Single-port laparoscopic appendectomy versus conventional laparoscopic appendectomy for acute appendicitis: a randomized controlled trial

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Background
Conventional laparoscopic appendectomy (CLA) is currently the gold standard operation for acute appendicitis even in cases of complicated appendicitis. Recently, advances in laparoscopic instruments enabled surgeons to perform intra-abdominal operations through a single incision around the umbilicus, in particular, single-port laparoscopy.
Patients and methods
This randomized, controlled open-label trial was conducted on 46 cases aged 20–45 years of both sexes, American Society Anesthesiologist physical status I and II diagnosed with acute appendicitis. Cases were classified into two equal groups: group single-port laparoscopic appendectomy (SPLA) (n=23) who underwent SPLA and group CLA (n=23) who underwent CLA.
Results
The mean operative time was significantly longer in the SPLA technique compared with CLA ($P<0.001$). Hospital stay and pain scores were insignificantly different between both groups. Postoperative cosmetic satisfaction was significantly higher in the SPLA group compared with the CLA group ($P<0.001$). Postoperative complications were insignificantly different between both groups. Surgical site infection occurred in 9.52% of patients in the SPLA group and 4.35% of patients in the CLA group. Readmission due to ileus did not occur in the SPLA group, and 4.35% of patients were in the CLA group.
Conclusions
SPLA technique presented better patient cosmetic satisfaction while taking longer operation time compared with CLA. Both techniques were comparable in postoperative pain, hospital stay, and complications.

Keywords:
appendectomy, laparoscopic, single port

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Introduction

Appendicitis is the inflammation of the cecal appendix caused by a luminal blockage by a fecalith [1].

Appendicitis is the most common cause of acute abdominal pain. Appendectomy can be done either open or laparoscopic appendectomy. Today, laparoscopic appendectomy is commonly used. Conventional three-port laparoscopic appendectomy (CLA) is risk-free and effective [2].

Reducing laparoscopic ports aimed to improve cosmetic outcomes [3] and decrease abdominal wall trauma [4].

Single-port laparoscopic appendectomy (SPLA) involves only a single incision and has numerous reported techniques, either at the right iliac fossa [5] or the suprapubic region [6]. The most popular was a single incision at the umbilicus [7].

SPLA represents a demanding method from an ergonomic perspective that has not yet acquired universal approval in the surgical community. It offers a limited operating field for the assistant and the operating surgeon [8], resulting in operator frustration and fatigue [9].

This randomized, controlled, single-center study was designed to compare the efficacy of single-port versus CLA in patients with acute appendicitis.

Patients and methods

This randomized controlled open-label trial was conducted on 46 cases aged from 20 to 60 years of

both sexes, American Society Anesthesiologist physical status I and II diagnosed with acute appendicitis.

The research was conducted between May 2021 and May 2022 at Tanta University Hospitals, Egypt, with permission from the Ethical Committee. An informed written consent was obtained from all patients.

Appendicitis was diagnosed based on the following criteria: right iliac pain, shifting pain from the umbilicus, nausea, a low-grade fever more than 37.3°C, elevated white blood cells of more than 10 000 cells per milliliter, and right iliac tenderness. Besides, pelvi-abdominal ultrasound and computed tomography were used to confirm the diagnoses.

Exclusion criteria included patient refusal of laparoscopic surgery, intra-abdominal abscess diagnosed by abdominopelvic computed tomography or sonography, cirrhotic patients, septic shock, pregnancy, and appendiceal tumor.

Randomization was conducted utilizing sealed envelopes. Cases were classified into two equal groups: SPLA (a group that underwent SPLA) and CLA (a group that underwent CLA).

All operations were done under general anesthesia; preoperative intravenous antibiotics prophylaxis 1 g ceftriaxone and 500 mg metronidazole were administered within 1 h from the skin incision.

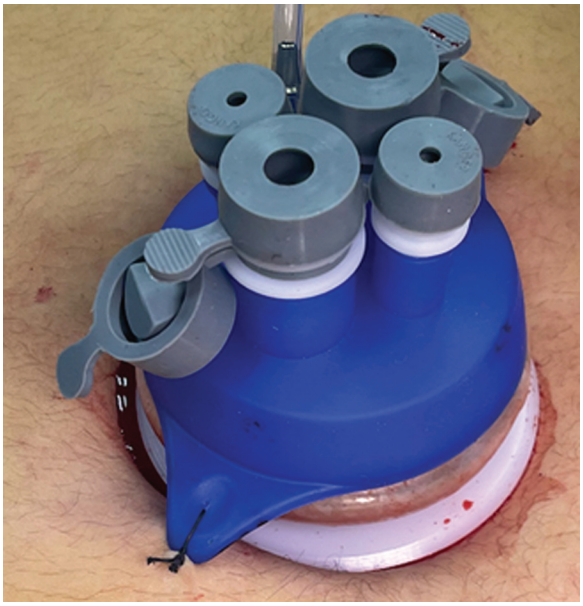
Conventional laparoscopic appendectomy

A circumumbilical incision was followed by Veress needle insufflation and placement of a 10 mm trocar. The abdominal cavity was insufflated with CO_2 at 12 mmHg pressure. A 10 mm, 30° lens camera was introduced through the 10 mm trocar. Two additional 5 mm trocars were introduced, one suprapubic and the other in the left iliac fossa. The patients were placed in the Trendelenburg position, with the right side elevated. A grasper was introduced through the 5 mm suprapubic port and the sealing device was inserted through the left iliac 5 mm port. The mesoappendix was sealed. The appendiceal base was ligated with an extracorporeal Vicryl zero Roeder knot and slid using a knot pusher. The appendix was cut with scissors. Then, it was extracted with a clamp through the 10 mm trocar. Finally, we repaired the fascial defect using Vicryl zero sutures and skin with subcuticular Vicryl 4–0 sutures.

Single-port laparoscopic appendectomy

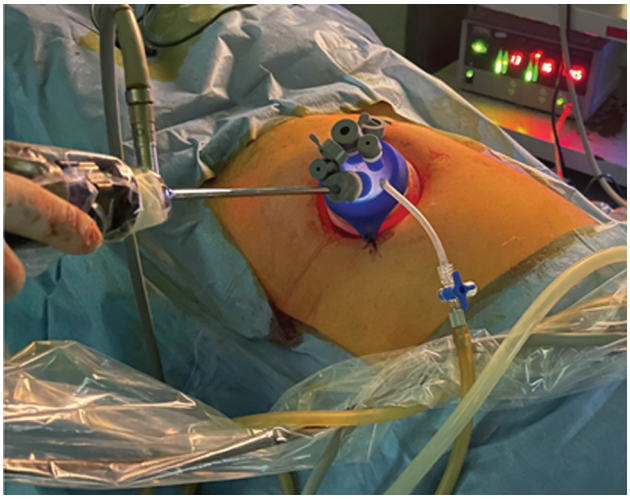
We utilized an single-incision laparoscopic surgery multitrocar port (Fig. 1), comprising an outer covering cap and an inner transparent sheath. The cap has four ports: two 5 mm and two 10 mm (reducible to 5 mm). The inner sheath is surrounded by a plastic ring and a flexible self-expanding ring allowing the port's base to remain within the peritoneum (Fig. 2). The tissues were dissected to the fascia through a 2.5 cm curved supraumbilical incision. On the umbilical raphe of the midline fascia, a Kocher clamp was placed and then a 1.5 cm vertical fascial incision was made. The single port's internal flexible ring was folded to enter the abdominal cavity. The transparent sleeve was pulled up and rolled over to tighten the plastic ring against the inner

Figure 1



SILS port. SILS, single-incision laparoscopic surgery.

Figure 2



SPLA technique. SPLA, single-port laparoscopic appendectomy.

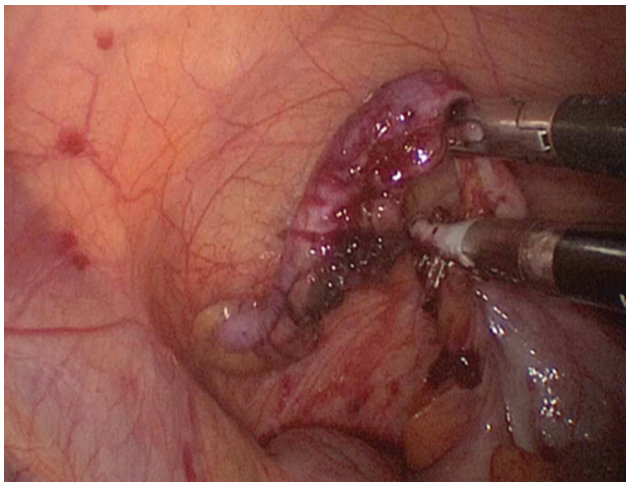
abdominal fascia. The covering cap was placed, and two skin stitches were taken at 6 and 12 o'clock positions to secure it to the underlying skin. The pneumoperitoneum was achieved with a predetermined 12–14 mmHg. Patients were positioned in the Trendelenburg position with the right side elevated. A 5 mm 30° lens, 5 mm grasper, and a 5 mm sealing device were introduced.

The cecal appendix and its mesentery were optimally visualized. Using the sealing device, the mesoappendix was sealed (Fig. 3). The base of the appendix was ligated with an extracorporeal Vicryl zero Roeder knot and slid with a knot pusher (Fig. 4). Using scissors, the appendix was sectioned off. Irrigation and suction were done, if necessary. The sectioned appendix was subsequently extracted through the single port using a clamp (Fig. 5). Finally, we repaired the fascial defect with interrupted Vicryl 0 sutures and the skin with Vicryl 4-0 subcuticular sutures (Fig. 6).

All patients received antiemetic, antibiotic, intravenous, and paracetamol 500 mg injections during the postoperative period. All patients received 8 mg of Lornoxicam intravenously on demand. After 6 h, the oral diet was typically reintroduced, beginning with a clear fluid. Patients were discharged when they could tolerate a soft diet, their pain score was less than 3, and there were no surgical complications. Patients were followed up early for 14 days after discharge and lately after 6 months of surgery.

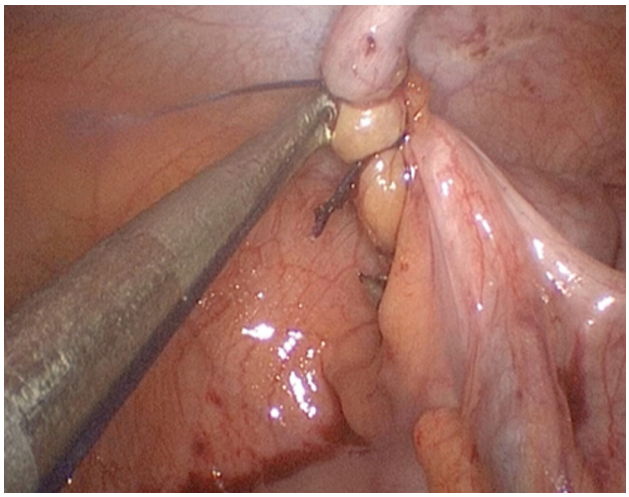
Operative time was recorded from the initial skin incision to the final suture placement. Conversion, intraoperative complications, and pathologies were recorded. During the early postoperative care period, postoperative pain by the numerical rating scale

Figure 3



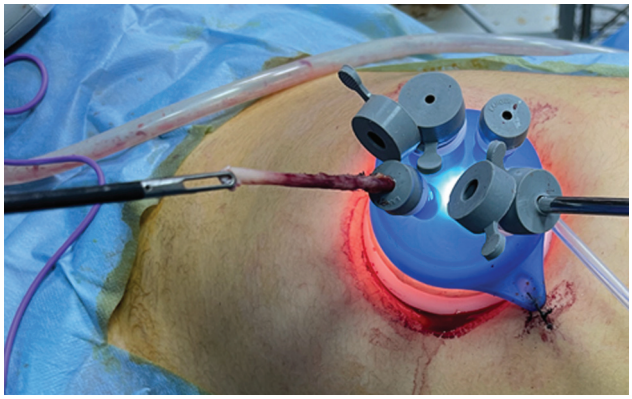
Sealing of the mesoappendix.

Figure 4



Ligation of the base of the appendix.

Figure 5



Extraction of the appendix.

Figure 6

Skin closure.

ranging from 0 (no pain) to 10 (worst pain) at 12 and 24 h and length of hospital stay were recorded.

During early postoperative follow-up, complications such as ileus and intra-abdominal fluid collection, surgical site infection, and readmission rate were recorded.

During the late follow-up in the outpatient clinic 6 months after surgery, complications such as hernia were evaluated. Also, cosmetic satisfaction was assessed by a numeric rating scale.

The primary outcome was patient cosmetic satisfaction. The secondary outcomes were operative time, postoperative pain scores, lengths of hospital stay, and surgical complications.

Sample size calculation

G*Power 3.1.9.2 (Universitat Kiel, Kiel city, Germany) was used to determine the sample size. The sample size was based on a 1.073 effect size, 95% confidence limit, and 90% power of the study, group ratio 1 : 1, and the mean±SD of cosmetic satisfaction (our primary outcome) was 8.6±0.9 in SPLA and 7.4±1.3 in CLA according to a previous study [10]. Three cases were added to overcome dropout. Therefore, 23 patients were recruited in each group.

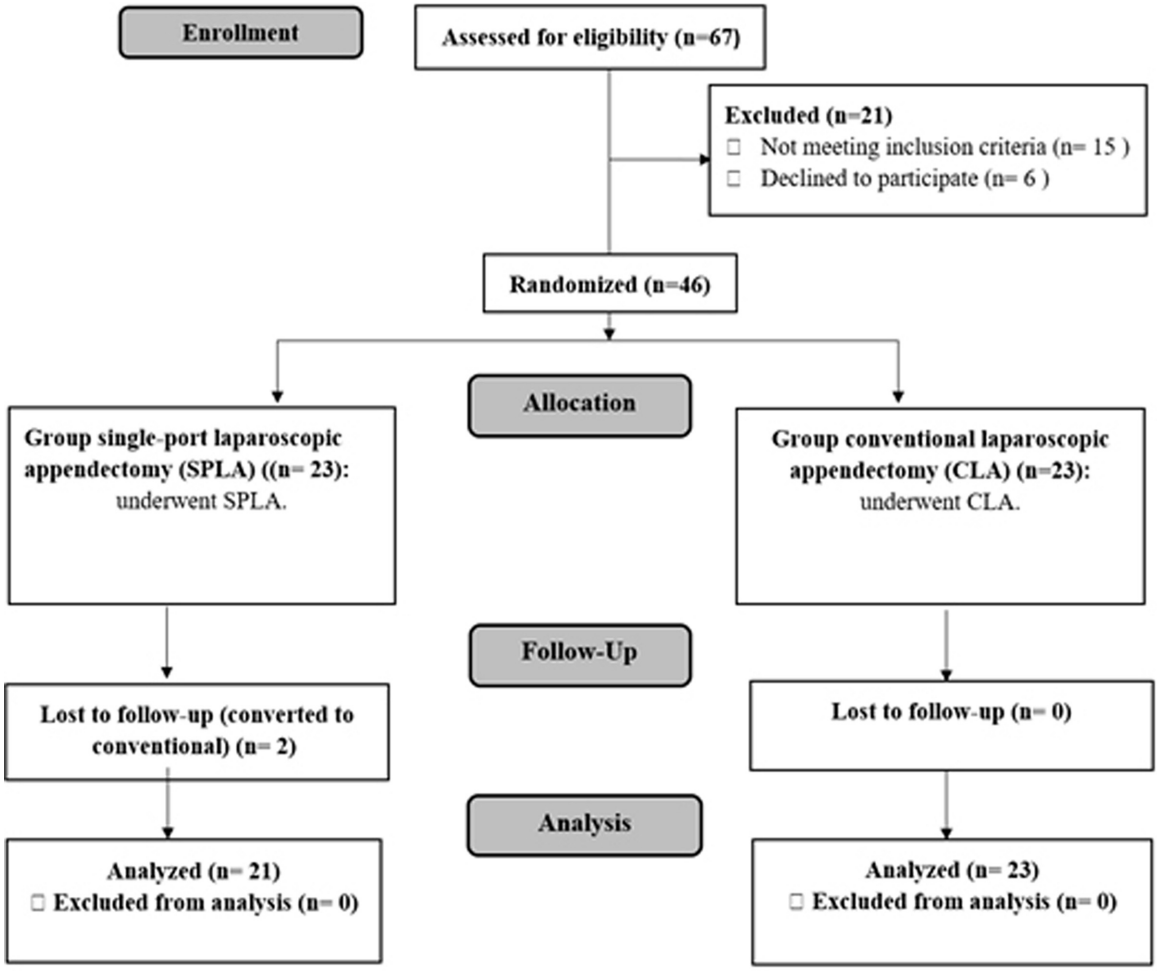
Statistical analysis

IBM's SPSS v26 (Chicago, Illinois, USA) was utilized to conduct the statistical analysis. The normality of data distribution was verified using the Shapiro–Wilks test and histograms. The unpaired Student's t test was used to evaluate quantitative parametric data as mean and SD. The χ^2 and Fisher's exact tests were used to examine qualitative data as frequencies and percentages. A P value of 0.05 was considered statistically significant for two tails.

Results

In this trial, 67 cases were evaluated for eligibility; 21 were excluded from the study (15 did not meet the

Figure 7



CONSORT flow diagram of the enrolled patients.

inclusion criteria, and six refused to participate). Due to adhesions and appendicular abscess, two patients in the SPLA group were converted to CLA and dropped out. Therefore, 21 cases from the SPLA group and 23 cases from the CLA group were analyzed (Fig. 7).

Demographic data and preoperative laboratory investigations did not differ significantly between the two groups (Table 1).

The mean operative time±SD for SPLA was 76.4 ±8.27 min compared with 52.0±7.4 min for CLA. The SPLA technique required significantly more time to perform than the CLA technique ($P<0.001$).

The mean±SD postoperative cosmetic satisfaction for the SPLA technique was 9.33±0.91 compared with 8.61±1.11 for the CLA technique. The SPLA group reported significantly greater postoperative cosmetic satisfaction compared with the CLA group ($P<0.001$).

Hospitalization duration and pain scores at 12, 24, and 48 h did not differ significantly between the two groups (Table 2).

Postoperative pathology did not differ significantly between the two groups (Table 3).

Concerning complications, ileus did not occur in the SPLA group, whereas one patient (4.35%) in the CLA group experienced ileus ($P=1.00$). Surgical site infection occurred in two (9.52%) patients in the SPLA group and one (4.35%) patient in the CLA group ($P=0.598$). In the SPLA group, no patients were readmitted due to ileus, while one (4.35%) patient in the CLA group was treated conservatively. Hernia at the port site occurred in one (4.8%) of the SPLA patients but in none of the CLA patients. Both groups lacked intra-abdominal collection, intra-abdominal abscess, and return to the operating room (Fig. 8).

Table 1 Patient characteristics and preoperative investigations

	Group SPLA (*N*=21)	Group CLA (*N*=23)	*P* value
Age (years)	29.91±6.93	32.39±7.88	0.264
Sex			
Male	15 (71.43)	11 (47.83)	0.112
Female	6 (28.57)	12 (52.17)	
Weight (kg)	72.76±8.5	70.91±7.25	0.441
Height (m)	1.69±0.04	1.68±0.04	0.537
BMI (kg/m^2)	25.58±3.1	25.15±2.58	0.619
ASA physical status			
I	16 (76.19)	19 (82.61)	0.598
II	5 (23.81)	4 (17.39)	
Hypertension	8 (34.78)	10 (43.48)	0.717
Preoperative investigations			
C-reactive protein	16.48±4.51	15.48±6.05	0.542
Hemoglobin	11.47±0.77	11.63±0.96	0.522
White blood cells	10.82±1.77	11.38±1.71	0.297

Data are presented as mean±SD and *n* (%). ASA, American Society Anesthesiologist; CLA, conventional laparoscopic appendectomy; SPLA, single-port laparoscopic appendectomy.

Table 2 Operative time, hospital stay, and pain score

	Group SPLA (*N*=21)	Group CLA (*N*=23)	*P* value
Operative time (min)	76.43±8.27	52.7±7.47	<0.001
Hospital stay (min)	23.09±7.08	24.48±7.42	0.519
Time to pass flatus	11±0.84	11.35±0.71	0.144
Analgesic requirements /ampule	2 (2–2.5)	2 (2–3)	0.307
Numerical rating scale			
12 h	2.24±0.83	2.57±0.73	0.171
24 h	1.62±0.59	1.78±0.6	0.368
Cosmetic satisfaction	9.33±0.91	8.61±1.11	<0.001

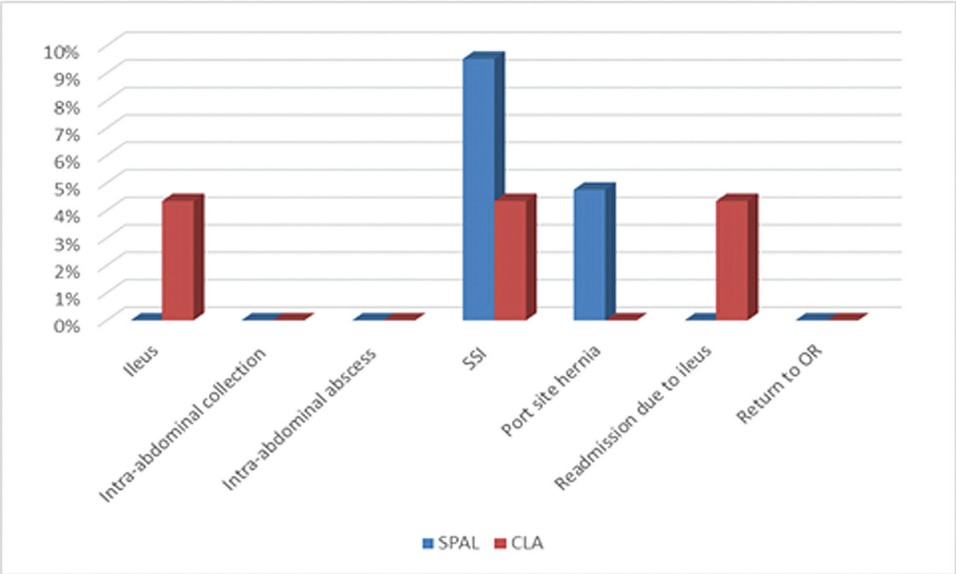
Data are presented as mean±SD. CLA, conventional laparoscopic appendectomy; SPLA, single-port laparoscopic appendectomy.

Table 3 Postoperative pathology

	Group SPLA (*N*=21)	Group CLA (*N*=23)	*P* value
Catarrhal appendicitis	13 (61.9)	12 (52.17)	
Suppurative appendicitis	7 (33.33)	10 (43.48)	0.705
Perforated appendicitis	1 (4.76)	0	
Peri-appendiceal abscess	0	1 (4.35)	

Data were presented as *n* (%). CLA, conventional laparoscopic appendectomy; SPLA, single-port laparoscopic appendectomy.

Figure 8



Complications of the studied groups. OR, operating room; SSI, surgical site infection.

Discussion

In this study, SPLA had a lower postoperative pain score at 12 and 24 h, but these differences were not statistically significant (*P*=0.172 and 0.192, respectively).

These results are comparable with the results reported by Kim *et al.* [11], which showed insignificant pain score differences at 48 and 27 h with a *P* value of 1.000.

These results are comparable with the results reported by Lee *et al.* [12], which showed a lower pain in SPLA at 24 h, which was statistically insignificant with a *P* = 0.555.

These findings are comparable with the results reported by Park *et al.* [13], which showed a higher pain in SPLA, but it was statistically insignificant with a *P* value of 0.318, justified by a significant fascial defect at the umbilicus.

Also, results reported by Teoh *et al.* [14] showed a higher pain in SPLA, which was statistically insignificant, *P*=0.253, justified by a sizeable fascial defect at the umbilicus.

These results were inconsistent with those reported by Duza *et al.* [2], who found a statistically significant reduction in SPLA pain within 12 h (*P*=0.000).

In this study, there was no statistical difference in analgesic requirement between groups (*P*=0.307). These results were comparable with the findings of Lee *et al.* [12], with a *P* value of 0.776, and those of Park *et al.* [13], who found a nonsignificant difference in analgesic requirements at 24 h (*P*=0.200).

In this study, cosmetic satisfaction was significantly higher with SPLA than with CLA, with a *P* value less than 0.001. These findings were comparable with Sozutek *et al.* (15), who found a statistically significant (*P*=0.001) improvement in cosmetic satisfaction in SPLA.

These findings were inconsistent with those reported by Duza *et al.* [2] and Lee *et al.* [12], who found a

statistically insignificant improvement in cosmetic satisfaction with a *P* value of 0.07 and 0.128, respectively.

In this study, hospital stay showed a shorter stay in SPLA, which was statistically insignificant (*P*=0.519). These results were comparable to those reported by Park *et al.* [13], who demonstrated a shorter hospital stay in SPLA with a statistically insignificant (*P*=0.215). These findings were comparable to those of Kang *et al.* [16] and Cho *et al.* [17], who found a statistically insignificant longer hospital stay in SPLA (*P*=0.240 and 0.791, respectively). Those results differed from those reported by Duza *et al.* [2], who found a statistically significant (*P*=0.000) shorter hospital stay in SPLA.

In this study, operative time was statistically significantly longer in SPLA than in CLA (*P*<0.001). These results were comparable to those reported by Liao *et al.* [18] and Kim *et al.* [11], who demonstrated a statistically significant longer operative time in SPLA (*P*=0.048 and 0.001, respectively). However, these results were inconsistent with results reported by Sozutek *et al.* [15] and Lee *et al.* [12], which showed longer operative time in SPLA, which was statistically insignificant with a *P* value of 0.172 and 0.845, respectively.

These results were also different from the results reported by Park *et al.* [13], which showed a shorter operative time in SPLA which was statistically insignificant with a *P* value of 0.318.

Also, Vahdad *et al.* [19], demonstrated a significantly shorter operative time in SPLA (*P*=0.04).

In our opinion, unlike multiport laparoscopic surgery, SPLS involves loss of triangulation and complicated instrumentation. SPLS necessitates that the surgeon and the assistant maintain an ergonomically undesirable position in contrast to conventional laparoscopic surgery. SPLS may be more difficult than CLA, with a longer operative duration, and therefore, a lengthy learning curve.

In this study, comparing SPLA and CLA, the incidence of complications was insignificant.

These results were comparable with those reported by Sozutek *et al.* [15] and Vahdad *et al.* [19], which showed no statistical difference between both groups with a *P* value of 0.433 and 1.0, respectively.

Conclusion

Laparoscopic appendectomy can be performed using both CLA and SPLA procedures. SPLA technique presented better patient cosmetic satisfaction while taking longer operation time compared with CLA. Both techniques were comparable in postoperative pain, hospital stay, and complications. We recommend continuing a multicenter study with a much larger volume of cases to obtain clear results on the safety and applicability of SPLA.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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