Received: 26 April 2019 | Revised: 17 June 2019 | Accepted: 28 June 2019

DOI: 10.1002/ags3.12277

ORIGINAL ARTICLE

AGSurg Annals of Gastroenterological Surgery Open Access WILEY

Clinical outcomes of single-site laparoscopic interval appendectomy for severe complicated appendicitis: Comparison to conventional emergency appendectomy

Masaaki Miyo[1,2] | Shoichiro Urabe[1] | Satoshi Hyuga[1] | Tomo Nakagawa[1] | Toshiya Michiura[1] | Nobuyasu Hayashi[1] | Kazuo Yamabe[1]

[1]Department of Surgery, Kinan Hospital, Tanabe, Japan

[2]National Hospital Organization Osaka National Hospital, Osaka, Japan

Correspondence
Masaaki Miyo, National Hospital Organization Osaka National Hospital, 2-1-14, Hoenzaka, Chuo-ku, Osaka, 540-0006, Japan.
Email: miyo.masaaki.rq@mail.hosp.go.jp

Abstract

Aim: Single-site laparoscopic interval appendectomy (SLIA) for severe complicated appendicitis after conservative treatment (CT) to ameliorate inflammation and eradicate the abscess should be safer and less invasive than emergency appendectomy (EA). However, only a few reports have been published regarding SLIA.

Methods: We retrospectively collected data on 264 consecutive patients admitted to Kinan Hospital for treatment of appendicitis between 2012 and 2018. The safety and feasibility of SLIA and its perioperative outcomes for severe complicated appendicitis were investigated.

Results: A total of 61 patients were included in this study, 25 of whom underwent CT and 36 EA. Among the 25 patients who underwent CT, 23 (92.0%) succeeded; a total of 16 patients (69.5%) underwent SLIA. Compared to the EA group, the SLIA group had less bleeding (median volume 8.5 vs 50 mL, $P = .005$) and lower rate of expansion surgery (0% vs 27.8%, $P = .022$). Although the postoperative hospital stay was shorter in the SLIA group than in the EA group (9 vs 12 days, $P = .008$), the total hospital stay, including the CT period, was longer in the SLIA group than in the EA group (24 vs 12 days, $P < .001$).

Conclusion: SLIA is safe, feasible, and less invasive than EA and may provide the advantages of minimally invasive surgery even if appendicitis is severe. SLIA may be a promising option for complicated appendicitis in select cases despite its disadvantage of prolonging the hospital stay.

KEYWORDS

complicated appendicitis, conservative treatment, emergency appendectomy, interval appendectomy, single-site laparoscopic appendectomy

1 | INTRODUCTION

Acute appendicitis is the most common abdominal surgical emergency, with an estimated lifetime risk of 7%-8% worldwide.[1] Appendicitis can be divided into uncomplicated and complicated appendicitis. Uncomplicated appendicitis is acute simple appendicitis without any signs of perforation, abscess, or necrosis. Complicated appendicitis is an intense inflammatory type with rapidly proceeding necrosis, perforation, or both and subsequent abscess formation. Complicated appendicitis accounts for approximately 4%-25% of cases.[2–6] Emergency appendectomy (EA) has been the gold standard treatment for acute appendicitis due to the risk of its progression, such as evolution of unperforated appendicitis to perforated appendicitis.[7] However, EA for complicated appendicitis can result in excessive tissue manipulation to detach adhesions, leading to increased morbidity and risk of unnecessary expansion surgery, including ileocecal resection.[4,8] The standard management for these cases is conservative treatment (CT) with antibiotics and drainage for the peri-appendiceal abscess, followed by interval appendectomy (IA).[9] The need for IA remains controversial because of the rate of recurrence and possible underlying malignancy, as well as perioperative risk.[10,11]

Laparoscopic surgery for uncomplicated appendicitis has been rapidly accepted, as it has several advantages over open surgery.[12–14] It has also been shown to be feasible and safe for complicated appendicitis, with the advantage of a reduced risk of surgical site infection.[15] Single-site laparoscopic surgery has developed in recent years due to minimized surgical trauma. It may be difficult to perform appendectomy for complicated appendicitis in single-site laparoscopic surgery because of severe adhesion, abscess, or some technical problems, including instrument crowding and in-line viewing. Single-site laparoscopic interval appendectomy (SLIA) after CT to ameliorate inflammation and eradicate the abscess may be safer and less invasive than EA, providing the advantages of minimally invasive surgery, such as reduced postoperative pain and improved cosmetic outcome, even if the appendicitis is severe. However, only a few studies of SLIA for complicated appendicitis have discussed its effectiveness.[8,16] Therefore, the present study investigated patients with severe complicated appendicitis who underwent SLIA and analyzed perioperative outcomes compared to EA.

2 | MATERIALS AND METHODS

2.1 | Patients

We retrospectively collected data on 264 consecutive patients admitted to Kinan Hospital for treatment of appendicitis between 2012 and 2018. Appendicitis accompanied with abscess and/or perforation based on ultrasound and/or computed tomography was defined as severe complicated appendicitis in this study (Figure 1A-D).[6] A total of 61 patients were diagnosed with severe complicated appendicitis and asked to select EA or CT with or without SLIA, 36 of whom underwent EA and 25 CT. Medical reports were reviewed

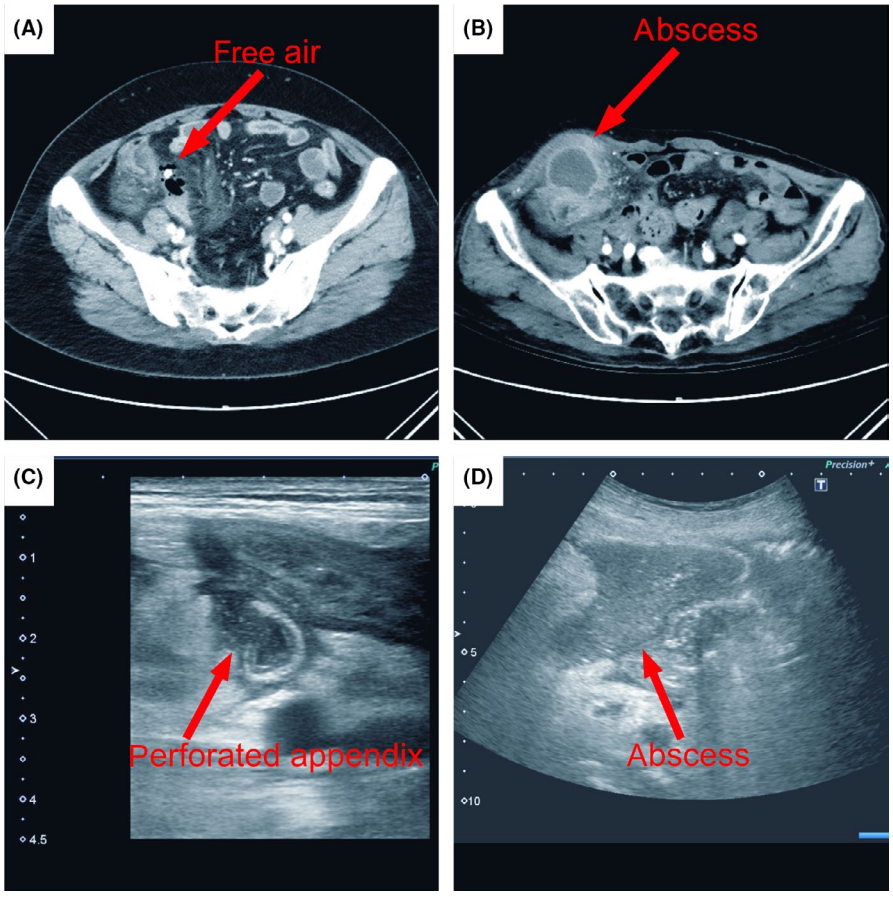

FIGURE 1 Definition of severe complicated appendicitis. A, Appendicitis accompanied by free air and/or (B) abscess based on computed tomography and (C) deficiency of the appendix wall and/or (D) a peri-appendiceal abscess based on ultrasound

to extract information regarding diverse clinicopathological parameters, including sex, age, body mass index (BMI), American Society of Anesthesiologists Physical Status (ASA-PS), white blood cell (WBC) count, C-reactive protein (CRP) level, duration from onset to admission, type and duration of antibiotics, presence or absence of drainage, length of hospital stay, and recurrence of appendicitis. We also recorded perioperative outcomes, such as operating time, bleeding volume, operation type, conversion to open surgery, postoperative complications, time to first diet, readmission, and mortality. Complications were defined as grade II or above in the Clavien–Dindo classification. Written informed consent was provided by all patients who participated in this study, and our study was approved by our Institutional Review Board (approval number 172).

2.2 | Conservative treatment

The patients were treated with intravenous antibiotics until fever and abdominal pain disappeared and the WBC count and CRP level reverted to nearly normal. Percutaneous drainage guided by ultrasound was judged by the attending physician. In case of exacerbation of fever, abdominal pain, WBC count, and CRP, operative treatment was performed. When appendicitis relapsed after CT, the patients were asked again to select EA or CT.

2.3 | Surgical techniques

Open surgery was performed through McBurney, para median, or midline incision. Appendectomy was completed by transection of the mesoappendix, and ligation and resection of the appendix at the radix. The appendix stump was embedded and the incision closed in layers with or without a drainage tube. When usual appendectomy was impossible due to inflammation, appropriate resection including cecectomy and ileocecal resection was performed. During laparoscopic surgery, a multichannel access device was fitted into a 2 to 3-cm vertical skin incision in the umbilicus, after which three 5-mm ports were inserted for the camera and instruments. Additional ports were inserted in cases with severe adhesion and inflammation if necessary. The appendix was ligated using an Endoloop (Ethicon) and the appendix stump was not embedded. The umbilical incision was used to pull out the specimen.

2.4 | Single-site laparoscopic interval appendectomy

Depending on the patient's request after successful CT, SLIA was performed when the abscess was absent 2-3 months after diagnosis. SLIA was planned for the patients who had recurrence of appendicitis and CT performed again as well. For safety, additional ports were inserted in cases with severe inflammation and adhesion.

2.5 | Statistical analysis

JMP Pro 14 software (SAS Institute Inc., Cary, NC. USA) was used for statistical analyses. Significant differences were evaluated using the Mann–Whitney test, χ^2 test, and Fisher's exact test as appropriate. Probabilities < .05 were considered to indicate significant differences.

3 | RESULTS

3.1 | Patient characteristics

Significant differences in patient characteristics were not observed between the CT and EA groups with regard to sex, age, BMI, or ASA-PS (Table 1). The two groups had similar median WBC counts, CRP levels and maximum diameter of abscess at admission, as well as duration from onset to admission (Table 1).

TABLE 1 Patient characteristics

Characteristic	CT (N = 25)	EA (N = 36)	*P*[a]
Sex, male/female	10/15	21/15	.198[b]
Age, y	68 (17-92)	58.5 (7-95)	.618
BMI, kg/m^2	21.9 (13.3-26.0)	20.1 (14.2-28.0)	.665
ASA-PS			
1	8 (32.0%)	8 (22.2%)	.657[c]
2	10 (40.0%)	15 (41.7%)	
3	7 (28.0%)	13 (36.1%)	
WBC count at admission, ×10^9/L	10.8 (5.1-18.0)	13.1 (4.1-23.7)	.064
CRP level at admission, mg/dL	12.7 (1.0-34.3)	15.5 (4.1-41.0)	.118
Maximum diameter of abscess, mm	24 (0-90)	27 (0-78)	.638
Days from onset to admission	5 (1-18)	2 (1-14)	.060

Note: Data are given as median (range) or n (%).
Abbreviations: ASA-PS, ASA Physical Status; BMI, body mass index; CRP, C-reactive protein; CT, conservative treatment; EA, emergency appendectomy; WBC, white blood cell.
P-values were determined by the Mann–Whitney test unless otherwise noted.
Fisher's exact test.
χ^2 test.

TABLE 2 Clinical outcomes of successful conservative treatment

Variable	N = 23
Duration of IV antibiotic therapy, d	10 (5-15)
Percutaneous drainage	1 (4.3%)
WBC count at admission, $\times 10^9$/L	12.7 (4.1-23.7)
WBC count at discharge, $\times 10^9$/L	5.1 (2.5-6.8)
CRP level at admission, mg/dL	13.2 (1.0-41.0)
CRP level at discharge, mg/dL	0.5 (0.0-3.5)
Length of hospital stay, days	14 (3-37)
Recurrence of appendicitis	3 (13.0%)

Note: Data are given as median (range) or n (%).
Abbreviations: CRP, C-reactive protein; IV, intravenous; WBC, white blood cell.

3.2 | Outcomes of conservative treatment

Among the 25 patients who underwent CT, two patients (8.0%) had exacerbation of fever and abdominal pain and underwent operative treatment; in both cases laparoscopic surgery was performed, but one case required conversion to open surgery with ileocecal resection. In the 23 patients (92.0%) with successful CT, the median duration of intravenous antibiotic therapy was 10 days (Table 2). Percutaneous drainage was performed for only one patient who had a large abdominal abscess with a maximum diameter of approximately 90 mm. CT was restarted in all of the patients with recurrence (Table 2). Two of the patients underwent SLIA and one did not desire surgery. Eventually the abscesses disappeared in all cases with successful CT.

3.3 | Typical treatment course of SLIA

A total of 16 patients in this study underwent SLIA. The abdominal abscesses shrunk over time due to intravenous antibiotic therapy and disappeared just before SLIA approximately 3 months after the initial treatment (Figure 2A-C). Although adhesions were present around the appendix in almost all cases, they could be peeled off; the appendix was resectable at the radix when the abscess disappeared and the inflammation was reduced (Figure 2D-F).

3.4 | Perioperative outcomes of SLIA and EA

Table 3 shows the perioperative outcomes of SLIA versus EA. The two groups had similar median operating times, but the SLIA group

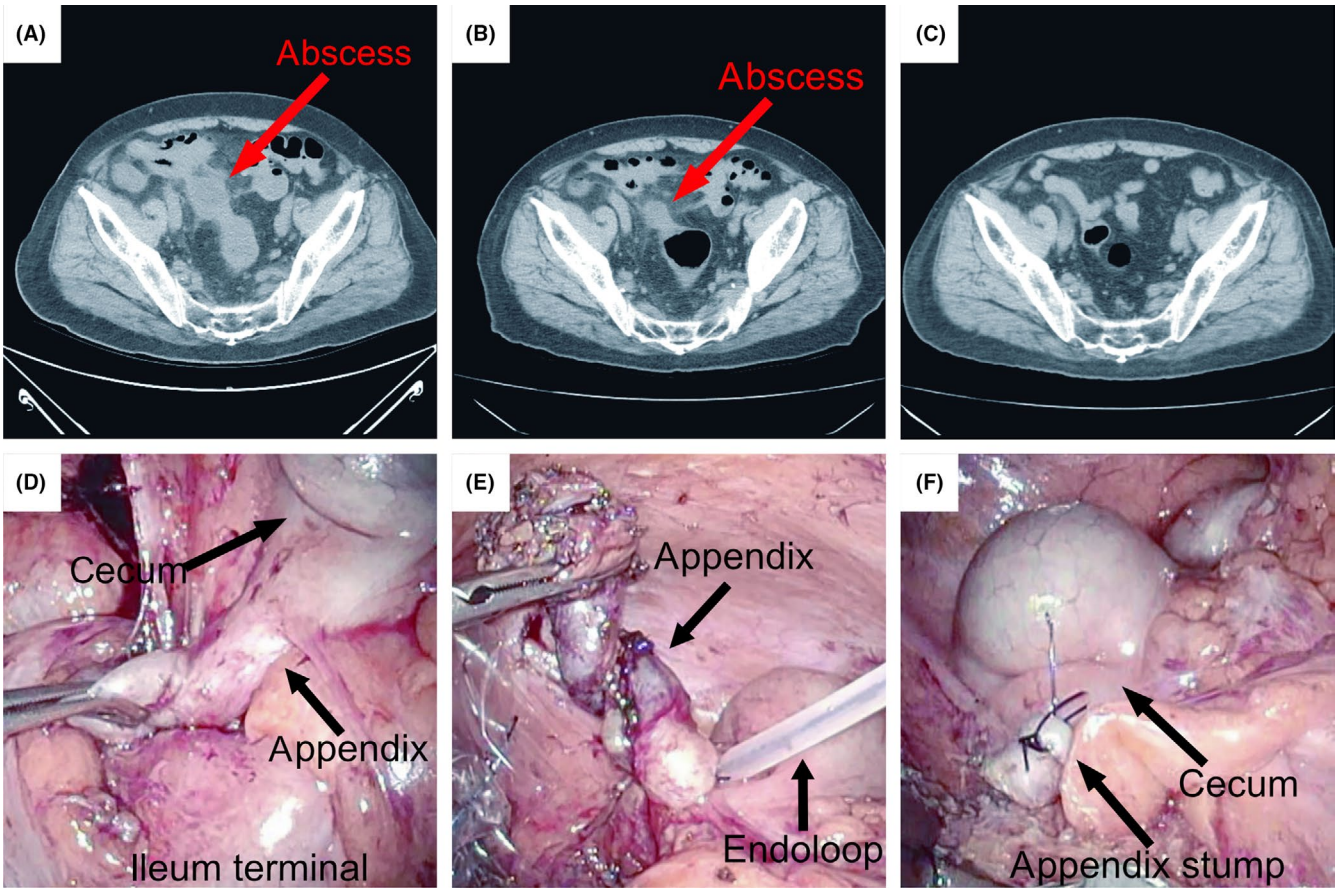

FIGURE 2 Typical treatment course of single-site laparoscopic interval appendectomy (SLIA). A, Abscess before conservative treatment (CT). (B and C) The abscess was shrining 2 wk after CT and eradicated 3 mo after CT, just before SLIA. D, Adhesions could be peeled off safely after successful CT. (E and F) The appendix was ligated using an Endoloop (E) and resected at the radix without the embedded appendix stump (F)

had significantly less bleeding (Table 3). Laparoscopic appendectomy was performed in all cases in the SLIA group, but in only nine cases (25.0%) in the EA group and expansion surgery including cecal or ileocecal resection was required in 10 cases (27.8%). Only two cases in the SLIA group required insertion of an additional port (data not shown). The two groups did not significantly differ with regard to the rate of postoperative complications and readmission and time to first diet (Table 3). No mortality within 30 days after surgery was observed in either group. Although the length of postoperative hospital stay was shorter in the SLIA group than in the EA group, the length of the total hospital stay, including the period of CT, was longer in the SLIA group than in the EA group (Table 3). When the total cases of the CT and EA groups were compared, there was no significant difference in complication rates (12.0% vs 33.3%; $P = .074$) and length of first hospital stay (14 vs 12 days; $P = .820$), respectively.

4 | DISCUSSION

Although there are various definitions of appendicitis, the definition by Gomes et al seemed to be useful for perioperative treatment planning; appendicitis with abscess and/or perforation was defined as severe complicated appendicitis because it is often clinically difficult to treat.[2,6,9] The failure rate of CT in this study was 8.0%, which is comparable to the 7.2% in systematic reviews and meta-analyses of appendiceal abscess or phlegmon.[4] However, the need for percutaneous drainage was 4.0% in this study and 19.7% in the previous study. These differences may be due to inconsistency in the policy of what kind of cases require drainage. Although abscesses in the pelvis were often difficult to drain due to the large and small intestine, most cases in our study were treatable with only antibiotics.

TABLE 3 Perioperative outcomes of SLIA and EA

Variable	SLIA (N = 16)	EA (N = 36)	P[a]
Operating time, min	92.5 (33-185)	99 (60-277)	.423
Bleeding volume, mL	8.5 (1-104)	50 (0-654)	.005
Operation type			.022[b]
Appendectomy	16 (100%)	26 (72.2%)	
Cecal or ileocecal resection	0	10 (27.8%)	
Laparoscopic surgery	16 (100%)	9 (25.0%)	<.001[b]
Conversion to open surgery	0	3 (8.3%)	.544[b]
Complications	2 (12.5%)	12 (33.3%)	.179[b]
Ileus	0	5 (13.9%)	
Wound infection	1 (6.3%)	4 (11.1%)	
Intraperitoneal abscess	0	2 (5.6%)	
Other	1 (6.3%)	1 (2.8%)	
Mortality	0	0	-
Time to first diet, d	2 (1-6)	3 (1-13)	.059
Length of postoperative hospital stay, d	9 (5-22)	12 (6-32)	.008
Length of total hospital stay, d	24 (11-59)	12 (6-32)	<.001
Readmission	0	2 (5.6%)	1.000[b]

Note: Data are given as median (range) or n (%).
Abbreviations: EA, emergency appendectomy; SLIA, single-site laparoscopic interval appendectomy.
P-values were determined by the Mann–Whitney test unless otherwise noted.
Fisher's exact test.

Recurrence of appendicitis occurred in only three patients (13.0%) after successful CT, all of whom underwent CT again and responded to antibiotics. Other studies on complicated appendicitis with different observation periods have reported that the risk of recurrence is 7%-34%.[4,10,17] Our follow-up periods were short (median 88 days, range 34-2106 days) because 16 patients (69.6%) with successful CT underwent SLIA approximately 3 months after diagnosis. Considering that some studies reported that the majority of recurrences occurred within 3-6 months after initial treatment, there was a possibility that our recurrence rate may increase further if IA was not performed. If the recurrence rate is high, IA for severe complicated appendicitis may be a more acceptable treatment depending on the cases.

CT is associated with a risk of missing or delaying the diagnosis of an underlying cancer (eg adenocarcinoma, mucinous cystadenoma, neuroendocrine tumor) or important benign disease (eg Crohn's disease) in approximately 2% of patients.[4,18] In this study, three of 25 cases undergoing CT were diagnosed as mucinous cystadenoma based on histopathological assessment after SLIA and all cases in the EA group were diagnosed as appendicitis. Our risk of missing or delaying diagnosis was higher than in other studies, possibly due to the small number of cases in the present study. This was one limitation of our single-center study. Seven cases that underwent only CT without SLIA have not been diagnosed as another disease during the follow-up, which consists of ultrasound, computed tomography, or colonoscopy. Our results suggest that although most cases with severe complicated appendicitis could be treated with CT, the risk of missing or delaying another underlying disease should be given sufficient attention, and IA could be an acceptable option, especially in cases of cancer predilection and an age over 40 years. If IA is not performed, appropriate follow-up taking malignant tumors into account is required.

Although laparoscopic appendectomy has been shown to offer many advantages with regard to shorter hospital stay, less postoperative pain, and lower rate of infections, few studies have assessed the safety and effectiveness of SLIA for patients with complicated appendicitis.[14,19] Ohno[16] and Kang et al[20] showed the safety and feasibility of SLIA without comparison with EA for appendicitis with a peri-appendiceal abscess in pediatric and adult patients, respectively, and reported that the complication rate was 8.0%. The morbidity rate reported in other reports on IA for complicated appendicitis without single-site laparoscopic appendectomy was 12.4%-15%, which is similar to our morbidity rate.[10,20,21] Our data

suggest that SLIA may provide the advantages of minimally invasive surgery, including improved cosmetic outcome, even if the appendicitis is severe. However, length of total hospital stay combined with CT and perioperative periods was twice as long in the SLIA group than the EA group. In line with the length of hospital stay, the median cost per patient for operative management was lower in the SLIA group than in the EA group (¥609 345 vs ¥785 160; P = .002), but the total hospitalization cost was higher in the SLIA group than in the EA group (¥1094 060 vs ¥785 160; P = .009) (data not shown). SLIA may be a promising option for some cases with severe complicated appendicitis, especially for women who place great significance on cosmetic outcomes, even if its disadvantages are taken into consideration.

In our study, determination of the operation type, open or laparoscopic appendectomy, in the EA group was inconsistent because it was based on the attending physician's discretion according to the severity of the appendicitis and whether it was performed at day or night. As some studies have reported that emergency surgery, and sometimes night-time surgery, is associated with several potential downsides, including higher morbidity and error rates, there was a tendency to perform open appendectomy to emphasize safety in the EA group.[22,23] And it was difficult to negate the bias for the severity of appendicitis completely, although the CT and EA groups showed similar WBC counts, CRP levels and the maximum diameter of abscess. These were other limitations of this retrospective study. Perioperative outcomes regarding the timing of appendectomy have been controversial, especially as disease presentation can vary with time of day. A meta-analysis of 11 non-randomized studies revealed that a delay of 12 to 24 hours after admission did not increase the risk of complex appendicitis, but after 48 hours the risk of surgical site infection and 30-day adverse events increased.[24] Duration from onset to surgery greatly affects the degree of intraperitoneal adhesion and is associated with the degree of difficulty in surgery. Considering that the onset is often unclear, SLIA may be effective in terms of standardizing treatment. Additional evidence is needed to confirm the usefulness of SLIA in this subset of patients with severe complicated appendicitis.

DISCLOSURE

Conflict of Interest: Masaaki Miyo and other co-authors have no conflict of interest to report.

ORCID

Masaaki Miyo https://orcid.org/0000-0002-8627-1308

REFERENCES

1. Stewart B, Khanduri P, McCord C, Ohene-Yeboah M, Uranues S, Vega Rivera F, et al. Global disease burden of conditions requiring emergency surgery. Br J Surg. 2014;101:e9–22.
2. Perez KS, Allen SR. Complicated appendicitis and considerations for interval appendectomy. Jaapa. 2018;31:35–41.
3. Wright GP, Mater ME, Carroll JT, Choy JS, Chung MH. Is there truly an oncologic indication for interval appendectomy? Am J Surg. 2015;209:442–6.
4. Andersson RE, Petzold MG. Nonsurgical treatment of appendiceal abscess or phlegmon: a systematic review and meta-analysis. Ann Surg. 2007;246:741–8.
5. Ahmed I, Deakin D, Parsons SL. Appendix mass: do we know how to treat it? Ann R Coll Surg Engl. 2005;87:191–5.
6. Gomes CA, Sartelli M, Di Saverio S, Ansaloni L, Catena F, Coccolini F, et al. Acute appendicitis: proposal of a new comprehensive grading system based on clinical, imaging and laparoscopic findings. World J Emerg Surg. 2015;10:60.
7. van Dijk ST, van Dijk AH, Dijkgraaf MG, Boermeester MA. Meta-analysis of in-hospital delay before surgery as a risk factor for complications in patients with acute appendicitis. Br J Surg. 2018;105:933–45.
8. Bae SU, Jeong WK, Baek SK. Single-port laparoscopic interval appendectomy for perforated appendicitis with a periappendiceal abscess. Ann Coloproctol. 2016;32:105–10.
9. Simillis C, Symeonides P, Shorthouse AJ, Tekkis PP. A meta-analysis comparing conservative treatment versus acute appendectomy for complicated appendicitis (abscess or phlegmon). Surgery. 2010;147:818–29.
10. Tanaka Y, Uchida H, Kawashima H, Fujiogi M, Suzuki K, Takazawa S, et al. More than one-third of successfully nonoperatively treated patients with complicated appendicitis experienced recurrent appendicitis: is interval appendectomy necessary? J Pediatr Surg. 2016;51:1957–61.
11. Lugo JZ, Avgerinos DV, Lefkowitz AJ, Seigerman ME, Zahir IS, Lo AY, et al. Can interval appendectomy be justified following conservative treatment of perforated acute appendicitis? J Surg Res. 2010;164:91–4.
12. Semm K. Endoscopic appendectomy. Endoscopy. 1983;15:59–64.
13. Tzovaras G, Baloyiannis I, Kouritas V, Symeonidis D, Spyridakis M, Poultsidi A, et al. Laparoscopic versus open appendectomy in men: a prospective randomized trial. Surg Endosc. 2010;24:2987–92.
14. Shaikh AR, Sangrasi AK, Shaikh GA. Clinical outcomes of laparoscopic versus open appendectomy. JSLS. 2009;13:574–80.
15. Yu MC, Feng YJ, Wang W, Fan W, Cheng HT, Xu J. Is laparoscopic appendectomy feasible for complicated appendicitis ?A systematic review and meta-analysis. Int J Surg. 2017;40:187–97.
16. Ohno Y. Role of the transumbilical laparoscopic-assisted single-channel, single-port procedure in an interval appendectomy for pediatric mass-forming appendicitis: a preliminary retrospective analysis. Asian J Endosc Surg. 2014;7:232–6.
17. Kim JK, Ryoo S, Oh HK, Kim JS, Shin R, Choe EK, et al. Management of appendicitis presenting with abscess or mass. J Korean Soc Coloproctol. 2010;26:413–9.
18. Charfi S, Sellami A, Affes A, Yaich K, Mzali R, Boudawara TS. Histopathological findings in appendectomy specimens: a study of 24,697 cases. Int J Colorectal Dis. 2014;29:1009–12.
19. Ward NT, Ramamoorthy SL, Chang DC, Parsons JK. Laparoscopic appendectomy is safer than open appendectomy in an elderly population. JSLS. 2014;18:1–8.
20. Garg P, Dass BK, Bansal AR, Chitkara N. Comparative evaluation of conservative management versus early surgical intervention in appendicular mass–a clinical study. J Indian Med Assoc. 1997;95(179–180):196.
21. Marya SK, Garg P, Singh M, Gupta AK, Singh Y. Is a long delay necessary before appendectomy after appendiceal mass formation? A preliminary report Can J Surg. 1993;36:268–70.
22. Kelz RR, Freeman KM, Hosokawa PW, Asch DA, Spitz FR, Moskowitz M, et al. Time of day is associated with postoperative

morbidity: an analysis of the national surgical quality improvement program data. Ann Surg. 2008;247:544–52.
23. Kelz RR, Tran TT, Hosokawa P, Henderson W, Paulson EC, Spitz F, et al. Time-of-day effects on surgical outcomes in the private sector: a retrospective cohort study. J Am Coll Surg. 2009;209:434–45. e432.
24. Bhangu A. Safety of short, in-hospital delays before surgery for acute appendicitis: multicentre cohort study, systematic review, and meta-analysis. Ann Surg. 2014;259:894–903.

How to cite this article: Miyo M, Urabe S, Hyuga S, et al. Clinical outcomes of single-site laparoscopic interval appendectomy for severe complicated appendicitis: Comparison to conventional emergency appendectomy. *Ann Gastroenterol Surg*. 2019;3:561–567. https://doi.org/10.1002/ags3.12277