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A Novel and Scarless Laparoscopic Appendectomy Technique: Two Ports in a Single Incision Plus One Puncture Without Trocar

Junko Takita[1], Norihiro Masuda[1], Norihiro Haga[1], Tomokazu Ito[1], Hiroyuki Kuwano[2]

[1]*Department of Surgery, National Hospital Organization Utsunomiya National Hospital, Tochigi, Japan*

[2]*Department of the First Surgery, Department of General Surgical Science, Graduate School of Medicine, Gunma University, Gunma, Japan*

Single-port laparoscopic appendectomy (SILS-A) is now being performed in a great number of patients. However, SILS-A requires extended operation time and does not markedly decrease postoperative pain or improve cosmesis. To solve these problems, we developed a new technique for laparoscopic appendectomy that relies on 2 ports in a single incision plus 1 puncture (POP-SILS), and we can prove that this useful technique allows SILS-A to be easier and more cosmetic. The cases of 112 patients treated by laparoscopic appendectomy (LA) at our hospital between 2010 and 2013 were studied retrospectively. Forty-one were cases of locally complicated appendicitis, and 71 were cases of simple appendicitis. In laparoscopic appendectomy with POP-SILS, we maintain instrument triangulation using two 5-mm ports in the umbilicus and needle instruments that are introduced by puncture above the pubic bone. We studied the safety and usefulness of this method from the standpoint of operation time, postoperative stay, and complications. From 2010 to 2013, we performed 77 POP-SILS-LAs. Thirty-five patients required 1 or more additional ports or underwent conventional LA. The time required for POP-SILS-LA was 54 minutes (range, 23–209) in cases of simple appendicitis. Even in 17 cases of locally complicated appendicitis, POP-SILS-LA was successful. There was no statistical difference in surgical complications between POP-SILS-LA and multiport LA. Both the umbilical scar and the puncture scar eventually became invisible. The outcomes

Corresponding author: Junko Takita, Department of Surgery, National Hospital Organization Utsunomiya National Hospital, 2160 Shimookamoto-cho, Utsunomiya, Tochigi, 329-1193, Japan.
Tel.: +81 28 673 2111; Fax: +81 28 673 6148; E-mail: mimiwhale@tochigi-med.or.jp

in our patient series showed POP-SILS-LA to be a safe and beneficial, minimally invasive approach to laparoscopic appendectomy.

Key words: Laparoscopic appendectomy – Reduced-port surgery – SILS

Laparoscopic appendectomy (LA) was first reported in 1983.[1] Since then the technique has been improved upon by many surgeons.[2,3] Because it is desirable to reduce the number of abdominal sites subject to skin trauma, single-port laparoscopic appendectomy (SILS-A) is being applied in an increasing number of cases. However, movement of the scope and other surgical instruments is quite limited because all are inserted through the same incision.[4–11] Having performed LA at the National Hospital Organization Utsunomiya National Hospital since 2004, we generally use 3 ports; and in standard conventional laparoscopic appendectomy (CLA), triangulation can be maintained throughout the operation. The use of a single port makes SILS-A more difficult, and some studies have shown that the operation time required for SILS-A is longer than that required for CLA.[4–11] In addition, when there is peritonitis or adhesion, SILS-A is sometimes abandoned because of the limitations in movement and parallel view. To resolve these SILS-A problems and still achieve the desired cosmetic result, we devised a new operative method for LA: the use of 2 ports via a single incision plus 1 puncture (POP-SILS-LA). We introduced this method at our hospital in 2010 and have applied it in 77 cases. The retrospective study described herein was conducted to investigate the safety and usefulness of POP-SILS-LA from the standpoint of operation time, postoperative stay, postoperative complications, and the annual percentage of POP-SILS-LAs performed for the years 2010 through 2013. The procedure itself is also described.

Patients and Methods

Patients

The study group comprised 125 patients treated for appendicitis at our institution between 2010 and 2013. Thirteen of these patients underwent open appendectomy, and 112 underwent LA. We attempted POP-SILS-LA in 77 of the 112 patients, and multiport LA was performed in the remaining 35. The multiport procedure was performed when an additional 5-mm port was needed or when CLA was required because of the patient's general status or because of surgical difficulties caused by local inflammation or abdominal adhesion.

Seventy-one cases were considered cases of simple appendicitis, and 41 were considered cases of complicated appendicitis. Local complications were found in 41 of these cases: appendix perforation, abscess formation, or panperitonitis.

Comparative study

To determine the safety and usefulness of POP-SILS-LA, we compared patient characteristics and surgical outcomes between those who underwent POP-SILS-LA and those who underwent multiport LA. Patient characteristics studied were age, sex, and presentation (simple versus complicated appendicitis), and LA outcomes studied were operation time, conversion to open appendectomy, postoperative length of stay, and postoperative complications. Patients were divided into subgroups based on presentation (simple appendicitis versus complicated appendicitis), and factors were again compared. The study protocol was approved by the National Hospital Organization Utsunomiya National Hospital Ethics Committee.

POP-SILS-LA procedure

We start the operation with the patient in the supine position under general anesthesia. We make a 12- to 15-mm incision in the umbilicus, place a multichannel access device (EZ Access, Hakko Co., Ltd., Nagano, Japan), and then insert two 5-mm ports (Figs. 1, 2). After inflating the abdominal cavity with carbon dioxide, we insert a needle instrument by piercing the patient's abdominal wall just above the pubic bone, using either 2.4-mm diameter forceps (End-Relief, Hope Denshi Co., Ltd., Chiba, Japan; Fig. 3a) or a 2-mm diameter catheter with a wire loop (Mini-Loop Retractor, Covidien, Tokyo, Japan; Fig. 3b). The operator stands at the patient's left side, and the assistant stands above the patient's left arm. The assistant uses a flexible 5-mm diameter scope through one of the ports and directs the scope across rather than parallel to the forceps held in the operator's right hand. The scope can be bent in the desired direction from this crossed position. Thus,

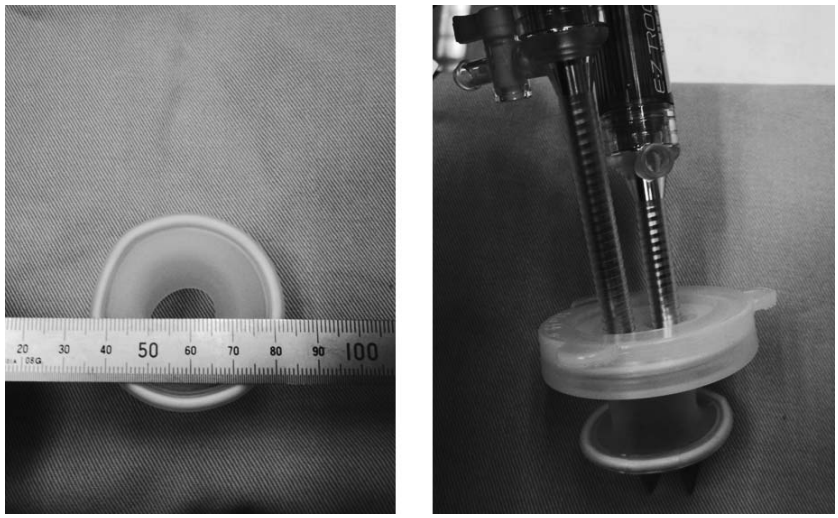

Fig. 1 Lap Protector Mini-Mini and EZ Access XS for multichannel access. The inner diameter of the Lap Protector Mini-Mini is about 15 mm (left). The EZ Access XS is slipped into the protector, and two 5-mm ports are inserted (right).

the needle instrument in the operator's left hand, the laparoscopic forceps in the operator's right hand, and the flexible scope held by the assistant are triangulated (Fig. 4).

Statistical analysis

Continuous variables are expressed as median values with and the respective range, and between-group differences were analyzed by Mann-Whitney *U* test. Differences in nominal variables were analyzed by χ^2 test. Statistical software package (StatFlex ver. 6.0 for Windows, Artec, Inc., Osaka, Japan) was used for all statistical analyses. A value of $P < 0.05$ was considered statistically significant.

Results

Clinical characteristics and surgical outcomes are shown for the POP-SILS-LA patients and multiport LA patients in Table 1. We achieved POP-SILS-LA in 75 of the 77 patients in whom it was attempted; 2 of the 77 patients required conversion to open appendectomy. Of the 35 patients who underwent multiport LA, 15 required one additional 5-mm port, and 20 required CLA or the addition of more than 4 ports. The median age of patients in the POP-SILS-LA group was 26 years (9–83 years), and that of patients in the multiport LA group was 36 years (11–87 years; $P < 0.01$). The male/female ratio also differed significantly between the 2 groups (45/32 versus 13/22, respectively, $P = 0.04$). The percentage

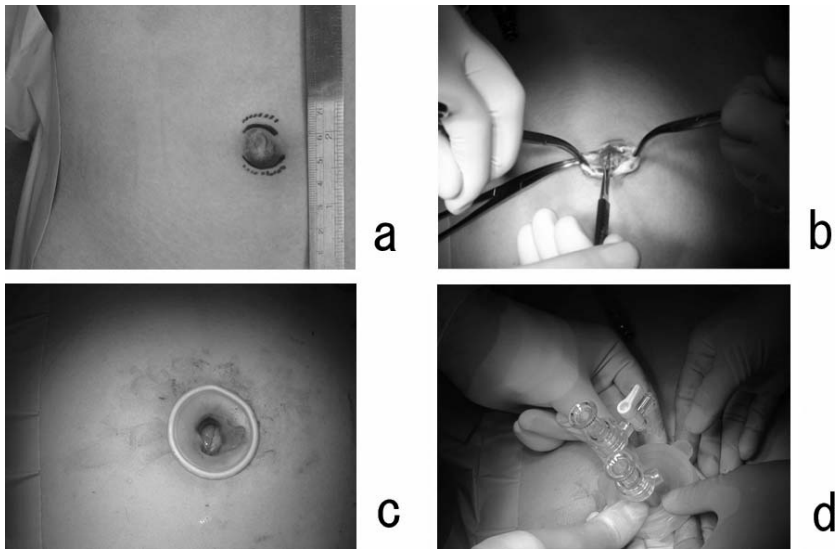

Fig. 2 Photographs showing establishment of multichannel access in a 17-year-old-woman in whom the POP-SILS-LA technique was used. The patient was only 150 cm tall and had a small navel of about 15 mm in diameter (a). The incision at the bottom of the navel did not extend beyond the border of the navel (b). After the Lap Protector Mini-Mini was inserted (c), the EZ Access XS was placed, and two 5-mm ports were inserted (d).

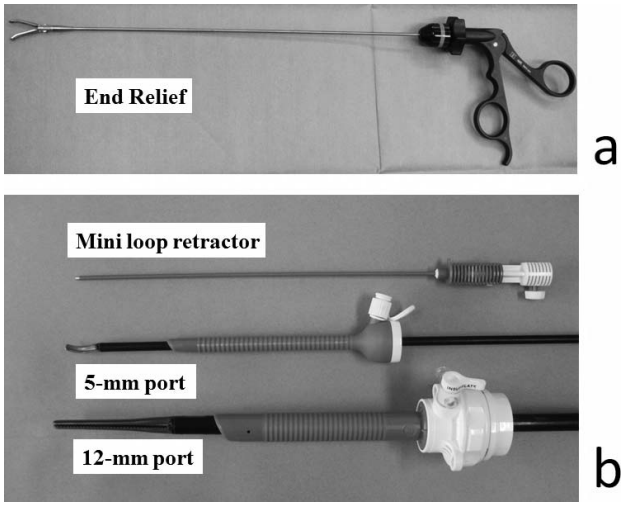

Fig. 3 Needle instruments that we use. The End-Relief is a 2.4-mm-diameter forceps, the shaft of which we insert through the abdominal wall directly before attaching the proximal end to the handle, which is held outside the body (a). The Mini-Loop Retractor is a 2-mm-diameter catheter with a wire loop that can also be used to puncture the abdominal wall directly (b).

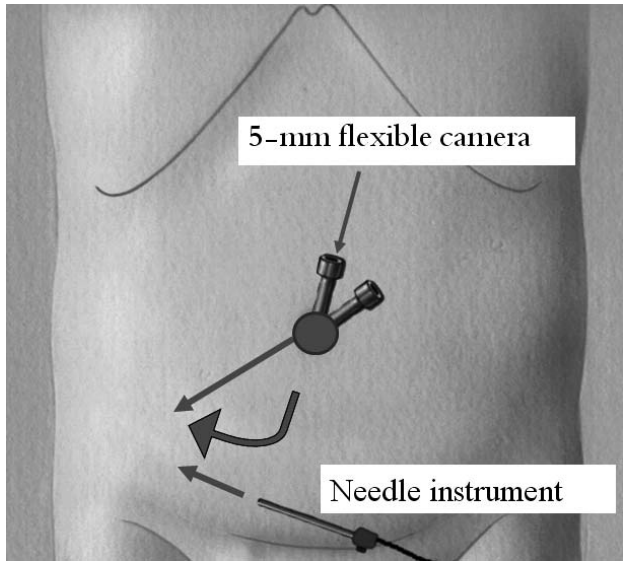

Fig. 4 Schematic drawing of the port positions and instrument use. The operator manipulates the laparoscopic forceps with his right hand through 1 umbilical port and with his left hand uses the needle instrument, which is inserted at the pubic line. A 5-mm diameter flexible scope is inserted through the other umbilical port, and it is bent to the right, so that triangulation can be maintained throughout the appendectomy procedure.

of cases of complicated appendicitis was significantly lower in the POP-SILS-LA group than in the multiport LA group ($P < 0.01$). In addition, operation time and postoperative stay were both significantly shorter in the POP-SILS-LA group than in the multiport LA group.

As shown in Table 2, the number of patients with simple appendicitis was greater than the number with complicated appendicitis (71 versus 41, respectively). Patients with simple appendicitis were significantly younger than patients with complicated appendicitis, and the male/female ratio differed significantly between the 2 groups, with a greater percentage of females in the simple appendicitis group. Operation time was shorter in the simple appendicitis group than in the complicated appendicitis group, and postoperative hospital stay was also shorter in this group (Table 2). Of the 77 patients who underwent POP-SILS-LA (Table 3), 60 had simple appendicitis and 17 had complicated appendicitis; this difference was statistically significant. Of the 77 patients who underwent POP-SILS LA, there was no difference in the sex ratio and age between those with simple appendicitis and those with complicated appendicitis, but operation time and postoperative stay were shorter in this group (Table 3). Postoperative complications in the POP-SILS group were subileus (n = 2, 2.6%) and surgical site infection (n = 1, 1.3%), with no significant difference in postoperative complications between the POP-SILS-LA group and the multiport LA group (Table 4). There was no occurrence of remnant abdominal abscess requiring reoperation or transabdominal drainage. The scar created by the needle instrument was almost invisible postoperatively, and no umbilical deformation was seen, even in the standing position (Fig. 5).

Discussion

Since first reported in 1983 by Semm *et al*,[1] LA has become increasingly popular, and several large-scale randomized controlled trials comparing LA and open appendectomy have been conducted.[2,3] These studies have shown that LA contributes to a reduction in postoperative pain, a shorter hospital stay, and a decrease in the postoperative complications that occur with open appendectomy.

Increasing numbers of SILS-LA have been reported, and surgeons have hoped that in comparison to 3-port surgery, SILS-LA would reduce postoperative pain and improve the cosmetic outcomes. In a systematic review of retrospective studies, however, no significant difference was found between CLA and SILS-LA in outcome variables such as operation

Table 1 Patient characteristics and surgical outcomes per operative method

	POP-SILS LA (n = 77)	Multiports (n = 35)	*P* value
Age, y	26 (9–83)	36 (11–87)	<0.01
Sex, male/female	32/45	22/13	0.04
Type of appendicitis			
Uncomplicated	60	11	
Complicated	17	24	<0.01
Operation time, min	54 (23–209)	78 (22–164)	<0.01
Postoperative stay, d	3 (1–13)	5 (2–14)	<0.01

time, blood loss, time to first oral intake, postoperative pain, and postoperative complications.[4] Qiu *et al*[5] reviewed 15 studies and reported that SILS-LA actually takes longer to perform than CLA and that SILS-LA yields no benefit over CLA in such outcome variables as postoperative pain and cosmesis. In a randomized controlled trial comparing CLA and SILS-LA, the reported operation time was longer with SILS-LA, but the pain was decreased, and no difference was found in the complication rate.[7] To the contrary, Lee *et al*[8] reported no difference between the 2 procedures in operation time, complication rate, postoperative pain, cosmesis, or patients' postoperative satisfaction. In a very recent study,[9] superiority of SILS-LA was not substantiated. To the contrary, SILS-LA resulted in more pain and increased operation time without improving short-term recovery or complications.[9]

The umbilical wound in patients treated by SILS-LA tends to be larger than that in patients treated by CLA and might explain the greater postoperative pain. Furthermore, deformation of the natural umbilicus affects patients' satisfaction with the cosmetic outcome. Single port laparoscopic surgery has been introduced into both cholecystectomy and colectomy, and cosmetic superiority has been reported[10]; but in appendectomy, the target organ

Table 2 Patient and operative details per type of appendicitis

	Simple[a] (n = 71)	Complicated[b] (n = 41)	*P* value
Age, y	25 (9–84)	38 (11–87)	<0.01
Sex, male/female	27/44	27/14	<0.01
Operation time, min	54 (22–117)	78 (84–209)	<0.01
Postoperative stay, d	3 (1–14)	7 (2–14)	<0.01
Operative method			
POP-SILS LA	60	17	
Multiport	11	24	<0.01

[a]Simple (uncomplicated) appendicitis.

[b]Complicated appendicitis.

Table 3 Patient and operative details per type of appendicitis in the POP-SILS LA group

	Simple[a] (n = 60)	Complicated[b] (n = 17)	*P* value
Age, y	23 (9–83)	32 (13–69)	0.051
Sex, male/female	22/38	10/7	0.1
Operation time, min	53.5 (23–117)	76 (34–209)	<0.01
Postoperative stay, d	3 (1–9)	7 (2–13)	<0.01

[a]Simple (uncomplicated) appendicitis.

[b]Complicated appendicitis.

is smaller. In pediatric patients, the appendix can be exteriorized via the umbilical wound, and thus laparoscopy-assisted appendectomy can carried out with only 1 or 2 ports inserted through the umbilical incision[11]; but in adult patients, at least 3 ports must be inserted through the umbilical incision, and thus the umbilical incision is made much larger than would otherwise be necessary for extraction of the appendix. In fact, for 3-channel multiport access in cases of SILS-LA, the umbilical fascia opening must be approximately 2.5 to 3.0 cm in diameter.[8] To avoid this problem, we insert only two 5-mm ports through the umbilicus, meaning that the skin incision can be less than 1.5 cm in diameter for the method we report herein, and we can hide the surgical scar in the bottom of the umbilicus because the wound is relatively small in diameter. Thus, in comparison to the umbilical scar that results from 3-port SILS-A, the umbilical scar that results from POP-SILS-LA is much improved. The needle instruments, such as End-Relief and Mini-Loop Retractor, serve as assistant forceps that are manipulated through 1 puncture at the pubic line. The scar resulting from the third (left-hand) port shrinks over time and is nearly invisible several months after the surgery[12] if we use a needle instrument as assistant forceps instead of a traditional 5-mm port (Fig. 5a, 5b).

Quite recently there have been reports of laparoscopic cholecystectomy achieved with needle instruments, and the usefulness of needle instruments

Table 4 Postoperative complications per operative method

	POP-SILS LA (n = 77)	Multiport (n = 35)	*P* value
Subileus	2	2	
Respiratory failure		1	
Surgical site infection	1	1	
Total, n (%)	3 (3.9%)	4 (11.4%)	0.10
Conversion[a]	2	1	

[a]Conversion to open surgery.

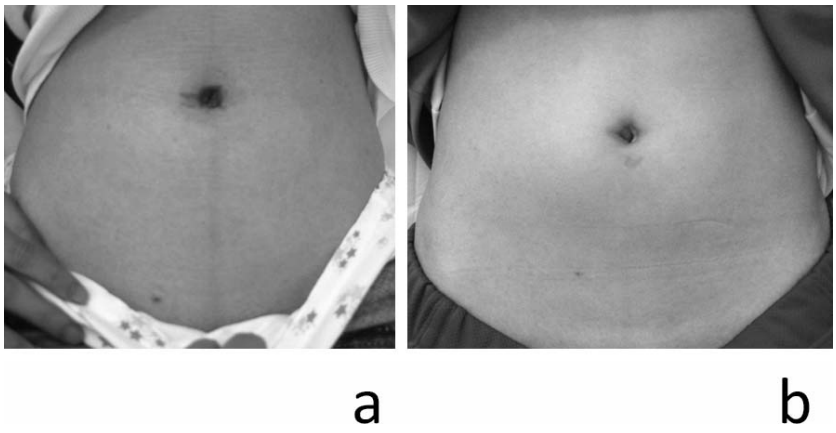

Fig. 5 Photographs of the surgical scar in a 13-year-old child, 140 cm in height, 5 days after the surgery (a), and 2 months after the surgery (b). The scar left by the needle instrument is barely visible, and deformation of the navel is only slight.

rather than traditional 5-mm ports is gradually gaining recognition.[13,14] There have been some reports of the use of percutaneous suture or wires to assist with LA,[15,16] but until now there has been no report of the use of a needle device to assist with LA.

Because the operator uses the needle instrument with the left hand, apart from the instrument used with the right hand at the umbilicus, the instruments are not viewed in parallel. With the POP-SILS-LA method, the operator can maintain instrument triangulation from the start to the end of surgery, and the operation is therefore easy enough that less experienced operators like 1- or 2-year residents can accomplish the procedure safely. Single port laparoscopic appendectomy sometimes requires more time than CLA, and it has resulted in a higher technical failure rate because of the level of difficulty.[17] Nevertheless, in our patient series, the time required for the POP-SILS-LA procedure in simple appendicitis cases did not differ from times reported for CLA,[2–4,18–20] even though more than half of the procedures were completed by residents as the first operator under the guidance of an instructor. In our patient series, both operation time and postoperative hospital stay were shorter after POP-SILS-LA than after multiport LA. This could be because a greater number of simple appendicitis cases were treated by POP-SILS-LA than by multiport LA. We tend to choose CLA or additional ports in cases of severe inflammation, and our cases of complicated appendicitis were the ones that required the longer operation times and longer postoperative stays, like cases previously reported.[18–20]

Our patients suffered only mild complications. Two cases of subileus were caused by adhesions of the small intestine, and those improved within a few days. Because the postoperative complication rate was the same in POP-SILS-LA cases as it was in multiport LA cases, POP-SILS LA was shown to be at least as safe as CLA.

In conclusion, our study showed that our novel POP-SILS-LA technique is feasible, safe, and beneficial. Furthermore, the POP-SILS-LA scar seems to be less visible than the CLA or SILS-A scar. To further validate the usefulness of this procedure, a randomized controlled trial is needed.

Acknowledgments

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