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The Feasibility of Single-Port Laparoscopic Interval Appendectomy for Complicated Appendicitis: A Comparison Study with Multi-Port Laparoscopic Appendectomy in a Single Institution in Korea

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Abstract

Purpose: Interval Appendectomy (IA) for complicated appendicitis after conservative treatment can reduce unnecessary manipulation during surgery, as well as postoperative complications. As minimally invasive surgery has developed, the use of laparoscopic appendectomy with a single-site incision is increasing. However, few studies have investigated the perioperative outcomes of Single-Port Laparoscopic Appendectomy (SPLA) compared with Multiport Laparoscopic Appendectomy (MPLA) in IA. The aim of this study was to evaluate the feasibility and safety of laparoscopic IA with a single port compared to conventional multi-port surgery.

Methods: This study was conducted retrospectively in Konyang University Hospital, Daejeon, Korea. We analyzed the records of 144 patients who underwent laparoscopic IA following conservative treatment for complicated appendicitis between March 2003 and August 2020. The operative outcomes and postoperative complications of SPLA were compared with those of conventional MPLA.

Results: A total of 92 patients were included in this study; 31 and 61 patients underwent SPLA and MPLA, respectively. Using chi-square test and independent Student's t-test, SPLA was associated with a significantly longer time interval between conservative management and operation (98.4 ± 24.4 days *vs.* 84.8 ± 22.2 days, p=0.009) and lower intraoperative blood loss (5.0 ml ± 3.0 ml *vs.* 8.3 ml ± 5.3 ml, p=0.005). However, operation time (59.2 ± 25.4 min *vs.* 53.4 ± 23.6 min, p=0.278), length of postoperative hospital stay (2.2 ± 0.7 days *vs.* 2.3 ± 0.9 days, p=0.537) and postoperative complication rate (9.7% *vs.* 6.6%, p=0.594) were comparable between the groups.

Conclusion: This study provides evidence that single-port laparoscopic interval appendectomy is safe and feasible after conservative management for complicated appendicitis.

Keywords: Complicated appendicitis; Interval appendectomy; Laparoscopic appendectomy; Single-port surgery

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Introduction

Acute appendicitis is one of the most common causes of acute abdominal pain, and it generally requires immediate surgical intervention [1,2]. Approximately 13% to 20% of patients with acute appendicitis are perforated [3], and appendiceal abscess or phlegmon is found in approximately 3.8% of patients [4]. Emergency appendectomy is the treatment of choice for acute appendicitis [5,6], but in cases of perforated appendicitis with periappendiceal abscess, immediate appendectomy can result in excessive tissue manipulation and adjacent organ injury. These complications can lead to increased morbidity and the risk of extended resection [4,7,8]. Therefore, Interval Appendectomy (IA) which is delayed appendectomy following conservative treatment, including percutaneous drainage and intravenous antibiotics, is widely accepted for complicated appendicitis [9,10].

Laparoscopic appendectomy is generally recommended for acute appendicitis in order to reduce surgical trauma and improve cosmetic outcomes [11-13]. Due to advances in surgical instruments and minimally invasive techniques, laparoscopic appendectomy with a single-site incision has been proposed [14]. Previous studies that compared Single-Port Laparoscopic Appendectomy (SPLA)

with Multi-Port Laparoscopic Appendectomy (MPLA) has reported that the single-port approach have shown comparable results for acute appendicitis [15-17].

However, there was no study that investigated the perioperative outcomes of SPLA compared with MPLA in IA for patients with complicated appendicitis. The aim of this study was to evaluate the feasibility and safety of laparoscopic IA with a single port compared to conventional multi-port surgery.

Materials and Methods

Patients

This study retrospectively collected data from Konyang University Hospital, Daejeon, Korea, between March 2003 and August 2020. A total of 144 patients who underwent laparoscopic IA, including SPLA and MPLA, following conservative treatment for complicated appendicitis, were enrolled in this study.

Appendicitis was diagnosed based on clinical presentation, physical examination, laboratory findings, and imaging studies, including Computed Tomography (CT). All patients enrolled in this study had appendiceal perforation, phlegmon, or periappendiceal abscess. The decision to use conservative treatment followed by IA was made by the surgeon based on the CT findings. The patients underwent surgery at least eight weeks after conservative treatment was begun. Intravenous antibiotics were administered until clinical manifestations improved and oral antibiotics were prescribed after discharge. A combination of second-generation cephalosporin (cefmetazole or cefotetan) or third-generation cephalosporin (cefotaxime or ceftriaxone) with metronidazole was used for conservative treatment. Percutaneous abscess drainage with Percutaneous Catheter Drainage (PCD) or percutaneous needle aspiration was performed if the periappendiceal abscess was anatomically accessible.

Out of 144 enrolled patients, 52 were excluded from this study: 42 because they had an interval of <8 weeks from conservative treatment to surgery, and ten because they underwent conversion to open surgery during a laparoscopic appendectomy. Thus, the data of 92 patients who met the inclusion criteria were analyzed (Figure 1).

The study was approved by the Institutional Review Board of Konyang University Hospital (IRB No. 2021-03-012) and performed in accordance with the principles of the Declaration of Helsinki. The need for informed consent was waived due to the retrospective nature of the study.

Operative techniques

Laparoscopic appendectomy was performed by six general surgeons at a single institution. SPLA was performed by one surgeon, and five surgeons performed only MPLA. The surgeon who performed either SPLA or MPLA decided on the type of operation based on the severity of inflammation found on follow-up CT. The patients were placed in a supine position under general anesthesia. For SPLA, a 2 cm vertical incision was made at the umbilicus after skin preparation, and subcutaneous fat and fascia were dissected into the peritoneum. A single-port device with four channels (Glove Port®, Neils, Bucheon, Gyeonggi-do, Korea) was inserted through the incision site. For MPLA, a vertical transumbilical incision was made, and an 11 mm trocar was inserted through the incision site. Two other 5 mm trocars for laparoscopic instruments were inserted in the suprapubic area and the left lower quadrant under laparoscopic vision. The port placements for SPLA and MPLA are shown in Figure 2. The abdomen was inflated with CO_2, and a 10 mm, 30°C rigid scope and instruments were inserted through the trocars. The instruments were crossed with each other and placed below the scope during SPLA. The mesoappendix was divided, and the appendiceal artery was ligated using metal clips. The appendix was ligated using an endoloop (Surgitie Ligating Loop® [Covidien]) and resected. The appendix was retrieved from the umbilical port site. The endobag was used for MPLA but not SPLA. The incision was closed layer by layer.

Data collection

Data from this study were obtained from medical records. Demographic data, perioperative outcomes, and histopathological data were collected. Operative reports were reviewed for operative time, estimated blood loss, extent of operation, and drain placement. Postoperative painkiller injection, complications, length of postoperative hospital stay, and readmission were also examined. Postoperative complications, including wound infection, postoperative ileus, intra-abdominal abscess, and incisional hernia were assessed using the Clavien-Dindo classification.

Statistical analysis

Demographic data are presented as frequency and percentage, and average values are presented as means with standard deviations. Categorical variables were analyzed using the chi-square test and continuous variables were analyzed using an independent Student's t-test. Statistical significance was set at $p<0.05$. Statistical analyses were performed using IBM SPSS Statistics (version 25.0; SPSS Inc., Chicago, IL, USA).

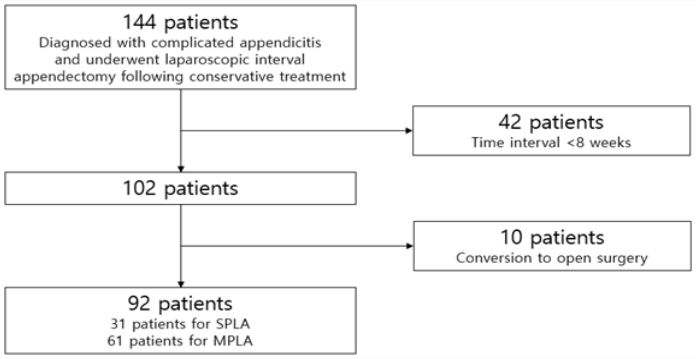

Figure 1: Flow chart showing patient selection.
SPLA: Single-Port Laparoscopic Appendectomy; MPLA: Multi-Port Laparoscopic Appendectomy

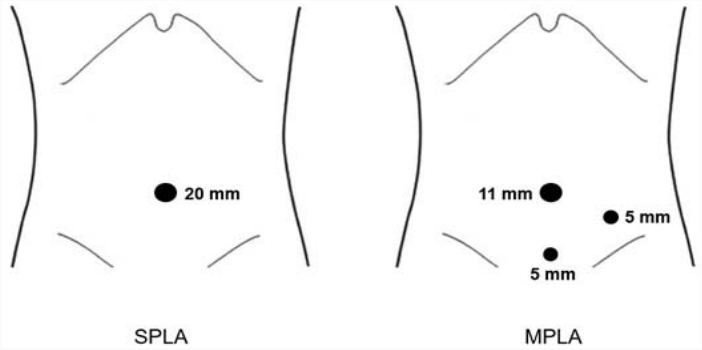

Figure 2: Port sites for laparoscopic appendectomy.
SPLA: Single-Port Laparoscopic Appendectomy; MPLA: Multi-Port Laparoscopic Appendectomy

Results

A total of 92 patients were included in the analysis. Of these patients, 31 (33.7%) underwent SPLA and 61 (66.3%) underwent MPLA (Table 1). The patients who underwent SPLA had a mean age of 50.0 ± 16.3 years (range, 23 to 84 years) and 38.7% were men. The mean age in the MPLA group was 52.1 ± 21.3 years (range, 8 to 89 years) and 39.3% were men. The mean Body Mass Index (BMI) was 24.2 ± 3.9 kg/m^2 (range, 17.3 kg/m^2 to 34.1 kg/m^2) in the SPLA group and 23.4 ± 4.1 kg/m^2 (range, 15.2 kg/m^2 to 34.2 kg/m^2) in the MPLA group. No significant difference was found in patients' basal characteristics, including age, sex, BMI, comorbidities, history of prior abdominal operation, or the American Society of Anesthesiologists score, between the SPLA and MPLA groups.

The two groups had similar White Blood Cell (WBC) counts (12,900 ± 4,700/mm^3 *vs.* 13,100 ± 4,100/mm^3, p=0.840) and C-Reactive Protein (CRP) levels (15.2 ± 10.9 mg/dl *vs.* 12.3 ± 7.8 mg/dl, p=0.220) at the first admission for complicated appendicitis (Table 2). In the SPLA group, periappendiceal abscess was found in 27 (87.1%) out of 31 patients and the mean abscess size was 5.1 ± 1.6 cm (range, 2.3 cm to 6.3 cm). In the MPLA group, 54 (88.5%) out of 61 patients showed periappendiceal abscess and the mean abscess size was 5.0 ± 2.1 cm (range, 1.8 cm to 10 cm). No significant difference was found in the presence (p=0.842) and size (p=0.830) of periappendiceal abscess between the SPLA and MPLA groups. Percutaneous abscess drainage, including PCD or percutaneous needle aspiration, was performed in 59.3% and 68.5% of patients in the SPLA and MPLA groups, respectively, with no significant difference (p=0.409).

Table 1: Patient basal characteristics.

	SPLA (n=31)	MPLA (n=61)	*p*
Age (year) (mean ± SD)	50.0 ± 16.3	52.1 ± 21.3	0.621
Sex (n, %)			0.953
Male	12 (38.7)	24 (39.3)	
Female	19 (61.3)	37 (60.7)	
BMI (kg/m^2) (mean ± SD)	24.2 ± 3.9	23.4 ± 4.1	0.362
Comorbidity (n, %)			0.271
No	12 (38,7)	31 (50.8)	
Yes	19 (61.3)	30 (49.2)	
History of abdominal operation (n, %)			0.745
No	24 (77.4)	49 (80.3)	
Yes	7 (22.6)	12 (19.7)	
ASA score (n, %)			0.866
1	9 (29.0)	18 (29.5)	
2	19 (61.3)	39 (63.9)	
3	3 (9.7)	4 (6.6)	

SPLA: Single-Port Laparoscopic Appendectomy; MPLA: Multi-Port Laparoscopic Appendectomy; SD: Standard Deviation; BMI: Body Mass Index; ASA: American Society of Anesthesiologists

Table 2: Clinical outcomes at first admission for complicated appendicitis.

	SPLA (n=31)	MPLA (n=61)	*p*
WBC count (× 10^3/mm^3) (mean ± SD)	12.9 ± 4.7	13.1 ± 4.1	0.84
CRP (mg/dl) (mean ± SD)	15.2 ± 10.9	12.3 ± 7.8	0.22
Abscess (n, %)			0.842
No	4 (12.9)	7 (11.5)	
Yes	27 (87.1)	54 (88.5)	
Abscess size (cm) (mean ± SD)	5.1 ± 1.6	5.0 ± 2.1	0.83
Percutaneous abscess drainage (n, %)			0.409
No	11 (40.7)	17 (31.5)	
Yes	16 (59.3)	37 (68.5)	

SPLA: Single-Port Laparoscopic Appendectomy; MPLA: Multi-Port Laparoscopic Appendectomy; SD: Standard Deviation; WBC: White Blood Cell; CRP: C-Reactive Protein

The comparison of perioperative outcomes between the SPLA and MPLA groups is shown in Table 3. The time interval between the date of the first discharge and operation was significantly longer in the SPLA group than in the MPLA group (98.4 ± 24.4 days *vs.* 84.8 ± 22.2 days, p=0.009). SPLA did not prolong the operative time significantly compared to MPLA (59.2 ± 25.4 min *vs.* 53.4 ± 23.6 min, p=0.278). Extended resection and drain insertion were performed in only eight patients in the MPLA group (p=0.035). All patients who underwent extended resection also underwent a laparoscopic cecectomy. Estimated blood loss was significantly greater in the MPLA group, but the difference was small (5.0 ± 3.0 ml *vs.* 8.3 ± 5.3 ml, p=0.005). Final histologic findings demonstrated acute and chronic appendicitis in 41.9% and 48.4% of patients, respectively, in the SPLA group, and in 47.5% and 42.6% in the MPLA group, respectively. Mucinous neoplasms were found in 6.5% and 4.9% of patients in the MPLA and SPLA groups, respectively, with no significant difference. Other pathologic findings, such as Crohn's disease, tubular adenoma, and neuroendocrine tumor, were observed in four patients. No malignancies were identified. The mean number of postoperative intravenous injections of analgesics was 1.3 ± 1.0 ampoules (range, 0 to 4 ampoules) for the SPLA group and 1.1 ± 0.8

Table 3: Perioperative outcomes.

	SPLA (n=31)	MPLA (n=61)	*p*
Time interval from first discharge to operation (days) (mean ± SD)	98.4 ± 24.4	84.8 ± 22.2	0.009
Operative time (minutes) (mean ± SD)	59.2 ± 25.4	53.4 ± 23.6	0.278
Extended resection (n, %)			0.035
No	31 (100)	53 (86.9)	
Yes	0 (0)	8 (13.1)	
Drain insertion (n, %)			0.035
No	31 (100)	53 (86.9)	
Yes	0 (0)	8 (13.1)	
Estimated blood loss (ml) (mean ± SD)	5.0 ± 3.0	8.3 ± 5.3	0.005
Gross findings (n, %)			0.003
Edematous	4 (12.9)	10 (16.4)	
Suppurative	12 (38.7)	23 (37.7)	
Gangrenous	0 (0)	7 (11.5)	
Perforated	1 (3.2)	6 (9.8)	
Abscess	1 (3.2)	8 (13.1)	
Chronically inflammated	13 (41.9)	7 (11.5)	
Histologic findings (n, %)			0.915
Acute appendicitis	13 (41.9)	29 (47.5)	
Chronic appendicitis	15 (48.4)	26 (42.6)	
Mucinous neoplasm	2 (6.5)	3 (4.9)	
Others	1 (3.2)	3 (4.9)	
Intravenous analgesics (ampule) (mean ± SD)	1.3 ± 1.0	1.1 ± 0.8	0.216
Complications (n, %)			0.127
No	28 (90.3)	58 (95.1)	
Wound infection	3 (9.7)	1 (1.6)	
Postoperative ileus	0 (0)	0 (0)	
Intra-abdominal abscess	0 (0)	0 (0)	
Incisional hernia	0 (0)	2 (3.3)	
Clavien-Dindo classification (n, %)			0.273
Grade I, II	3 (100)	2 (66.7)	
Grade III, IV	0 (0)	1 (33.3)	
Length of postoperative hospital stay (days) (mean ± SD)	2.2 ± 0.7	2.3 ± 0.9	0.537

SD: Standard Deviation; SPLA: Single-Port Laparoscopic Appendectomy; MPLA: Multiport Laparoscopic Appendectomy

ampoules (range, 0 to 4 ampoules) for the MPLA group, with one patient in each group taking narcotics once. No significant difference in the requirement for intravenous analgesics was found (p=0.216). Postoperative complications were observed in three (9.7%) patients in the SPLA group, all of which were wound infections, and in three (4.9%) patients in the MPLA group, one of which was wound infection and two of which were incisional hernias. Only one patient who required surgical intervention for an incisional hernia was classified as Clavien-Dindo grade III. No mortality was observed in either group. The frequency (p=0.127) and severity (p=0.273) of postoperative complications were not significantly different. Length of postoperative hospital stay was similar between the SPLA and MPLA groups (2.2 ± 0.7 days *vs.* 2.3 ± 0.9 days, p=0.537).

Discussion

In this study, we compared perioperative outcomes of SPLA to MPLA to evaluate the feasibility and safety of SPLA when performing an IA for complicated appendicitis. SPLA did not increase the operative time or intraoperative blood loss compared with MPLA. In addition, no significant difference was found in the requirement for postoperative intravenous analgesics, incidence of postoperative complications, or length of postoperative hospital stay between the SPLA and MPLA groups. These results suggest that SPLA could be a safe and feasible method as an IA for complicated appendicitis.

However, the need for IA is controversial. In some studies, the incidence of appendiceal neoplasms has increased in patients undergoing IA [18,19]. These studies reported the incidence of appendiceal neoplasms to be 1.5% to 12.5% in the immediate appendectomy group and 12.2% to 12.4% in the IA group. A meta-analysis of eight studies by Peltrini et al. [20] showed a similar incidence of appendiceal neoplasms after IA (11%), 29% of which were adenocarcinoma. In this study, mucinous neoplasms were found in 5.4% of all patients, which is lower than the incidence reported in previous studies, but higher than the rate reported in patients who underwent immediate appendectomy. Additionally, medical costs were generally higher in patients who underwent IA following conservative treatment than in those who underwent emergency surgery [21,22].

In contrast, other studies have shown that an IA has a lower rate of postoperative morbidity and extended resection than emergency appendectomy for both adults and children [8,21,23-26]. Akingboye et al. [23] reviewed 9,264 patients including both adults and children and reported that IA significantly reduced the operative time and number of unplanned bowel resections, although there were no significant differences in postoperative complications, length of postoperative hospital stay, or mortality rate. In a multicenter propensity score matching prospective study, Kim et al. [26] compared early surgery with elective interval surgery for complicated appendicitis. Their results showed a significantly lower rate of extended surgery, a lower postoperative complication rate, and an even shorter postoperative hospital stay in the IA group. For these reasons, IA was considered for patients with complicated appendicitis at this institution.

Many studies have shown that SPLA was not inferior to MPLA in terms of operative outcomes, including postoperative complications [27,28]. Chen et al. [29] conducted a meta-analysis with seven randomized controlled trials for the comparison of the two procedures and found comparable results of conversion rate, drain insertion, length of hospital stay, and postoperative complications. However, SPLA showed a better cosmetic satisfaction score and shorter recovery time significantly than MPLA. Unlike the results of this study, SPLA had a longer operative time than MPLA. In this study, perioperative outcomes, including operative time, requirement of intravenous analgesics, postoperative complication rate, and length of hospital stay were similar between the two groups.

However, several perioperative outcomes were significantly different in the present study. The time interval from the first discharge to operation was significantly longer in the SPLA group than in the MPLA group. In the most recent international guidelines for acute appendicitis, no definitive criteria exist for the optimal timing of IA [30], but it is generally recommended 6 to 12 weeks after the resolution of the abscess [30-32]. The five surgeons who performed MPLA in the present study determined the operative timing based on these studies, and the surgeon who performed SPLA decided to conduct the operation after eight weeks of sufficient remodeling of previous

intra-abdominal inflammation. The difference in the time interval between the two groups could have resulted from the differences in operative timing between the surgeons. Other differences in extended resection and intraoperative drain placement were also observed in this study. Extended resections were more frequent in the MPLA group than in the SPLA group. Since the decision to perform SPLA or MPLA was based on the severity of intra-abdominal inflammation on follow-up CT, extended resections were performed more frequently in patients in the MPLA group who might have more severe inflammation. Similarly, a drain was placed more frequently in the MPLA group. Moreover, the surgeon who performed SPLA minimized drain placement, because some previous studies have shown that abdominal drainage after appendectomy does not reduce complications, such as intra-abdominal abscess, in either adults or children [33,34].

This study had several limitations. First, it was a retrospective study with a relatively small number of patients. Second, there were selection biases. The decision to perform SPLA or MPLA was made based on the surgeon's preference. Third, there was a lack of data on postoperative pain and cosmesis. Therefore, further large-scale prospective cohort studies are needed in order to determine the advantages of SPLA in interval operation settings.

Conclusion

In conclusion, SPLA had similar perioperative outcomes, including operative time, postoperative pain, postoperative complications, and length of postoperative hospital stay, compared with MPLA. Thus, SPLA is feasible and safe for IA in patients with complicated appendicitis. Further large-scale comparative studies are required to confirm this hypothesis.

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Authors' Contribution

All authors contributed to the conception and design of the study. Material preparation, data collection, and analysis were performed by Ran Song, Nak Song Sung, and Seung Jae Roh. The first draft of the manuscript was written by Ran Song, and all authors commented on the previous versions of the manuscript. All authors read and approved the final manuscript.

Ethical Approval

Ethical approval was waived by the local Ethics Committee of Konyang University (IRB No.2021-03-012) in view of the retrospective nature of the study, and all procedures performed were part of routine care.

References

1. Bhangu A, Søreide K, Di Saverio S, Assarsson JH, Drake FT. Acute appendicitis: Modern understanding of pathogenesis, diagnosis, and management. Lancet. 2015;386(10000):1278-87.
2. Stewart B, Khanduri P, McCord C, Ohene-Yeboah M, Uranues S, Rivera FV, et al. Global disease burden of conditions requiring emergency surgery. Br J Surg. 2014;101(1):e9-22.
3. Andersson RE, Hugander A, Thulin AJ. Diagnostic accuracy and perforation rate in appendicitis: Association with age and sex of the patient and with appendicectomy rate. Eur J Surg. 1992;158(1):37-41.
4. Andersson RE, Petzold MG. Nonsurgical treatment of appendiceal abscess or phlegmon: A systematic review and meta-analysis. Ann Surg. 2007;246(5):741-8.
5. 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(8):933-45.
6. United Kingdom National Surgical Research Collaborative; 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(5):894-903.
7. Bae SU, Jeong WK, Baek SK. Single-port laparoscopic interval appendectomy for perforated appendicitis with a periappendiceal abscess. Ann Coloproctol. 2016;32(3):105-10.
8. Miyo M, Urabe S, Hyuga S, Nakagawa T, Michiura T, Hayashi N, et al. Clinical outcomes of single-site laparoscopic interval appendectomy for severe complicated appendicitis: Comparison to conventional emergency appendectomy. Ann Gastroenterol Surg. 2019;3(5):561-7.
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(6):818-29.
10. Vane DW, Fernandez N. Role of interval appendectomy in the management of complicated appendicitis in children. World J Surg. 2006;30(1):51-4.
11. Markides G, Subar D, Riyad K. Laparoscopic versus open appendectomy in adults with complicated appendicitis: Systematic review and meta-analysis. World J Surg. 2010;34(9):2026-40.
12. Wei B, Qi CL, Chen TF, Zheng ZH, Huang JL, Hu BG, et al. Laparoscopic versus open appendectomy for acute appendicitis: A meta analysis. Surg Endosc. 2011;25(4):1199-208.
13. Ohtani H, Tamamori Y, Arimoto Y, Nishiguchi Y, Maeda K, Hirakawa K. Meta-analysis of the results of randomized controlled trials that compared laparoscopic and open surgery for acute appendicitis. J Gastrointest Surg. 2012;16(10):1929-39.
14. Macdonald ER, Ahmed I. True single-port appendectomy: First experience with the "puppeteer technique". Surg Endosc. 2010;24(6):1506.
15. Gao J, Li P, Li Q, Tang D, Wang DR. Comparison between single-incision and conventional three-port laparoscopic appendectomy: A meta-analysis from eight RCTs. Int J Colorectal Dis. 2013;28(10):1319-27.
16. Zhou H, Jin K, Zhang J, Wang W, Sun Y, Ruan C, et al. Single incision versus conventional multiport laparoscopic appendectomy: A systematic review and meta-analysis of randomized controlled trials. Dig Surg. 2014;31(4-5):384-91.
17. Christensen AM. Randomized prospective study to compare laparoscopic appendectomy versus umbilical single-incision appendectomy. Ann Surg. 2015;261(6):e164.
18. Son J, Park YJ, Lee SR, Kim HO, Jung KU. Increased risk of neoplasms in adult patients undergoing interval appendectomy. Ann Coloproctol. 2020;36(5):311-5.
19. Furman MJ, Cahan M, Cohen P, Lambert LA. Increased risk of mucinous neoplasm of the appendix in adults undergoing interval appendectomy. JAMA Surg. 2013;148(8):703-6.
20. Peltrini R, Cantoni V, Green R, Lionetti R, D'Ambra M, Bartolini C, et al. Risk of appendiceal neoplasm after interval appendectomy for complicated appendicitis: A systematic review and meta-analysis. Surgeon. 2021;19(6):e549-58.
21. Watanabe R, Otsuji A, Nakamura Y, Higuchi T, Takahashi A, Saito T, et

al. Superior outcomes (but at higher costs) of non-operative management with interval appendectomy over immediate surgery in appendicitis with abscess: Results from a large adult population cohort. Asian J Endosc Surg. 2020;13(2):186-94.

22. Sugiura K, Suzuki K, Umeyama T, Omagari K, Hashimoto T, Tamura A. Cost-effectiveness analysis of initial nonoperative management versus emergency laparoscopic appendectomy for acute complicated appendicitis. BMC Health Serv Res. 2020;20(1):1019.

23. Akingboye AA, Mahmood F, Zaman S, Wright J, Mannan F, Mohamedahmed AYY. Early versus delayed (interval) appendicectomy for the management of appendicular abscess and phlegmon: A systematic review and meta-analysis. Langenbecks Arch Surg. 2021;406(5):1341-51.

24. Duggan EM, Marshall AP, Weaver KL, St Peter SD, Tice J, Wang L, et al. A systematic review and individual patient data meta-analysis of published randomized clinical trials comparing early versus interval appendectomy for children with perforated appendicitis. Pediatr Surg Int. 2016;32(7):649-55.

25. Handa N, Muramori K, Taguchi S. Early appendectomy versus an interval appendectomy for appendiceal abscess in children. Fukuoka Igaku Zasshi. 1997;88(12):389-94.

26. 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. 2019;97(2):103-11.

27. Duza G, Davrieux CF, Palermo M, Khiangte E, Azfar M, Rizvi SAA, et al. Conventional laparoscopic appendectomy versus single-port laparoscopic appendectomy, a multicenter randomized control trial: A feasible and safe alternative to standard laparoscopy. J Laparoendosc Adv Surg Tech A. 2019;29(12):1577-84.

28. Park J, Kwak H, Kim SG, Lee S. Single-port laparoscopic appendectomy: Comparison with conventional laparoscopic appendectomy. J Laparoendosc Adv Surg Tech A. 2012;22(2):142-5.

29. Chen JM, Geng W, Xie SX, Liu FB, Zhao YJ, Yu LQ, et al. Single-incision versus conventional three-port laparoscopic appendectomy: A meta-analysis of randomized controlled trials. Minim Invasive Ther Allied Technol. 2015;24(4):195-203.

30. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. World J Emerg Surg. 2020;15(1):27.

31. Farr BJ, Carey DE, Mooney DP. When to take it out? Optimal timing of interval appendectomy in 500 consecutive children. J Pediatr Surg. 2021;56(10):1822-5.

32. Skoubo-Kristensen E, Hvid I. The appendiceal mass: Results of conservative management. Ann Surg. 1982;196(5):584-7.

33. Qian S, Vasileiou G, Pust GD, Zakrison T, Rattan R, Zielinski M, et al. Prophylactic drainage after appendectomy for perforated appendicitis in adults: A post hoc analysis of an EAST multi-center study. Surg Infect (Larchmt). 2021;22(8):780-6.

34. Castro BA, Cano I, García A, Yuste P, Ferrero E, Gómez A. Abdominal drainage after laparoscopic appendectomy in children: An endless controversy? Scand J Surg. 2018;107(3):197-200.