ORIGINAL ARTICLE

pISSN 2234-778X • eISSN 2234-5248
J Minim Invasive Surg 2019;22(1):11-17

JMIS Journal of Minimally Invasive Surgery

Single-Incision, Two-Port Laparoscopic Appendectomy as an Alternative to Transumbilical Single-Port Laparoscopic Appendectomy

Han Sol Chung, M.D.[1], Sung Min Jung, M.D.[1], Mee-ri Lee, M.D.[2], Yong Chan Shin, M.D.[1], Heung Man Jun, M.D.[1], Jae Il Kim, M.D.[1], Pyung Wha Choi, M.D.[1]

[1]Department of Surgery, University of Inje College of Medicine, Ilsan Paik Hospital, Goyang, [2]Department of Preventive Medicine and Institute of Occupational and Environmental Medicine, Soonchunhyang University College of Medicine, Cheonan, Korea

Purpose: We designed a modified technique to perform an advanced procedure using conventional instruments and did not employ specialized single-incision laparoscopic surgery (SILS) port equipment. We compared postoperative results for transumbilical, single-port laparoscopic appendectomy (TUSPLA) and single-incision, 2-port laparoscopic appendectomy (SITPLA).

Methods: This retrospective study enrolled 77 patients who underwent TUSPLA or SITPLA to provide more minimally invasive surgery between May 2017 and April 2018. TUSPLA was performed in 39 patients and 38 underwent SITPLA. In the SITPLA group, two 5-mm trocars were inserted through the umbilicus and an extra puncture site was used for a left-handed instrument. Demographic characteristics, operative data, and postoperative outcomes were collected and compared between the groups.

Results: The mean total operative time in the SITPLA group was shorter than in the TUSPLA group (p=0.003). The mean laparoscopic instrumental time was also shorter (p<0.001) in the SITPLA. The number of postoperative analgesics in the SITPLA group was less than in the TUSPLA group (p=0.002). The length of hospital day after surgery was shorter in the SITPLA group than in the TUSPLA group (p=0.008). There were no other significant differences between the groups.

Conclusion: SITPLA had a shorter operative time, required less pain management, and had a similar cosmetic outcome when compared with TUSPLA.

Keywords: Appendectomy, Laparoscopic surgery, Operation duration, Residency education

Received July 3, 2018
Revised July 25, 2018
Accepted July 30, 2018

Corresponding author
Sung Min Jung
Department of Surgery, University of Inje College of Medicine, Ilsan Paik Hospital, 170 Juhwa-ro, Goyang 10380, Korea
Tel: +82-31-910-7993
Fax: +82-31-910-7319
E-mail: sungmin@paik.ac.kr
ORCID:
http://orcid.org/0000-0001-5346-7315

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Copyright © 2019 The Journal of Minimally Invasive Surgery. All rights reserved.

INTRODUCTION

Appendicitis is defined as inflammation of the vermiform appendix and is a common disease, with a life-long occurrence rate of 7~8%.[1] Surgical treatment of appendicitis has greatly advanced from open surgery of an incision at McBurney's point to laparoscopic minimally invasive surgery. Laparoscopic appendectomy (LA) has been accepted as the gold standard for acute appendicitis and is now performed more often than open appendectomy (OA). LA is indispensable technique in terms of cosmetic merits, less postoperative pain, reduced wound infection, and shorter hospital stay.[2,3]

Over the years, efforts are ongoing to minimize visible scarring and size of the abdominal incision despite the advantage

https://doi.org/10.7602/jmis.2019.22.1.11

of conventional LA (CLA) using 3 ports. The recently developed single-port technique has further improved this minimally invasive surgery. Transumbilical single-port laparoscopic appendectomy (TUSPLA) that has a reduced incision and the cosmetic merit is widly used with subsequent development of various single-port products.[4-6] Although there is an advantage in using a single port technique, disadvantages include a larger incision diameter which can lead to greater damage to fascia, more postoperative pain, longer operative time, and a higher conversion rate.[7,8] It is also more difficult for residents because the learning curve for TUSPLA is slow due to the acute angle between the laparoscope and working devices.[9,10]

Two-port LA (TLA) is a minimally invasive surgical procedure that complements and takes advantage of the technical difficulty of SILS. Many studies have been performed with TLA.[11,12] TLA was also developed to place 2 basic trocars into a single incision, with the aim of reducing the number of incisions and lowering the cost.[13] We designed a modified technique to perform an advanced procedure using conventional instruments and did not employ specialized SILS port equipment. The trocar scar with this single-incision, 2-port LA (SITPLA) technique is the same as for TUSPLA.

To date, no clinical trials have compared SITPLA with TUSPLA, and the potential advantages and merits of SITPLA have not been proven beyond single-port laparoscopic surgery using a specialized port. Therefore, this study was undertaken to assess the efficacy of SITPLA as an alterntive and equivalent to TUSPLA.

MATERIALS AND METHODS

This retrospective study enrolled 77 patients who underwent TUSPLA and SITPLA to provide more minimally invasive surgery between May 2017 and April 2018. In our center, residents started performing SITPLA in May 2017 after mastering all the processes of this modified technique under the guidance of a consultant through more than 5 cases. Each resident was required to perform two types of operation alternately, and the professor instructed the procedures in the operation field together with the residents. Among the enrolled patients, 39 underwent TUSPLA and 38 underwent SITPLA. Our study protocol was approved by the institutional review board of the ethics committee of our hospital (approval number: ISPAIK 2018-04-001).

We primarily performed LA for all patients with acute appendicitis. If colonic resection was expected, we first tried to delay appendectomy with external drainage. This study included 77 patients (age range, 6~53 years) who had been radiologically diagnosed with acute appendicitis less than grade 3 on abdominopelvic computed tomography (CT), or with magnetic resonance imaging (MRI) in 2 pregnant women.[14] CLA was performed in patients with complicated appendicitis. We retrospectively reviewed medical records for age, sex, history of abdominal surgery, surgical procedure, operative time, surgical complications, and length of hospital stay.

Operative procedure

Patients were placed supine in Trendelenburg and left lateral position under general anesthesia without Foley catheter insertion. All surgeries were performed by residents who experienced at least 50 cases of CLA. All procedures were performed by a trainee under direct supervision of the professor. Before surgery, all patients self-voided. A 5-mm diameter 30° laparoscope was used. The main incision was made to vertically transect the umbilicus. Appendiceal artery ligation and appendix resection were performed with a LigaSure™ (Valleylab, Boulder, Colorado, USA). The appendiceal base was ligated with an endoloop. When needed, we used silicone container-type drainage. The fascia was closed with Vicryl 2-0 interrupted suture, and skin was closed with Vicryl 4-0 interrupted subcuticular suture. These methods were performed concurrently.

SITPLA technique

A vertical incision lesser than 2 cm was made at the umbilicus. For the best cosmetic results, we took care not to extend the incision beyond the umbilical ring. Dissection was continued down to fascia followed by the preperitoneal fat layer. The peritoneum was opened under direct vision. Two 5-mm ports were inserted into the peritoneal cavity. For prevention of extraperitoneal gas leakage, a single suture and tie were placed between 2 ports (Fig. 1). Two techniques for traction of the appendix were used. One used a needle grasper device (Mediflex Surgical Products, Islandia, NY) in the right lower quadrant. Another used a suprapubic MiniSite MiniPort Introducer (Medtronic, Dublin, Ireland). The specimen was taken out with a 5-mm endobag. Steri-Strips™ was applied to the extra device puncture site instead of suture.

TUSPLA technique

The same method was used for an intraperitoneal approach. The incision was made at 2.5 to 3 cm considering the insertion and the operation range of the three devices. After opening the fascia and peritoneum, a Glove port A (Meditech Inframed, Paju, Korea) was inserted. In contrast with SITPLA, the specimen was taken out through the incision site without an endobag.

Postoperative management

Intravenous antibiotics were given from before surgery un-

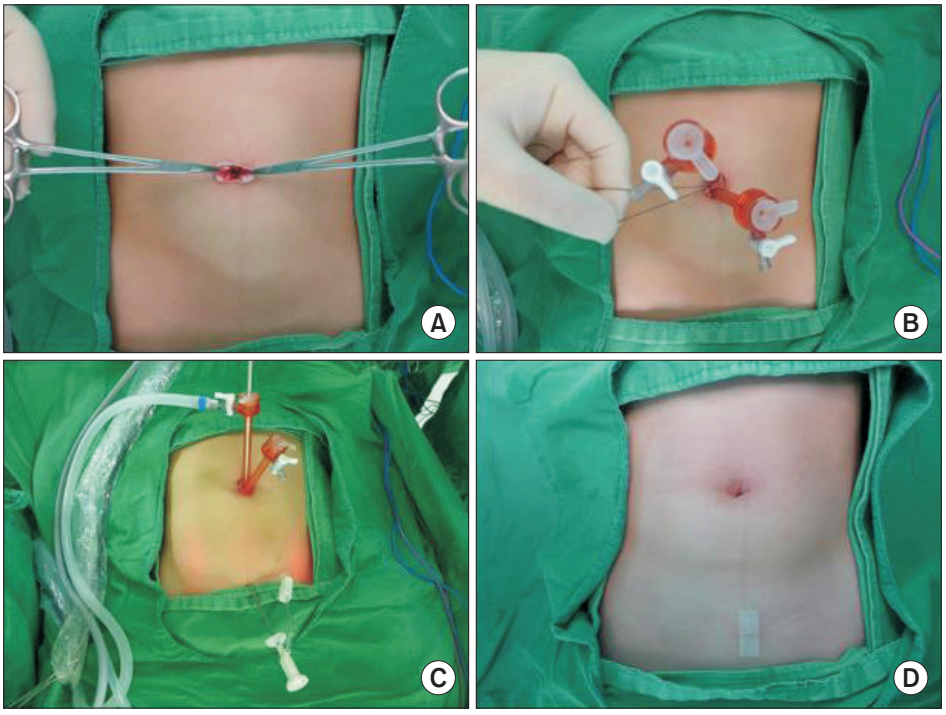

Fig. 1. Operation field of Single-incision two-port laparoscopic appendectomy (SITPLA). (A) Trans-umbilical incision. The umbilicus was retracted for a full exposure and vertical incision was made on the bottom of umbilicus. (B) For prevention of extraperitoneal gas leakage, single suture & tie was done between two ports. (C) Minisite miniport or needle grasper introducer at suprapubic site. (D) 3M Steri-Strips™ was applied for extra-device puncture site instead of suture.

til the day after surgery. Uncomplicated appendicitis patients only received a second-generation cephalosporin, while complicated appendicitis patients received a second-generation cephalosporin plus metronidazole. Anyone with a positive reaction to a skin test received ciprofloxacin. Sips of water were allowed regardless of flatus, and a soft diet was started after omission of one meal. We performed a routine complete blood count to assess inflammatory status on the day after surgery. The postoperative pain score using a numerical rating scale was reviewed in the medical record. Postoperative pain was controlled with intravenous ketorolac or tramadol, or pethidine in pregnant women. Tolerance of a diet and reduced pain determined the time of discharge. Residents examined the surgical site in the ward. Professors examined the surgical site in the outpatient department a week after discharge.

Statistical analysis

Continuous and categorical variables were expressed as the mean±standard deviation and number (%), respectively. Differences in demographic and anthropometric characteristics according to trocar were compared using the chi-square test, or Fisher's exact test when appropriate. Student's t-test was used to compare means across categories. All analyses used 2-sided tests, and a p value<0.05 was significant. Statistical analyses were conducted using SAS EG 5.1 server version 9.3 (SAS Institute Inc., Cary, NC, USA).

Table 1. Demographic characteristics of patients

Variables	TUSPLA (n=39)	SITPLA (n=38)	p value
Age (years)	19.90±12.0	26.76±14.48	0.027
Gender (M:F)	13:26	20:18	0.087
Height (cm)	154.64±15.71	159.36±17.33	0.893
Weight (kg)	49.22±14.47	55.42±16.29	0.959
BMI (kg/m^2)	20.10±3.39	21.30±3.30	0.939
ASA			0.263
I:II:III	37:2:0	33:5:0	
WBC (10^3/mm^3)	11.54±35.66	12.05±43.84	0.711
CRP (mg/dL)	2.12±3.15	1.71±3.24	0.291
Hx of OP	2 (5.13)	2 (5.26)	1

Values are presented as mean±standard deviation or number. TUSPLA = Trans-umbilical single-port laparoscopic appendectomy; SITPLA = Single-incision two-port laparoscopic appendectomy; BMI = Body mass index; ASA = American Association of Anesthesiology Score; Hx of Op = previous abdominal operation history.

RESULTS

In total, 39 patients underwent TUSPLA and 38 underwent SITPLA. The characteristics of the patient group are compared in Table 1. A total of 35 patients was aged <19 years. The mean age in the TUSPLA group (19.90 years) was younger than in

Table 2. Operative data

Variables	TUSPLA (n=39)	SITPLA (n=38)	*p* value
Appendicolith	18 (46.15)	14 (36.84)	0.407
Grade of appendicitis			1
Grade 1	34	34	
Grade 2A	5	4	
Operation time (min)	53.97±19.94	43.16±11.88	0.003
Laparoscopic time (min)	25.77±8.97	19.5±7.38	<0.001
Preparation time (min)	28.21±13.11	24.11±9.87	0.062
Surgeon			1
Resident	38 (97.4)	37 (97.4)	
Consultant	1 (2.6)	1 (2.6)	
Open conversion	0	0	
Drain (+)	3 (7.69)	0	0.240
Antibiotic			0.911
2nd cephalosporin	31	29	
2nd cephalosporin + metronidazole	7	7	
Ciproproxacin	1	2	

Values are presented as mean±standard deviation or number. Grade 1 = Inflammed appendix (Hyperemia, edema±fibrin without or little pericolic fluid; Grade 2A = Segmental necrosis (without or little pericolic fluid); Operation time = Total operation time from incision to dressing; Laparoscopic time = Laparoscopic procedure time from trocar insertion to specimen removal; Preparation time = Operation time–Laparoscopic time.

Table 3. Postoperative outcomes

Variables	TUSPLA (n=39)	SITPLA (n=38)	*p* value
NRS scores			
NRS (1 hr)	4.56±1.70	4.14±1.78	0.151
NRS (8 hr)	3.28±1.89	2.76±1.50	0.093
NRS (16 hr)	2.85±1.74	2.87±2.03	0.521
NRS (24 hr)	2.82±1.89	2.68±2.24	0.357
Number of analgesics	2.05±1.50	1.13±1.19	0.002
Hospital stay (hours)	49.49±16.15	41.68±11.14	0.008
Overall morbidity	6 (15.38)	4 (10.53)	0.737
Wound erythema	3	1	
Wound abscess*	2	3	
Intra-abdominal abscess	1	0	
Mortality	0	0	

Values are presented as mean±standard deviation or number. NRS = Numerical Rating Scale. *Wound abscess, including clear or haemoserous discharge.

the SITPLA group (26.76) (p=0.027). Of the 4 patients with a previous history of surgery, 3 had a caesarean section and 1 had a laparoscopic myomectomy. There was no significant difference between the groups, except for age.

Surgery-related variables between are compared in Table 2. Total operative time was measured from the skin incision to the completion of dressing. The mean total time for SITPLA (43.16 min) was shorter than that for TUSPLA (53.97 min), with a significant difference (p=0.003). Laparoscopic instrumental time was measured from the point of insertion of the trocar to the point of removal of specimen. The mean laparoscopic instrument time for SITPLA (19.50 min) was shorter than for TUSPLA (25.77 min), with a significant difference (p<0.001). Other than laparoscopic instrumental time, there was no statistically significant difference between TUSPLA (28.21 min) and SITPLA (24.11 min) for operative time (p=0.062).

Pain management, number of analgesic doses, length of hospital day, and morbidities are compared in Table 3. The postoperative pain scale scores at 1, 8, 16, and 24 hours showed no significant difference between the groups. However, the number of postoperative pain control doses showed a statistically significant difference (p=0.002) between the TUSPLA group (2.05 times) and SITPLA group (1.13 times). The length of hospital day after surgery also showed a significant difference (p=0.008) between the TUSPLA group (49.49 hours) and SITPLA group (41.68 hours). Overall morbidity in the TUSPLA group included 3 cases with wound erythema, 2 with a wound abscess, and 1 with an intra-abdominal abscess (who needed additional drainage). In the SITPLA group, 1 patient had wound erythema and 3 had a wound abscess. However, there was no significant difference between the groups (p=0.737). There were no deaths in either group.

DISCUSSION

Laparoscopic surgery has been accepted as a standard procedure in the treatment of acute appendicitis. With the development of laparoscopic techniques, LA has rapidly progressed from CLA into SILS. Several studies have compared the outcomes of CLA and SILS. The cosmetic effect was a major benefit of single-incision LA as demonstrated in several studies. However, they concluded that SILS is difficult to perform, resulting in a longer operative time and a steep learning curve, and requires a larger incision that is associated with increased

risk of wound infection and incisional hernia.[15,16] Despite conflicting results, the larger umbilical incision in SILS tends to cause more pain.[17,18] Despite some limitations as with other single-incision techniques, TUSPLA has proven its value in managing appendicitis. With respect to cosmetic merit, the transumbilical port scar is not visible because it is naturally concealed.[19]

Because of patient preference for laparoscopic surgery, CLA and TUSPLA have been used to train residents to perform appendectomy with little opportunity to perform OA. Despite its advantages, TUSPLA takes longer for a resident to master due to the difficulty of the operative technique. Therefore, we thought it was necessary to develop an intermediate technique that is technically easier but has all the advantages of SILS in the process of moving from CLA to TUSPLA. Several studies have used a reduced number of ports, e.g., port exteriorization appendectomy, needle-scopic appendectomy, extracorporeal appendectomy, laparoscope-assisted appendectomy, and needle loop retractor appendectomy, as a bridge between CLA and SILS.[11,12] Even intermediate techniques should have advantages similar to those of SILS, with cosmetic effects superior to those of CLA. SITPLA satisfies these conditions.

When compared to TUSPLA, SITPLA can be performed more easily because of the distance between two working instruments that leads to a wider angle between instruments. In this technique, a needle grasper device or MiniSite MiniPort was used instead of a 5-mm grasper. Total operative time for SITPLA in our study was similar to that in other studies using 2 ports.[11,20] The operative time is thought to be an indirect but objective assessment of the difficulty of a technique. Subjectivity could be involved when using a method in which the operator alone evaluates the difficulty of a technique. Total operative time, and laparoscopic instrumental time showed significant differences between the groups, with a shorter time in the SITPLA group than in the TUSPLA group. This difference is thought to be due to the technical difficulty in making a surgical plane with a narrow angle in TUSPLA. Other than for laparoscopic instrumental time, there was no significant difference between the groups in operative time. There was no significant difference in the cases in which a consultant participated in the operation while the resident performed the operation, but there was only one such case in each group. Although the TUSPLA was more familiar to the residents, the operative time for SITPLA was significantly shorter. It is expected that the operative time for SITPLA will be further reduced with an increase in the number of trials, as reported in another study.[21] When the operative time for CLA and TUSPLA was compared in a previous randomized controlled trial, the time for CLA was found to be significantly shorter.[22] Compared to CLA, a technical limitation in SITPLA is the need to hold the appendiceal mesentery during manipulation with the needle grasper or MiniSite MiniPort, caused by thickening and fragility of a severely inflamed mesoappendix. A future study comparing CLA and SITPLA is needed to verify the technical benefit of SITPLA.

The most important technical aspect of single-incision appendectomy and 2-port appendectomy is the need to properly expose the mesoappendix. The mesoappendix should be retracted adequately to cauterize and cut the appendiceal artery. In the present study, SITPLA was performed with a needle grasper or MiniSite MiniPort with the left hand of the surgeon at McBurney's point or a suprapubic site to hold the mesoappendix for retraction. The diameters of the needle grasper and miniport were 2.1 and 2.3 mm, respectably. Insertion of an assistive device for suprapubic traction was more comfortably performed at the left side of the patient. The mesoappendix was cauterized with an endo LigaSure, entering through the umbilical trocar, and the appendix was skeletonized. The appendix was sutured at the neck using an endoloop, entering through the umbilical trocar, and subsequent appendectomy was performed. The diameter of the assistive device was 2.1~2.3 mm and there was no need for a suture.

Conversion of minimal laparoscopic technique to insertion of an extra port or open surgery should be performed without any hesitation when the operation is not progressing or organ injury is expected. Conversion to open surgery was not needed in this study. There were no statistically significant differences, but 3 cases required operative expansion with insertion of an extra port in the TUSPLA group, compared to 0 cases in the SITPLA group. It is assumed that the additional trocar was needed for the unconstrained left hand to avoid fighting between the working ports due to the narrow angle. In SITPLA, we first checked intra-abdominal conditions (inflammation, adhesion, and fluid collection, etc.) through 2 umbilical 5-mm trocars before inserting an assistive device. In severe cases, it is possible to insert a 5-mm trocar for freer use of a grasper (ability to rotate and lock) instead of using an assistive device at the suprapubic site. Thus, SITPLA is easier than TUSPLA in terms of operative expansion, although this was never actually implemented in this study.

Postoperative pain after appendectomy may occur because of surrounding tissue inflammation as well as the surgical wound itself. The severity of pain will vary due to surgical factors including incision size. The intensity of pain in this study, which was performed in patients with similar severity, could be differentiated by surgical factors including incision size. In a study conducted by shifting a port from the right iliac fossa to the umbilicus, with insertion of 2 trocars through a single umbilical incision, the intensity of pain was not different from that in CLA.[23] In the present study, both groups

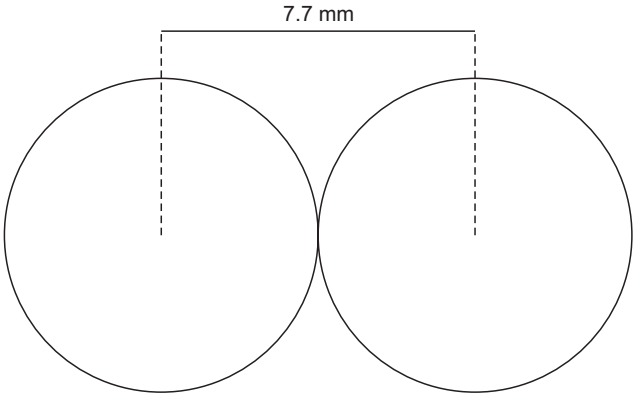

Fig. 2. Calculated length of fascia incision for SITPLA using 5 mm-trocar with a diameter of 7.7 mm. Expected incision size, $(7.7\pi + 15.4)/2 \fallingdotseq 19.79$ mm; SITPLA, Single-incision two-port laparoscopic appendectomy.

experienced similar postoperative pain at all postoperative time points. However, there was a significant difference between the 2 groups in the number of analgesic doses and the length of hospital day after surgery. For TUSPLA, a 2.5~3.0-cm fascial incision is required for instrument operation, whereas SITPLA required a <2-cm incision.[24] Expected incision size is shown in Fig. 2, and a smaller incision was required given the elasticity of the fascia. It is thought that the reduction in pain due to the reduction of the fascial defect has resulted in a statistically significant reduction in the number of analgesic doses and a reduction in the length of hospital day after surgery. Initially, an extra Endo Closure device was used at the right lower quadrant site, but the use of a 2-mm port at the suprapubic site made the operation easier without a difference in wound size.[25] With the help of a needle grasper device or MiniSite MiniPort, postoperative pain and scar formation may be minimized in SITPLA.

The two 5-mm ports used in CLA often produced obvious visible scars. SITPLA did not require a 5-mm port other than at the umbilicus, and the suprapubic insertion site for assistive devices was strategically placed below the underwear-line and left a barely-visible scar after wound healing. There was no reduction in the number of ports in a comparison between SITPLA and 2-port LA. However, moving a 5-mm port to the umbilicus enabled one scar to be hidden in the umbilicus while avoiding the need for a large incision at the umbilicus, as in SILS.

In our study, transumbilical incision was performed in all patients. Transumbilical single-port surgery can be considered a type of natural orifice transluminal endoscopic surgery (NOTES). In order to take advantage of NOTES, the incision should be made vertically at the umbilicus rather than as a sub-umbilical incision to avoid a visible scar. The rates of wound-related complications were tolerable compared to previous studies.[8] This is consistent with previous studies in which transumbilical incisions were not associated with increased surgical site infections or incidence of hernia.[26-28]

Considering the high prevalence of appendectomy, the cost-effectiveness of surgery should be considered. Compared with CLA and TUSPLA, the cost savings of SITPLA, with only the need for a trocar/miniport introducer and endobag, were 10% and 30% in our institution, respectively.

This study was conducted as a retrospective clinical trial and there are limitations associated with this research design. In particular, demographic differences between the two groups illustrated these limitations. We found that TUSPLA was frequently performed in young female patients, even though each operator was required to alternately perform TUSPLA and SITPLA for training. This may be because the operators was more familiar with TUSPLA and preferred this method in more vulnerable patients. The removal of bias can be achieved by a randomized controlled trial. We could not compare CLA with minimally-invasive surgical technique in this study, because CLA was performed mainly for complicated appendicitis in our institution. We expect to be able to compare outcomes of SITPLA with CLA after extending the indication for SITPLA to complicated appendicitis in the future.

Overall, the results of this study suggest that SITPLA has clinical outcomes equivalent to those of TUSPLA. SITPLA also has an advantage over TUSPLA in terms of postoperative pain and operative time, and does not require specialized instruments. Therefore, SITPLA may act as a bridge between CLA and TUSPLA, especially for residents. In conclusion, SITPLA can have similar cosmetic merit, while overcoming the technical limitations of TUSPLA.

REFERENCES

1) Bhangu A, Soreide K, Di Saverio S, Assarsson JH, Drake FT. Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. Lancet 2015;386:1278-1287.
2) Li X, Zhang J, Sang L, et al. Laparoscopic versus conventional appendectomy - a meta-analysis of randomized controlled trials. BMC Gastroenterology 2010;10:129.
3) Yau KK, Siu WT, Tang CN, Yang GP, Li MK. Laparoscopic versus open appendectomy for complicated appendicitis. J Am Coll Surg 2007;205:60-65.
4) Panait L, Bell RL, Duffy AJ, Roberts KE. Two-port laparoscopic appendectomy: minimizing the minimally invasive approach. J Surg Res 2009;153:167-171.
5) Frutos MD, Abrisqueta J, Lujan J, Abellan I, Parrilla P. Randomized prospective study to compare laparoscopic appendectomy versus umbilical single-incision appendectomy. Ann Surg 2013;

257:413-418.
6) Hong TH, Kim HL, Lee YS, et al. Transumbilical single-port laparoscopic appendectomy (TUSPLA): scarless intracorporeal appendectomy. J Laparoendosc Adv Surg Tech A 2009;19:75-78.
7) Lee J, Baek J, Kim W. Laparoscopic transumbilical single-port appendectomy: initial experience and comparison with three-port appendectomy. Surg Laparosc Endosc Percutan Tech 2010;20:100-103.
8) St Peter SD, Adibe OO, Juang D, et al. Single incision versus standard 3-port laparoscopic appendectomy: a prospective randomized trial. Ann Surg 2011;254:586-590.
9) Cai YL, Xiong XZ, Wu SJ, et al. Single-incision laparoscopic appendectomy vs conventional laparoscopic appendectomy: systematic review and meta-analysis. World J Gastroenterol 2013;19:5165-5173.
10) Chow A, Purkayastha S, Nehme J, Darzi LA, Paraskeva P. Single incision laparoscopic surgery for appendicectomy: a retrospective comparative analysis. Surg Endosc 2010;24:2567-2574.
11) Donmez T, Hut A, Avaroglu H, et al. Two-port laparoscopic appendectomy assisted with needle grasper comparison with conventional laparoscopic appendectomy. Ann Surg Treat Res 2016;91:59-65.
12) Olijnyk JG, Pretto GG, da Costa Filho OP, Machado FK, Silva Chalub SR, Cavazzola LT. Two-port laparoscopic appendectomy as transition to laparoendoscopic single site surgery. J Minim Access Surg 2014;10:23-26.
13) Pattanshetti VM, Krishna KL. Conventional laparoscopic appendectomy versus double-incision, three-port laparoscopic appendectomy: A 1-year randomized controlled trial. Asian J Endosc Surg 2018 Feb 19 [Epub]. DOI: 10.1111/ases.12467.
14) Gomes CA, Sartelli M, Di Saverio S, 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.
15) Udwadia TE. Single-incision laparoscopic surgery: An overview. J Minim Access Surg 2011;7:1-2.
16) Switzer NJ, Gill RS, Karmali S. The evolution of the appendectomy: from open to laparoscopic to single incision. Scientifica (Cairo) 2012;2012:895469.
17) Kim HO, Yoo CH, Lee SR, et al. Pain after laparoscopic appendectomy: a comparison of transumbilical single-port and conventional laparoscopic surgery. J Korean Surg Soc 2012;82:172-178.
18) Lee CH, Jeon WJ, Youn SJ, et al. The experience of transumbilical endoscopic appendectomies. Ann Surg Treat Res 2014;86:278-282.
19) Lee JS, Choi YI, Lim SH, Hong TH. Transumbilical single port laparoscopic appendectomy using basic equipment: a comparison with the three ports method. J Korean Surg Soc 2012;83:212-217.
20) Rammohan A, Jothishankar P, Manimaran AB, Naidu RM. Two-port vs. three-port laparoscopic appendicectomy: A bridge to least invasive surgery. J Minim Access Surg 2012;8:140-144.
21) Lin YY, Shabbir A, So JB. Laparoscopic appendectomy by residents: evaluating outcomes and learning curve. Surg Endosc 2010;24:125-130.
22) Carter JT, Kaplan JA, Nguyen JN, Lin MY, Rogers SJ, Harris HW. A prospective, randomized controlled trial of single-incision laparoscopic vs conventional 3-port laparoscopic appendectomy for treatment of acute appendicitis. J Am Coll Surg 2014;218:950-959.
23) Teoh AY, Chiu PW, Wong TC, et al. A double-blinded randomized controlled trial of laparoendoscopic single-site access versus conventional 3-port appendectomy. Ann Surg 2012;256:909-914.
24) Lee WS, Choi ST, Lee JN, et al. Single-port laparoscopic appendectomy versus conventional laparoscopic appendectomy: a prospective randomized controlled study. Ann Surg 2013;257:214-218.
25) Bhatia P, Sabharwal V, Kalhan S, John S, Deed JS, Khetan M. Single-incision multi-port laparoscopic appendectomy: How I do it. J Minim Access Surg 2011;7:28-32.
26) Morita Y, Yamaguchi S, Ishii T, et al. Does transumbilical incision increase incisional hernia at the extraction site of laparoscopic anterior resection? Am J Surg 2015;209:1048-1052.
27) Tsuji Y, Maeda K, Ono S, Yanagisawa S, Baba K, Usui Y. A new paradigm of scarless abdominal surgery in children: transumbilical minimal incision surgery. J Pediatr Surg 2014;49:1605-1609.
28) Yamamoto M, Tanaka K, Asakuma M, et al. Does Transumbilical Incision Influence Surgical Site Infection Rates of the Laparoscopic Sigmoidectomy and Anterior Resection? Am Surg 2015;81:1232-1236.