Original Article

Single-port Laparoscopic Appendectomy versus Multiple-port Laparoscopic Appendectomy

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Key Words
Single-port;
Appendectomy;
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Laparoscopy

Background. The aim of this study was to present the results of first-tried cases of single-port laparoscopic appendectomy by a single surgeon at one institution.
Materials and Methods. There were 52 patients with non-complicated acute appendicitis who were enrolled in this study. Patients were allocated into two separate groups to receive either single-port laparoscopic appendectomy (SPLA) or multiple-port laparoscopic appendectomy (MPLA) from November 2018 to April 2019. We compared operation times, conversion rates, overall complications, length of hospital stay, total wound lengths, and visual analog score (VAS score) for both groups. We also examined the learning curve for the surgeons in this study.
Results. The SPLA group was younger than the MPLA group (31.5 ± 15.56 vs. 43.17 ± 16.52, $p = 0.0160$). Other demographic characteristics were not significantly different between both groups. There was no significant difference in average operation time between the SPLA group and the MPLA group (50.2 ± 11.1 vs. 51.4 ± 12.2 minutes). Both total wound length and postoperative date 1 (POD 1) VAS score were significantly lower in the SPLA group than in the MPLA group. The learning curves showed a trend toward a reduction in operation time across the three SPLA subgroups.
Conclusions. Single-port laparoscopic appendectomy is a technically feasible and safe option for appendicitis. The number of cases of non-complicated acute appendicitis treated in our study suggests an achievable level of surgical skill required for SPLA. The SPLA group had some favorable outcomes: lower total wound length and reduced VAS score in postoperative date 1 in this study. Further studies should be conducted in complicated acute appendicitis cases.
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Laparoscopic appendectomy was first introduced by Semm[1] in 1983. It is now a widely used procedure, preferred to open appendectomy when possible. Open appendectomy still plays a critical role in the treatment of acute appendicitis, especially in cases of intractable intra-abdominal cavity adhesion due to a previous operation or severe bowel dilatation preventing the creation of a pneumoperitoneum for laparo-

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scopic appendectomy. However, there are specific advantages to laparoscopic appendectomy including less invasiveness, reduced post-surgical pain, earlier bowel function recovery and return to normal diet, shorter postoperative hospital stay, and lower rates of complications.[2] Furthermore, there is evidence to support the use of laparoscopic appendectomy in children, in the obese population, and in adults with complicated appendicitis.[3]

Following rapid advances in the technique of natural orifice transluminal endoscopic surgery, the use of single-incision intracorporeal appendectomy was first reported in 2003.[4] In recent years, the number of single-port laparoscopic appendectomy (SPLA) procedures conducted has increased. Typically, movements in single-incision laparoscopic surgery are restricted and triangulation is extremely limited or completely impossible to achieve. Recent systematic reviews and meta-analyses of randomized controlled trials in 2015[5] suggest that SPLA took longer to conduct than multiple-port laparoscopic appendectomy (MPLA). However, patients who undergo SPLA return to full activities earlier than MPLA-treated patients. The results provide Level 1a support that SPLA is a feasible, effective and safe option for treating acute appendicitis. In our institution, MPLA procedures have been carried out since 2008, with little to no SPLA procedures carried out. Accordingly, our study aimed to evaluate the safety and feasibility of SPLA compared to MPLA in a cohort of subjects at a single institution.

Materials and Methods

Prior to this study, patients with complicated and non-complicated appendicitis were routinely considered for laparoscopic appendectomy. From November 2018 to April 2019, 65 patients with clinical and computer tomography (CT) diagnosis of acute appendicitis met with the same surgeon. Of these patients, thirteen patients were excluded because of perforated appendicitis or delayed appendicitis with localized abscess formation. A total of consecutive 52 patients with non-complicated acute appendicitis were prospectively included in this study. 28 patients accepted MPLA procedure. The cut-point was set at the 1st February 2019. The cases before this date included for MPLA. The other 24 cases of SPLA were conducted since the cut-point. The indication for MPLA and SPLA in our study is simple appendicitis. Complicated cases, defined as perforation, gangrenous change, and abscess formation, were excluded.

The surgeon had performed over fifty MPLA procedures prior to this study. However, he had not performed any SPLA procedures. Furthermore, no routine SPLA procedures had been previously performed at this institution.

Postoperatively, patients were seen in seven to ten-day intervals for estimations of wound status, pain, return to normal daily activities and complications. Oral intake was started 6 hours post-operation. If there was no morbidity, treatment was terminated. Complications detected during scheduled and unscheduled procedures were recorded. Additional outpatient clinic visits resulting from new symptoms were also recorded. On postoperative days 1 and 2, postoperative pain was estimated using a visual analog scale (VAS) from 0 to 10. All surgeries were performed after obtaining informed consent from the patients.

Surgical technique

Multiple-port laparoscopic appendectomy

Patients were put in supine position and under general anesthesia. One 10 or 12-mm bladeless trocar (Covidien, Mansfield, MA, USA) was inserted through the umbilicus using the Hasson technique. Thereafter, the other two 5 mm trocars were inserted suprapubically and lower at midline. The operator and scope-man were positioned on the left side of the patient, who was placed in the Trendelenburg position with the left side down. We used a rigid 30-degree 5-mm laparoscope along with straight rigid 5-mm laparoscopic instruments. After adequate adhesiolysis, the mesoappendix was divided using a monopolar hook instrument and hemoclips. The appendix was ligated using two endo-loops (or Endo-GIA 30-3.5 Covidien, Mansfield, MA, USA) and then resected. The appendix was placed in a glove-made bag and retri-

eved through the umbilical wound. After hemostasis was achieved and intra-abdominal normal saline irrigation were performed, one closed-suction drain was placed at the right paracolic gutter space extending into the pelvic cavity. The wound was then closed using 2-0 Vicryl and 4-0 Nylon sutures.

Single-port laparoscopic appendectomy

Patients were placed in an identical position as required for an MPLA procedure. A transumbilical midline incision about 2 cm in size was made. Safe open access to the abdominal cavity was obtained under direct vision after a peritoneal layer incision. The incision at the level of the fascia was enlarged up to 2.5 cm achieving wider triangulation and rotation of the laparoscopic instruments when working inside the abdominal cavity. Once proper umbilical access had been obtained, the double-ring wound protector (Covidien, Mansfield, MA, USA) was positioned and tightened within the incision, providing a circumferential atraumatic retraction. It also guaranteed avoiding contamination of the surgical site during retrieval of the appendix specimen. We used one surgical glove, (usually size 6.0) to fit the external ring of the wound protector and slid down to obtain a tight air seal. Small cuts were then made at the tips of the fingers of the glove to allow access for the trocars cannulas. A tie was wrapped around the cannula and glove edges to prevent leakage of CO_2 from the space inside the glove. The surgical procedures and instruments used in SPLA were similar to those used in MPLA. We placed one closed-suction drain at the right paracolic gutter space extending into the pelvic cavity same as in MPLA if needed. The external part of the drain was pulled through the umbilical wound and fixed at the fascia layer via 2-0 Vicryl. In SPLA, Ligasure (5 mm blunt tip Sealer/Divider, Covidien, Mansfield, MA, USA) was used to divide the mesoappendix in the event that it was caught in surrounding dense and thick inflammatory adhesions.

Statistical analysis

Statistical analysis was performed using the software package SPSS 13.0 (SPSS Inc). Data were expressed as numbers (percentage) and means (SD). Mean, SD, and frequency were used as descriptive statistics. The results were analyzed using the chi-square test and the Fisher's exact test, as appropriate for proportions in discrete data. For continuous numeric data, we used the unpaired t-test and the one way ANOVA (f-test) for data normally and non-normally distributed, respectively. Data were previously tested for normality by the Kolmogorov-Smirnov test. A p value < 0.05 was considered to be statistically significant.

Results

The demographic characteristics of the patients in this study are shown in Table 1. Twenty four patients underwent SPLA, while the other 28 patients underwent MPLA. The patient age in the SPLA group was significantly lower than in the MPLA group (31.33 ± 15.56 vs. 43.17 ± 16.52, $p = 0.02$). There were no sig-

Table 1. Patient demographics for both SPLA and MPLA groups

	SPLA (N = 24)	MPLA (N = 28)	p
Age	31.33 ± 15.56	43.17 ± 16.52	0.02*
Gender (M/F)	10/14	15/13	
BMI, kg/m^2	22.54 ± 3.55	24.18 ± 4.61	0.18
Smoking (Y/N)	3/21	5/23	
ASA score (I/II/III)	17/6/1	19/7/2	
Previous intra-abdominal operation history (Y/N)	3/21	4/24	
Pre-operative pain period (Day)	1.50 ± 0.58	1.46 ± 0.58	0.81
WBC (C/μL)	13500 ± 3598	13442 ± 3911	0.96
CRP (mg/dL)	1.25 ± 1.23	1.73 ± 1.96	0.33
Period, days	2.25 ± 0.97	2.83 ± 1.07	0.06

nificant differences in gender, body mass index (BMI), smoking, ASA score, preoperative pain period, white blood count, C-reactive protein level, and history of abdominal surgery between the two groups.

The operative time was similar between the two groups (50.25 ± 11.15 vs. 51.42 ± 12.21 minutes) (Table 2). Drain insertion was required more frequently in the MPLA group than in the SPLA group (16.6% vs. 32.1%, $p < 0.001$). There was no significant intraoperative complication noted in either group, including troublesome appendiceal arterial bleeding, small bowel or cecal injuries, or appendiceal stump fractures during ligation. In the SPLA group, there was no conversion to additional ports or to the open method. In the MPLA group, there was no conversion to the open method as well. Only one superficial incisional surgical site infection was noted in the SPLA group. No other complications including organ space surgical site infection or paralytic ileus were observed.

There were no significant differences in the length of hospital stay between the two groups. The VAS score for postoperative pain evaluation was significant lower on postoperative date 1 (POD 1) in the SPLA group than in the MPLA group (2.50 ± 0.23 vs. 3.58 ± 0.23, $p = 0.0120$). However, there was no significant difference in the degree of pain on POD 2 between both groups (1.75 ± 0.60 vs. 1.92 ± 0.64 $p = 0.2830$). Total wound length was also significantly lower in the SPLA group than in the MPLA group (2.50 ± 0.23 vs. 3.58 ± 0.23 cm).

Across the groups of SPLA, we divided it into three groups of 8 patients: Series 1 (the first 8 cases), Series 2 (the second 8 cases), Series 3 (the third 8 cases). There was no statistical differences in operation time in Series 1, Series 2, Series 3, and MPLA group (54.2 ± 9.8 versus 48.2 ± 6.3 versus 48.2 ± 14.5 versus 51.4 ± 12.2, $p = 0.74$). We made the nonparametric smoothing plot for modeling the mean value of operation time (Fig. 1). It revealed that cases in Series 1 had an upward slope (+0.15 minutes/case) compared to Series 2 and Series 3 with downward slopes (-0.40 minutes/case and -0.03 minutes/case).

Discussion

Laparoscopic appendectomy was first used to treat acute appendicitis by Schreiber in 1987.[6] There is convincing evidence that shows that clinical outcomes from the laparoscopic method are superior to the open method.[2,7,8] SPLA continues to evolve rapidly and gain popularity particularly because it pro-

Table 2. Postoperative outcomesin both groups

	SPLA Group				MPLA group (N = 28)	*p* value
	Series 1 (N = 8)	Series 2 (N = 8)	Series 3 (N = 8)	Total (N = 24)		
Operation time (min)	54.2 ± 9.8	48.2 ± 6.3 ($p = 0.20$)	48.2 ± 14.5 ($p = 0.38$)	50.2 ± 11.1	51.4 ± 12.2 ($p = 0.57$)	0.74
Size (length, cm)				6.3 ± 0.6	6.5 ± 0.3	0.572
Blood loss						
< 50 ml	8	8	8	24	28	
> 50 ml	0	0	0	0	0	
Type						
Antececal/retrocecal	8/0	6/2	7/1	21/3	23/5	
Total wound length (cm)	2.50 ± 0.21	2.68 ± 0.2 ($p = 0.13$)	2.33 ± 0.15 ($p = 0.09$)	2.5 ± 0.23	3.58 ± 0.23 ($p < 0.0001$)	< 0.001
Drain (Y/N)	1/7	2/6	1/7	4/20	9/19	
Hospital stay (days)	2.25 ± 1.20	2.63 ± 0.70 ($p = 0.49$)	1.88 ± 0.78 ($p = 0.50$)	2.25 ± 0.97	2.83 ± 1.07 ($p = 0.22$)	0.06
Number of complications	0	1	0	1	0	0.32
Infection	0	1	0	1	0	
VAS score date 1				3.29 ± 0.89	3.96 ± 0.98	0.012
VAS score date 2				1.75 ± 0.60	1.92 ± 0.64	0.283

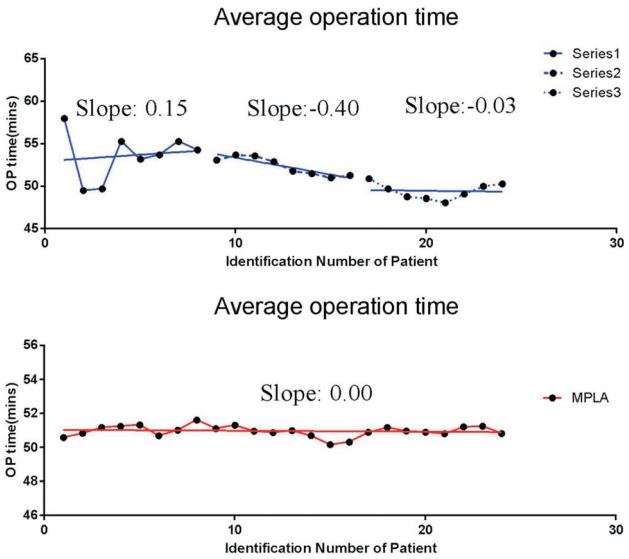

Fig. 1. Learning curves for both treatment groups.

vides the unique advantage of concealing the surgical wound within the umbilicus. Several trials have evaluated the SPLA technique mainly among selective adults and patients with uncomplicated acute appendicitis.[9-11] Six systematic reviews of non-randomized controlled trials (non-RCTs) concluded that SPLA was comparable to conventional laparoscopic appendectomy (MPLA) in safety and effectiveness.[12-17] A recent meta-analysis of eight RCTs published from 2009 to 2013 showed some similar results.[5] Although it showed a significant increase of approximately 5 minutes in operative time for the SPLA group, this difference is not clinically appreciable. There is hope that with advances in instrumentation like the development of angled and flexible endoscopes, improvements in ergonomics, and fine-tuning of surgical techniques, SPLA operation time will ultimately decrease. A longer, steeper learning curve for surgical and therapeutic team may be expected. Some issues that can be resolved include conflicts in recording from external instruments and limitations in range of movement caused by parallel and approaching apparatus which make adequate triangulation of traction and countertraction difficult.

This is a prospective study that we included non-complicated appendicitis cases from November 2018 to April 2019. We prospectively included the patients, 28 in MPLA and 24 in SPLA. All the cases in the first 3 months were included in the MPLA group; on the other hand, SPLA cases were conducted in the last 3 months. In the Table 1 for patient demographics, it revealed the only difference in the age parameter. The SPLA (31.3 ± 15.5) patients were significantly younger than the MPLA (43.1 ± 16.5). Since the ASA scores for two groups were similar, we thought the age might not influence the result.

All the patients were non-complicated cases, which meant there was no appendix perforation noted during the operation. The indication for drain tube insertion was that if any turbid reactive ascites observed in the surgical field, no matter how much the amount was it. We placed the drain mainly at the right side of paracolic gutter space and pelvic cavity. There was no leakage or bleeding noted in both groups. The drain tube was removed on the discharge day. Although the rate of tube insertion in two groups seemed almost two-fold (16.6% vs. 32.1%, $p < 0.001$) in the MPLA group, the operation time, hospital stay and complications were similar.

We had no conversion cases in both groups. There were 3 cases with previous intra-abdominal operation history in SPLA group. Total hysterectomy, unilateral ovarian cystectomy, and Cesarean section for delivery were the all cases. We still finished single-port appendectomy without conversion to multiple-port or open procedure. The retrocecal type of appendix could also interfere the surgical plane and probably increase the rate of conversion. Even though, there is little reference mentioned about the conversion rate for SPLA in non-complicated appendicitis. We think the advancement in energy device and addition 1 port could almost resolve the problem.

In our institution, there had been no single-incision laparoscopic appendectomy procedure for adult patients since 2008. Since SPLA is the most conducted procedure in single-incision surgery,[18] this trial became necessary thereafter. Although there was learning curve to overcome, a single surgeon performed all 52 operations for both SPLA and MPLA patients. In our study, the surgeon seemed to be at some learning stage by the 24 cases in SPLA. However, there were still some critical points to consider for this procedure. First of all, the movement in traditional multi-

ple-port laparoscopy is achieved by triangulation on the horizontal axis. However, in mono-port access, it was mostly made vertically with one instrument grasping and pulling the tip of the appendix upward and the second instrument moving downward for dissecting the planes. This is a concern especially when SPLA is conducted using a rigid straight instrument. Initially, we thought frequent use of the harmonic scalpel in cutting, followed by dissecting and cauterizing, could lessen operating times. Actually, it is crucial to be familiar with the fine movement of monopolar hook in both clockwise and counterclockwise rotations when dividing the mesoappendix. Full 360-degree rotation of the hook by fingers may reduce the collision of instruments.

Another feature of SILA is the use of the laparoscope. The handling of the instruments by the operating surgeon and the manipulation of the camera by the assisting surgeon must be excellently coordinated to avoid frequent and substantial collisions. In cases that resulted in conflicts while operating and maneuvering instruments within the abdomen, the assisting surgeon usually stood toward the upper edge of the umbilical hole, with the operating instruments being inserted and handled on the left toward the lower end of the umbilical incision. The maximal rotation of the fiber optic cable of the 30-degree scope can be used to change the angle of the view and allow the surgeon to view the operative field.

There are many parameters to evaluate whether reaching the mature of single-port technique in laparoscopic appendectomy. In the past few studies, especially for non-complicated appendicitis, the amount of cases was about ten to twenty.[19,20] In our study, Series 1 still revealed the elevated slope in operation time. Till Series 2, the slope of average operation time turned from +0.15 to -0.40, which meant the beginning of decrease in operation time. In both Series 2 and Series 3, there was no significant difference in operation time compared to the MPLA group. It seemed that our surgeon accumulated the surgical experience in single-port laparoscopic appendectomy within 20 cases and reached the same result as the conventional laparoscopic appendectomy.

Certainly, there were many limitations in our comparable small sample size study. The previous randomized control trials and systematic reviews had already showed there is no difference between MPLA and SPLA. There is increasing cases we encountered that patients visited at emergent department asking for single-port appendectomy. So, we needed our own data base to discuss with them about two ways to conduct laparoscopic appendectomy. So far, in our study, we could provide a cosmetic benefit in SPLA without increased peri-operative complications in non-complicated appendicitis cases.

Conclusion

Single-port laparoscopic appendectomy is a technically feasible and safe option for appendicitis. With 24 cases of non-complicated acute appendicitis, our study suggests that surgical skills for SPLA are achievable. The SPLA group in our study had some favorable outcomes included of reduced total wound length and postoperative date 1 (POD 1) VAS score. Further studies should be conducted in more complicated acute appendicitis at our institution.

Disclosure

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原　著

急性闌尾炎分別在腹腔鏡單孔及多孔手術的比較

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背景　本篇研究是要探討在單一機構由單一位外科醫師進行首次多例腹腔鏡單孔闌尾切除手術的相關結果。

研究來源與方法　從 2018 年 11 月至 2019 年 4 月，總共有 52 位非複雜性急性闌尾炎病人收案在本研究中。他們分配在腹腔鏡單孔與多孔兩個組別，並且比較兩組手術相關的結果。包含手術時間、術中由單孔轉成多孔、術後併發症、住院天數、傷口長度以及術後疼痛程度。也同時分析學習曲線。

結果　兩個組別在術前的基本資料除了年紀有統計上的差異以外，其他因素都沒有差別。在術後的比較上，單孔手術的傷口長度與術後第一天的疼痛程度上明顯比多孔要短以及不痛。依照手術時間來看，顯示腹腔鏡單孔闌尾切除手術在本篇研究有達到克服學習曲線。

結論　腹腔鏡單孔闌尾切除技術上來說是安全且可行的。從本篇研究來看，24 個闌尾炎的案例足以讓之前沒單孔手術經驗的外科醫師達到技術上的成熟。腹腔鏡單孔闌尾切除手術提供傷口較小以及術後第一天比較不痛的好處。之後的研究要致力於增加複雜性闌尾炎在單孔手術的數量。

關鍵詞　單孔、闌尾切除、經肚臍、腹腔鏡。