Solo Single-Incision Laparoscopic Appendectomy versus Conventional Single-Incision Laparoscopic Appendectomy: A Retrospective, Single Center Study

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Purpose: Single incision laparoscopic appendectomy (SILA) attempts to advance laparoscopic appendectomy with the aim of quicker recovery, less pain, a smaller scar, and better patient satisfaction, and it might offer better outcomes than conventional laparoscopic appendectomy. However, conventional SILA (C-SILA) is not widely practiced. C-SILA is associated with several ergonomic challenges when compared with standard multiport laparoscopy owing to the handling of straight instruments in parallel with a camera. The aim of this retrospective study was to review and compare the outcomes of SILA performed by residents in solo approach and a conventional non-solo approach in order to determine whether S-SILA can be performed effectively by residents.

Methods: Between March 2016 and February 2018, at SNUBH, 87 patients underwent SILA performed by residents, and of these patients, 36 underwent S-SILA and 51 underwent C-SILA.

Results: Patient characteristics and severities of appendicitis were different between the S-SILA and C-SILA groups. Although cases were more complicated in the S-SILA group, the surgical outcomes were similar between the S-SILA and C-SILA groups. These findings suggest that S-SILA can be a reasonable alternative to C-SILA for surgeons who can competently perform SILA.

Conclusion: The surgical outcomes were similar between S-SILA and C-SILA. Moreover, S-SILA could reduce the number of required personnel, resulting in a reduction in healthcare cost. S-SILA can be considered a reasonable alternative to C-SILA for surgeons who can competently perform SILA.

Keywords: Appendectomy, Laparoscope, Laparoscopic surgery, Solo surgery

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INTRODUCTION

Appendicitis is a common disease, and surgical appendectomy is currently the most widely accepted treatment approach.¹ The first report on resection of the appendix was published in 1735.² The procedure was performed on an 11-year-old boy with an inguinal hernia containing an inflamed appendix. Conventional open appendectomy through a right iliac fossa

incision was described by McBurney in 1894,³ and the first laparoscopic appendectomy was reported by Semm in 1983.⁴

The advantages of minimally invasive surgical techniques include quick and less painful recovery, few postoperative complications and good cosmetic results.⁵ Conventional laparoscopic appendectomy has now become the standard for the treatment of suspected appendicitis in many countries.⁵

Many centers have reported on single-incision laparoscopic

appendectomy (SILA) in retrospective studies and randomized control trials.⁶⁻¹¹ SILA attempts to advance laparoscopic appendectomy with the aim of quicker recovery, less pain, a smaller scar, and better patient satisfaction, and it might offer better outcomes than conventional laparoscopic appendectomy.¹²

However, conventional SILA (C-SILA) is not widely practiced. C-SILA is associated with several ergonomic challenges when compared with standard multiport laparoscopy, owing to the handling of straight instruments in parallel with a camera.¹³ Single-incision access decreases the range of movement for the surgeon and scope assistant, and this has been shown to be associated with increased levels of surgeon fatigue and frustration (Fig. 1A).¹⁴

Single-incision laparoscopic surgery (SILS) is performed in many fields, and this approach is not restricted to appendectomy.¹⁵ Previous studies have proposed solo-surgeon SILS, which is an alteration of conventional SILS, in order to overcome its inconveniences.^{16,17} In Seoul National University Bundang Hospital (SNUBH), solo-surgeon SILS, using a scope holder instead of a scope assistant was performed for gastrectomy and cholecystectomy.¹⁸ In March 2016, at SNUBH, a second-grade resident designed and performed solo SILA (S-SILA) (Fig. 1B).

Only one center has reported on S-SILA previously.¹⁷ This previous report described 60 patients who underwent S-SILA performed by surgical specialists at Department of Surgery, Daejeon St. Mary's Hospital. However, as most appendectomies in Korea are performed by residents from Department of Surgery, it is important to determine whether S-SILA can be performed effectively by residents.

The aim of this retrospective study was to review and compare the outcomes of SILA performed by residents between a solo approach and a conventional non-solo approach in order

to determine whether S-SILA can be performed effectively by residents.

Surgical technique for S-SILA

The patient was placed in the supine position, and the scope holder (Laparostat®; CIVCO, Coralville, IA, USA) was on the right side of the patient, at the nipple level. The operator was on the left side of the patient. A 1.8~2.5 cm longitudinal umbilical incision was made at the umbilicus alone, and a commercial four-channel single-port trocar (Gloveport®; Nelis, Bucheon, Korea) was inserted through the umbilical incision. With regard to pneumoperitoneum CO₂ pressure was maintained below 13 mmHg. The scope holder was bent over the patient and a 5 or 10 mm flexible laparoscope (Endoeye®;

Fig. 2. Solo single incision laparoscopic appendectomy.

Fig. 1. (A) Conventional single incision laparoscopic appendectomy: the movements of the operator and scope assistant are very limited. (B) Solo single incision laparoscopic appendectomy: the operator can move freely without obstacles.

Olympus, Tokyo, Japan) was held at the left upper side of the patient (Fig. 2).

Adhesiolysis and dissection of inflammatory tissues were performed in a meticulous approach. After visualization of the appendix and mesoappendix, the appendix was held with 5 mm laparoscopic Babcock forceps. The mesoappendix and appendix artery was ligated with an energy device (LigaSure®; Medtronic, Minneapolis, MN, USA). After further meticulous dissection to clear the appendix base, appendix was ligated with two 12 mm hemoclips (Weck®; Teleflex, Morrisville, NC, USA). After ligation, the appendix was transected with the energy device.

The specimen was removed through the glove port. Gauze debridement and meticulous hemostasis were performed. If the patient had severe peritonitis, a Jackson-Pratt drain was inserted. It was not necessary to place a drainage tube if the operation field was clean without a technical break during the procedure. Fascia closure was performed with simple interrupted suturing using 1-0 Vicryl, and dermal skin closure was performed bury-

ing the knot suture with 4-0 PDS or 4-0 Vicryl.

MATERIALS AND METHODS

Between March 2016 and February 2018, 635 patients underwent laparoscopic appendectomy at SNUBH, and of these, 151 underwent SILA. Among these 151 patients, 87 patients underwent SILA performed by residents.

Patient characteristics (e.g., age, sex, height, body weight, and operation history), and clinical outcomes (e.g., operating time, amount of blood loss, and postoperative complications, including wound complications) were evaluated.

Statistical analyses were performed using SPSS ver. 19.0 (IMB Corp., Armonk, NY, USA). Numerical data are presented as means and standard deviations or as medians and ranges. Continuous variables were analyzed using the independent t-test, and categorical variables or proportions were compared using Fisher's exact tests. All *p* values were two-tailed. A *p* value < 0.05 was considered statistically significant.

Table 1. Patient characteristics

	Total (n=87)	S-SILA (n=36)	C-SILA (n=51)	<i>p</i> value
Age (years)				0.001 <
Mean (± SD)	29.62 (± 19.91)	41.36 (± 20.77)	21.33 (± 14.53)	
Median (range)	28 (4 ~ 78)	43 (9 ~ 78)	15 (4 ~ 59)	
Height (cm)				0.002
Mean (± SD)	156.67 (± 17.79)	163.67 (± 12.23)	151.77 (± 19.48)	
Median (range)	161.40 (105.5 ~ 182.7)	165.90 (130 ~ 182.7)	158.30 (105.5 ~ 181)	
Body weight (kg)				0.001 <
Mean (± SD)	53.59 (± 18.15)	62.07 (± 15.80)	47.65 (± 17.45)	
Median (range)	54.00 (17 ~ 102)	63.50 (22 ~ 102)	48.65 (17 ~ 80.2)	
BMI (kg/m ²)				0.001
Mean (± SD)	21.06 (± 4.01)	22.79 (± 3.94)	19.86 (± 3.63)	
Median (range)	21.19 (13.02 ~ 33.06)	22.81 (13.02 ~ 33.06)	19.28 (13.38 ~ 2.42)	
Sex, n (%)				0.08
Male	38 (43.7)	20 (55.6)	18 (35.3)	
Female	49 (56.3)	16 (44.4)	33 (64.7)	
ASA score, n (%)				0.02
1	67 (77.0)	23 (63.9)	44 (86.3)	
2	20 (23.0)	13 (36.1)	7 (13.7)	
History of abdominal operations, n (%)	6 (6.9)	3 (8.3)	3 (5.9)	0.688
Preoperative WBC count (× 10 ³ /ml)				0.475
Mean (± SD)	13.49 (± 4.69)	13.06 (± 4.54)	13.8 (± 4.81)	
Median (range)	13.30 (4.62 ~ 25.66)	12.35 (5.98 ~ 25.66)	14.10 (4.62 ~ 21.90)	

RESULTS

Patients characteristics

A total of 87 patients underwent SILA, performed by residents without intervention of staff. Of these 87 patients, 36 underwent S-SILA procedures (S-SILA group) and 51 underwent C-SILA procedures (C-SILA group). Patient characteristics were slightly different between the S-SILA and C-SILA groups (Table 1). The median age of all patients was 28 years. Patient age was lower in the C-SILA group than in the S-SILA group (median 15 versus 43 years, $p<0.001$). With regard to female sex, 33 patients (64.7%) were female in the C-

SILA group, whereas 16 patients (44.4%) were female in the S-SILA group ($p=0.08$). Overall, six patients (6.9%) had a history of abdominal surgery. Additionally, the median preoperational white blood cell (WBC) count was 13,300/ml, and it was similar between the S-SILA and C-SILA groups ($p=0.475$).

Intraoperative variables

Intraoperative variables are presented in Table 2. Estimated blood loss (EBL) was not different between the S-SILA and C-SILA groups ($p=0.084$). The median EBL was 5.0 ml and the mean EBL was 9.31 ml. The median of total operation time was 55 min, and it was similar between the two groups

Table 2. Intraoperative variables

	Total (n=87)	S-SILA (n=36)	C-SILA (n=51)	p value
EBL (mL)				0.084
Mean ($\pm$ SD)	9.31 ($\pm$ 15.10)	12.64 ($\pm$ 20.72)	6.96 ($\pm$ 8.84)	
Median (range)	5.0 (5 ~ 50)	5.0 (5 ~ 100)	5.0 (5 ~ 50)	
Operative time (min)				0.922
Mean ($\pm$ SD)	59.31 ($\pm$ 21.80)	59.58 ($\pm$ 27.21)	59.12 ($\pm$ 17.28)	
Median (range)	55.00 (25 ~ 135)	52.50 (25 ~ 135)	55.00 (35 ~ 105)	
Adhesion, n (%)	25 (28.7)	18 (50.0)	7 (13.7)	0.001<
Ascites, n (%)	27 (31.0)	13 (36.1)	14 (27.5)	0.482
Perforation, n (%)	16 (18.4)	12 (33.3)	4 (7.8)	0.023
Pan-peritonitis or localized peritonitis, n (%)	7 (8.0)	7 (19.4)	0	0.001
Appendicolith, n (%)	19 (21.8)	8 (22.2)	11 (21.6)	1

Table 3. Postoperative outcomes

	Total (n=87)	S-SILA (n=36)	C-SILA (n=51)	p value
NRS 24 hours postoperatively				0.212
Mean ($\pm$ SD)	3.43 ($\pm$ 0.923)	3.28 ($\pm$ 0.815)	3.53 ($\pm$ 0.987)	
Median (range)	3.00 (1 ~ 8)	3.00 (1 ~ 5)	3.00 (2 ~ 8)	
Time until gas passage (days)				0.11
Mean ($\pm$ SD)	1.32 ($\pm$ 1.33)	1.68 ($\pm$ 1.86)	1.11 ($\pm$ 0.84)	
Median (range)	1.00 (0 ~ 9)	2.00 (0 ~ 9)	1.00 (0 ~ 3)	
Postoperative hospital stay (days)				0.13
Mean ($\pm$ SD)	2.40 ($\pm$ 1.65)	2.72 ($\pm$ 2.26)	2.18 ($\pm$ 1.00)	
Median (range)	2.00 (1 ~ 10)	2.00 (1 ~ 10)	2.00 (1 ~ 6)	
Postoperative complications, n (%)	14 (16.1)	4 (11.1)	10 (19.6)	0.38
Wound complications, n (%)	13 (14.9)	3 (8.3)	10 (19.6)	0.224
Ileus, n (%)	0	1 (2.8)	0	0.414

($p=0.922$). Perforated appendicitis was noted in twelve patients (33.3%) from the S-SILA group and in only four patients (7.8%) from the C-SILA group ($p=0.023$). In the S-SILA group, seven patients had pan-peritonitis or localized peritonitis, and in the C-SILA group, no patient had complicated peritonitis. Overall, 21.8% of the patients had appendicolith, and the distribution was similar between the two groups ($p=1.000$).

7 patients were associated with panperitonitis or localized peritonitis in S-SILA group, and no patients had complicated peritonitis in C-SILA group. 21.8% of patients had appendicolith and the distribution in two group was similar ($p=1.000$).

Postoperative outcomes

Postoperative outcomes are shown in Table 3. Twenty-four hours after the operation, the pain intensity was judged using the numeric rating scale (NRS) in all patients. The median NRS score was 3.00, and the mean score was 3.43. The score was similar between the two groups ($p=0.212$). The mean time to passage of gas was 1.68 days in the S-SILA group and 1.11 days in the C-SILA group ($p=0.13$). Wound complications were noted in ten patients (19.6%) from the C-SILA group and in three patients (8.3%) from the S-SILA group. Only one patient experienced postoperative ileus. The patient had perforated appendicitis with pan-peritonitis and was operated on with the S-SILA approach. The patient passed gas on postoperative day 9 and was discharged on postoperative day 10.

DISCUSSION

Patient characteristics and severities of appendicitis were different between the S-SILA and C-SILA groups. In the C-SILA group, only cases of simple and uncomplicated appendicitis underwent operation. Additionally, the C-SILA group included many children and young female patients. This was because residents tended to avoid single-incision approaches in complicated appendicitis cases. It is well known that a good cosmetic outcome with small scar is the greatest benefit of SILA.⁹ However C-SILA is difficult to perform for complicated appendicitis, because of issues between the scope assistant and the operator. As the operator and assistant share the same operative field, the arms and devices of the operator and assistant cross each other. Because of this limitation of movement, sometimes the operator cannot perform fine, fast and exact movements, and the camera assistant cannot display the exact visual field clearly.

However, S-SILA allows the operator to have full control over the visual field, and the scope holder needs less space than a human assistant does. Using a scope holder, the operator does not need to cross arms and devices with an assistant.

Thus the operator can move more freely in S-SILA than in C-SILA. Many residents at SNUBH believe that C-SILA is not an adequate procedure for complicated appendicitis, and S-SILA can be one of the options. In this study, seven patients with pan-peritonitis or localized peritonitis were operated on using S-SILA technique.

S-SILA was comparable to C-SILA with regard to operative variables and postoperative outcomes, including postoperative NRS score, time to passage of gas, postoperative hospital stay and incidence of postoperative complications. However, S-SILA was much more beneficial from an economic point of view, as it lowered the operating cost by reducing surgical personnel. Since the Korean government started regulating the working hours of residents, shortage of hands in the operating room became an issue in Korea. Additionally, resident applications to surgical departments have been decreasing, and this has resulted in the shortage of assistants at many hospitals in Korea, Taiwan, Canada, and other countries.¹⁹⁻²¹ In regions with such a shortage, S-SILA could allow a large number of operations to be performed.

Kim et al.¹⁷ previously described several disadvantages of S-SILA. First, there might be a delay for emergency operations, as a waiting period might be present for a surgical specialist who can operate alone. Second, solo surgery might restrict the opportunity for resident training. However, as shown in this study, residents of Department of Surgery can perform solo surgery alone, without any supervision surgical specialists. Residents in SNUBH information with each other and learn surgical techniques. The author was the only resident who could perform S-SILA previously. However, currently, seven residents can operate alone without any intervention of staff, and the number is increasing.

The present study had several limitations. This retrospective review included a relatively small number of patients. Additionally, selection bias cannot be completely avoided in a retrospective study.

In conclusion, the surgical outcomes were similar between S-SILA and C-SILA. These results are likely associated with the operative feasibility of S-SILA, which enables better operator hand-eye coordination. Moreover, S-SILA could reduce the number of required personnel, resulting in a reduction in healthcare cost. S-SILA can be considered a reasonable alternative to C-SILA for surgeons who can competently perform SILA.

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