)	0 (0)	-
Intraoperative findings, n (%)			0.222
Uncomplicated appendicitis	15 (9.8)	0 (0.0)	
Complicated appendicitis	138 (90.2)	20 (100.0)	
Operative duration [min ; median (IQR)]	78 (63.0–93.0)	144 (127.2–180.2)	< 0.001*
Blood loss [mL ; median (IQR)]	0 (0–60.0)	135.5 (65.5–372.5)	< 0.001*
Postoperative hospitalization [day ; median (IQR)]	7 (5.0–8.0)	9.5 (8.0–13.3)	< 0.001*
Postoperative readmission rate, n (%)	9 (5.9)	1 (5.0)	1.000

IQR, interquartile range. *Statistically significant.

Table 3. Postoperative complications according to the Clavien-Dindo classification (grade II or higher)

	Appendectomy (n = 153)	Extensive resection (n = 20)	p-value
All complications	28(18.3)	4(20.0)	0.768
Intra-abdominal abscess	18(11.7)	3(15.0)	0.715
Paralytic ileus	6(3.9)	2(10.0)	0.233
Superficial surgical site infection	7(4.8)	0(0)	1.000
Respiratory diseases	2(1.3)	0(0)	1.000
Bleeding	1(0.7)	1(5.0)	0.218
Pseudomembranous colitis	1(0.7)	0(0)	1.000
Drug eruption	1(0.7)	0(0)	1.000
Mortality	0(0)	0(0)	-

Data are shown as n (%).

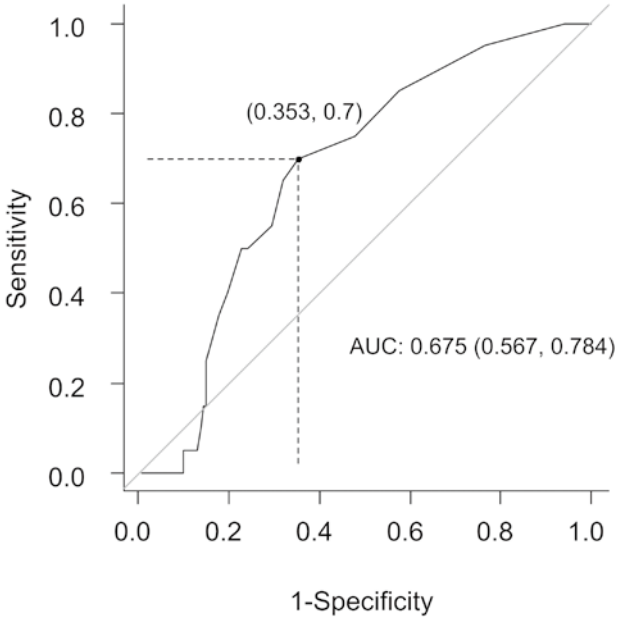

Fig 3. Receiver operating characteristic curve analysis for identification of the optimal cutoff value of the number of days from symptom onset to surgery to predict the outcome of the extensive resection procedure. The area under the curve was 0.675 (95% confidence interval: 0.567-0.784), and the threshold number of days from onset to surgery was 5, with a sensitivity of 70.0% and a specificity of 64.7%

Univariate and multivariate analyses for extensive resection

The results of univariate and multivariate analyses are presented in Table 5. Univariate analysis showed that defects in the wall structure at the appendix root and 5 days or longer from onset to surgery were associated with predictors of extensive resection. In addition, multivariate analysis showed that defects in the wall structure at the appendix root (odds ratio, 4.31 ; 95% CI, 1.38–13.84 ; p = 0.004) and 5 days or longer from onset to surgery (odds ratio, 2.58 ; 95% CI, 1.15-6.40 ; p = 0.011) were identified as independent predictors for extensive resection.

The predictive score of need for extensive resection was created with the two variables (Table 6). The presence of both variables had a predictive probability of 53.8% that extensive resection will be required. Conversely, the absence of both variables had a predictive probability of 4.0% for same event.

DISCUSSION

In this single-institution retrospective study, 20 of 173 patients with complicated appendicitis underwent extensive resection. The days from onset to surgery were significantly longer in the extensive resection group than in the appendectomy group. Our study demonstrated that wall structure defects at the appendix root and 5 days or longer from onset are independent predictive factors of extensive resection in patients with complicated appendicitis. The presence of both variables had a predictive probability of 53.8% that extensive resection will be needed.

Table 4. Diagnostic accuracy of CT for detecting complicated appendicitis

(Number)	Complicated at surgery	Uncomplicated at surgery	Total
Complicated on CT	158	15	173
Uncomplicated on CT	40	210	250
Total	198	225	423

		95% CI	
(Percent)		Lower	Upper
Sensitivity	79.8	73.5	85.2
Specificity	93.3	89.2	96.2
Positive predictive value	91.3	86.1	95.1
Negative predictive value	84.0	78.9	88.3
Accuracy	87.0	83.4	90.1

CT, computed tomography ; CI, confidence interval.

Table 5. Univariate and multivariate analyses of predictors for extensive resection

	Univariate			Multivariate		
	OR	95% CI	p-value	OR	95% CI	p-value
Defects in the wall structure at the appendix root, yes vs. no	4.81	1.60–15.01	0.001*	4.31	1.38–13.84	0.004*
Days from onset (vs. < 5 days)	2.79	1.28-6.80	0.005*	2.58	1.15-6.40	0.011*

CRP, C-reactive protein ; OR, odds ratio ; CI, confidence interval ; *Statistically significant.

Table 6. Predicted need for extensive resection according to the number of risk factors

Risk factors (number)	Number of patients	Predicted rate for extensive resection (%)	OR	95% CI	p-value
2	13	53.8	27.7	5.44–173.62	< 0.001*
1	61	14.8	4.11	1.08–19.66	0.024*
None	99	4.0	1.00	-	-

OR, odds ratio; CI, confidence interval. *Statistically significant.

Surgery has been the gold standard treatment for acute appendicitis for several decades. Recently, conservative treatment for appendicitis has been reported to be safe and feasible for adults and children (2, 15). Appendicitis is classified into two types : uncomplicated without signs of gangrene, perforation, an abdominal abscess, or purulent free fluid, and complicated with either gangrenous inflammation with or without perforation, intra-abdominal abscess, or inflammatory mass (4). For uncomplicated appendicitis, either surgical or conservative treatment is selected owing to the surgeon and/or hospital situation (1, 4). Meanwhile, complicated appendicitis occasionally makes it difficult for surgeons to decide whether to select surgical or conservative treatment because of the difficulty of surgical techniques and the relatively high failure rate for conservative treatment (16). According to the WSES guidelines for appendicitis, conservative treatment is a reasonable first-line treatment for appendicitis with phlegmon or abscess, while surgical treatment is a safe alternative to conservative treatment under experienced surgeons (4). Thus, the optimal treatment for complicated appendicitis remains controversial.

Initial conservative treatment following interval/delayed appendectomy has been reported to reduce not only missing an underlying and untreated malignancy but also undergoing extensive resection (9). Furthermore, several studies have suggested that interval/delayed appendectomy has advantages only for the treatment of appendicitis with an abdominal abscess (17, 18). However, the preoperative criterion for decision-making of initial conservative treatment with or without interval/delayed appendectomy for complicated appendicitis is still unclear according to the EAES and WSES guidelines (1, 4). Therefore, there is a need to develop preoperative criteria that can guide the therapeutic strategy for patients with complicated appendicitis.

In a previous study, conservative treatment including intravenous antibiotic therapy with or without abscess drainage was successful in 93% patients with acute appendicitis (2). However, in our study, 16 of 24 patients scheduled to undergo conservative treatment underwent unplanned surgery due to treatment failure or recurrent appendicitis. A reason for this discrepancy may be the low performance rate of preoperative percutaneous abscess drainage in our hospital possibly due to lack of experience with the procedure. Therefore, percutaneous abscess drainage should be actively performed to increase the success rate of conservative treatment following interval or delayed appendectomy.

In approximately 20% of patients, acute appendicitis is diagnosed as a complicated type, leading to local or diffuse peritonitis (19). In our study, 173 of 423 patients (40.9%) were diagnosed with complicated appendicitis, which was approximately twice as high as that in a previous study. A possible reason for this discrepancy was that patients who initially received conservative treatment were excluded, and only patients who needed surgical treatment for some reasons were referred to our hospital in the tertiary emergency facility. Therefore, the rate of complicated appendicitis was relatively high in our study.

Generally, appendectomy can be technically challenging and occasionally converted to extensive resection in the presence of an abdominal abscess (16). Extensive resection has been reported to be performed approximately 3–30% of appendicitis patients with abscess and is associated with more technical demands and higher rates of morbidity than appendectomy (2, 9, 10). Similarly, in our study, approximately 10% of complicated appendicitis patients underwent extensive resection. Thus, surgical indications for extensive resection were comparable between our study and previous studies.

Although the useful diagnostic modalities for acute appendicitis include ultrasonography, CT, and magnetic resonance imaging, CT is generally accepted as the most reliable tool for the diagnosis of appendicitis (20). A previous meta-analysis has reported that CT has relatively low sensitivity and high negative predictive value for complicated appendicitis (mean sensitivity : 78%, mean specificity : 91%, mean positive predictive value : 74%, mean negative predictive value : 93%) (21). In our study, the diagnostic accuracy of CT for complicated appendicitis was comparable to that reported in the abovementioned study, supporting the reliability of our findings.

Recently, appendiceal mass and non-visualization of the appendix using CT images have been reported to be independent predictive factors for performing extensive resection in both uncomplicated and complicated acute appendicitis patients (9). Similarly, defects in the wall structure at the appendix root detected by CT images were associated with conversion to extensive resection procedure in our study. This result suggested that the defects in the wall structure at the appendix root indicated gangrenous inflammation and/or formation of an inflammatory mass around the root of the appendix, which made it difficult to ligate and to resect the root of the appendix during appendicitis surgery. Thus, for patients with complicated appendicitis, confirmation of wall structure defects at the appendix root using preoperative CT is clinically important to avoid extensive resection.

Surgical timing for appendicitis is reportedly associated with the length of hospital stay and postoperative outcome (22). Several studies have reported that the relationship between a delay in surgery from symptom onset and complicated appendicitis and delayed surgery for more than 36 or 48 h increased postoperative complications (23, 24). Conservative treatment has been reported to reduce postoperative complications and to mitigate the risk of needing extensive resection (22). However, few reports have shown the optimal surgical timing for complicated appendicitis. In our study, five days or longer from onset was identified as a predictor of extensive resection. Moreover, the presence of the two factors including the duration of five days or longer from onset and defects in the wall structure at the appendix root highly predicted the need for extensive resection. Therefore, surgeons may choose conservative treatment in complicated appendicitis patients with the two predictive factors for extensive resection to decrease postoperative complications and the risk of needing extensive resection.

The present study has some limitations. First, this was a retrospective analysis of a small number of patients from a single

institute. Second, in this study, the cutoff value of days from onset was established based on the data of patients from a single institution. Thus, a multicenter study or studies on other patient populations are needed to verify these results and to determine a comprehensive cutoff value of days from onset.

CONCLUSION

In complicated appendicitis patients, defects in the wall structure at the appendix root and the duration of five days or longer from onset were preoperative predictors of extensive resection. These factors may help surgeons avoid extensive resection and in determine the therapeutic strategy for complicated appendicitis patients.

ACKNOWLEDGEMENTS

We would like to thank Editage (www.editage.com) for English language editing.

FUNDING

The authors did not receive support from any organization for the submitted work.

CONFLICTS OF INTEREST/COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

ETHICAL APPROVAL

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board of Ehime Prefectural Central Hospital (approval no. 02-46).

Ethical approval was waived by the Institutional Review Board of Ehime Prefectural Central Hospital in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

AUTHOR'S CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation and data collection were performed by Yuhei Waki, Daichi Utsunomiya and Masayoshi Obatake, and analysis were performed by Yuhei Waki and Masanori Hotchi. The first draft of the manuscript was written by Yuhei Waki and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

REFERENCES

1. Gorter RR, Eker HH, Gorter-Stam MA, Abis GS, Acharya A, Ankersmit M, Antoniou S. A, Arolfo S, Babic B, Boni L, Bruntink M, van Dam D. A, Defoort B, Deijen C. L, DeLacy F. B, Go P. M, Harmsen A. M, van den Helder R. S, Iordache F, Ket J. C, Muysoms F. E, Ozmen M. M, Papoulas M, Rhodes M, Straatman J, Tenhagen M, Turrado V, Vereczkei A, Vilallonga R, Deelder J. D, Bonjer J : Diagnosis and management of acute appendicitis. EAES consensus development conference 2015. Surg Endosc 30 : 4668-4690, 2016
2. Andersson RE, Petzold MG : Nonsurgical Treatment of Appendiceal Abscess or Phlegmon : A Systematic Review and Meta-analysis. Ann Surg 246 : 741-748, 2007
3. Buckius MT, McGrath B, Monk J, Grim R, Bell T, Ahuja V : Changing Epidemiology of Acute Appendicitis in the United States : Study Period 1993-2008. J Surg Res 175 : 185-190, 2012
4. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, Boermeester M, Sartelli M, Coccolini F, Tarasconi A, De'Angelis N, Weber D. G, Tolonen M, Birindelli A, Biffl W, Moore E. E, Kelly M, Soreide K, Kashuk J, Ten Broek R, Gomes C. A, Sugrue M, Davies R. J, Damaskos D, Leppaniemi A, Kirkpatrick A, Peitzman A. B, Fraga G. P, Maier R. V, Coimbra R, Chiarugi M, Sganga G, Pisanu A, De'Angelis G. L, Tan E, Van Goor H, Pata F, Di Carlo I, Chiara O, Litvin A, Campanile F. C, Sakakushev B, Tomadze G, Demetrashvili Z, Latifi R, Abu-Zidan F, Romeo O, Segovia-Lohse H, Baiocchi G, Costa D, Rizoli S, Balogh Z. J, Bendinelli C, Scalea T, Ivatury R, Velmahos G, Andersson R, Kluger Y, Ansaloni L, Catena F : Diagnosis and treatment of acute appendicitis : 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg 15 : 27, 2020
5. Kaminski A, Liu I-LA, Applebaum H, Lee SL, Haigh PI : Routine Interval Appendectomy Is Not Justified After Initial Nonoperative Treatment of Acute Appendicitis. Arch Surg 140 : 897-901, 2005
6. Mentula P, Sammalkorpi H, Leppaniemi A : Laparoscopic Surgery or Conservative Treatment for Appendiceal Abscess in Adults? A Randomized Controlled Trial. Ann Surg 262 : 237-242, 2015
7. Simillis C, Symeonides P, Shorthouse AJ, Tekkis PP : A meta-analysis comparing conservative treatment versus acute appendectomy for complicated appendicitis (abscess or phlegmon). Surgery 147 : 818-829, 2010
8. Saida F, Matsumoto S, Kitano M : Preoperative predictor of extensive resection for acute appendicitis. Am J Surg 215 : 599-602, 2018
9. Deelder JD, Richir MC, Schoorl T, Schreurs WH : How to Treat an Appendiceal Inflammatory Mass : Operatively or Nonoperatively? J Gastrointest Surg 18 : 641-645, 2014
10. Olsen J, Skovdal J, Qvist N, Bisgaard T : Treatment of appendiceal mass--a qualitative systematic review. Dan Med J 6 : A4881, 2014
11. de Jonge J, Bolmers MDM, Musters GD, van Rossem CC, Bemelman WA, van Geloven AAW : Predictors for interval appendectomy in non-operatively treated complicated appendicitis. Int J Colorectal Dis 34 : 1325-1332, 2019
12. Charlson ME, Pompei P, Ales KL, MacKenzie CR : A new method of classifying prognostic comorbidity in longitudinal studies : Development and validation. J Chronic Dis 40 : 373-383, 1987
13. Dindo D, Demartines N, Clavien PA : Classification of surgical complications : a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240 : 205-213, 2004
14. Youden WJ : Index for rating diagnostic tests. Cancer 3 : 32-35, 1950
15. Vons C, Barry C, Maitre S, Pautrat K, Leconte M, Costaglioli B, Karoui M, Alves A, Dousset B, Valleur P, Falissard B,

Franco D : Amoxicillin plus clavulanic acid versus appendicectomy for treatment of acute uncomplicated appendicitis : an open-label, non-inferiority, randomised controlled trial. Lancet 377 : 1573-1579, 2011
16. Hori T, Machimoto T, Kadokawa Y, Hata T, Ito T, Kato S, Yasukawa D, Aisu Y, Kimura Y, Sasaki M, Takamatsu Y, Kitano T, Hisamori S, Yoshimura T : Laparoscopic appendectomy for acute appendicitis : How to discourage surgeons using inadequate therapy. World J Gastroenterol 23 : 5849-5859, 2017
17. Hoffmann J, Lindhard A, Jensen HE : Appendix mass : conservative management without interval appendectomy. Am J Surg 148 : 379-82, 1984
18. Lai HW, Loong CC, Chiu JH, Chau GY, Wu CW, Lui WY : Interval appendectomy after conservative treatment of an appendiceal mass. World J Surg 30 : 352-357, 2006
19. Livingston EH, Woodward WA, Sarosi GA, Haley RW : Disconnect between incidence of nonperforated and perforated appendicitis : implications for pathophysiology and management. Ann Surg 245 : 886-892, 2007
20. Horton MD, Counter SF, Florence MG, Hart MJ : A prospective trial of computed tomography and ultrasonography for diagnosing appendicitis in the atypical patient. Am J Surg 179 : 379-381, 2000
21. Bom WJ, Bolmers MD, Gans SL, van Rossem CC, van Geloven AAW, Bossuyt PMM, Stoker J, Boermeester M : Discriminating complicated from uncomplicated appendicitis by ultrasound imaging, computed tomography or magnetic resonance imaging : systematic review and meta-analysis of diagnostic accuracy. BJS open 5 : zraa030, 2021
22. Kim JY, Kim JW, Park JH, Kim BC, Yoon SN : Early versus late surgical management for complicated appendicitis in adults : a multicenter propensity score matching study. Ann Surg Treat Res 97 : 103-111, 2019
23. Bhangu A : Safety of short, in-hospital delays before surgery for acute appendicitis : multicentre cohort study, systematic review, and meta-analysis. Ann Surg 259 : 894-903, 2014
24. Kim M, Kim SJ, Cho HJ : Effect of surgical timing and outcomes for appendicitis severity. Ann Surg Treat Res 91 : 85-89, 2016