Risk factors for additional port insertion in single-port laparoscopic appendectomy

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Abstract
Introduction: Single-port laparoscopic appendectomy (SPLA) was expected to have reduced risk of wound infection, less postoperative pain, and improved patient’s satisfaction with better cosmesis compared with conventional laparoscopic appendectomy (CLA). When SPLA is converted to CLA, the additional incision for another port insertion can lead to a decrease in the surgical advantages and clinical benefit.

Aim: To evaluate risk factors for conversion to CLA during SPLA.

Material and Methods: Between August 2015 and December 2016, patients who underwent intended SPLA were retrospectively reviewed. Conversion was defined as any insertion of an additional port, and complicated appendicitis was defined as gangrenous or perforated appendicitis, abscess, or peritonitis in preoperative computed tomography. Postoperative complication was defined as any deviation in the routine postoperative course within 30 days postoperatively.

Results: Of 409 patients, 65 (15.9%) were treated with additional port insertion. The overall complication rate was 1.5% in each group, of which 1 patient developed superficial SSI and 4 patients developed deep surgical site infections in the SPLA group. After univariable and multivariable analysis, old age, male sex, increased serum C-reactive protein (OR = 2.944; 95% CI: 1.433–6.047; p = 0.003), and complicated appendicitis (OR = 3.330; 95% CI: 1.304–8.503; p = 0.012) were significant risk factors for conversion to CLA.

Conclusions: The conversion rate to CLA was 15.9%. Serum C-reactive protein level and complicated appendicitis were strong predictive factors for conversion from SPLA in acute appendicitis.

Key words: appendectomy, risk factors, laparoscopy, appendicitis, single port, conversion.

Introduction
Laparoscopic appendectomy has been recognized as the gold standard for treatment of acute appendicitis. Numerous studies have reported that laparoscopic appendectomy provides better cosmetic benefits, less postoperative pain, and short recovery time compared with open appendectomy [1–3]. According to the development of minimally invasive surgery, single-port laparoscopic appendectomy (SPLA) has been widely adopted. Compared with conventional laparoscopic appendectomy (CLA), it was expected to have reduced risk of wound infection due to fewer port sites, faster recovery, less postoperative pain, and improved patient’s satisfaction with better cosmesis because of a single wound site. Numerous institutions have also reported its safety and feasibility including...
many studies comparing SPLA with CLA using multiple ports [4–7].

Despite advances in laparoscopic surgical techniques, several factors are required to convert SPLA to CLA [7, 8]. The suggested reasons for conversion were technical difficulty including adhesion, retroperitoneal location of the appendix, bleeding, and stump amputation [8]. When SPLA is converted to CLA, the additional incision for another port insertion can lead to a decrease in the surgical advantages and clinical benefit. However, there are few data and studies on the risk of conversion or port addition in SPLA, and no definite indication criteria for SPLA application have been established.

Aim

The aim of this study was to evaluate the risk factors for conversion to CLA from SPLA in acute appendicitis.

Material and methods

All of the patients who were diagnosed with acute appendicitis underwent attempted SPLA in Chung-Ang University Hospital. Between August 2015 and December 2016, a total of 409 consecutive patients who were diagnosed with acute appendicitis and initially underwent SPLA were included in this study. This study was reviewed and approved by the institutional review board committee of the Chung-Ang University Hospital (IRB No. 1708-002-16087).

Laparoscopic appendectomy was initially performed by umbilical single-port procedure using a glove port (Nelis, Bucheon, Korea) documented in a previous report [9]. Under the pneumoperitoneum with intra-abdominal pressure of 12 mm Hg, 5-mm straight and 30º-angled laparoscopes were used. The appendiceal base was ligated with 2 applications of Vicryl Endoloop. When inflammation was present at the appendiceal base, cecectomy was performed using a linear stapler (Endo GIA; Medtronic, Seoul, Korea) according to the intraoperative decision of the operator. Conversion to CLA was defined as any additional port insertion during SPLA [10]. The use of antibiotics in our institution was described in a previous study [11].

The clinical characteristics including age, sex, American Society of Anesthesiologists score, body mass index, underlying comorbidities, previous abdominal surgery, preoperative laboratory results, and perioperative data were retrospectively reviewed. Complicated appendicitis was defined as gangrenous or perforated appendicitis or if abscess formation was found in the preoperative image, regardless of the presence of fluid collection [10]. Postoperative complication was defined as any deviation in the routine postoperative course within 30 days postoperatively. Patients who had surgical site infections (SSIs) were classified into two groups according to the guideline from the Centers for Disease Control and Prevention: superficial SSI and organ/space SSI [12]. All postoperative intra-abdominal abscesses were included as organ/space SSIs.

Statistical analysis

Continuous variables were reported as mean and standard deviation. Non-continuous variables were reported as numbers and frequencies. To evaluate the risk factors for conversion to CLA, differences in clinicopathologic characteristics were evaluated between the two groups (SPLA and conversion group) using the χ² test, Fisher’s exact test, and Student’s t-test, depending on the nature of the variables. In multivariable analysis, binary logistic regression analysis was used for variables with p-values < 0.05 on univariate analysis. All statistical analyses were performed using SPSS software (version 20.0, SPSS, Inc., Chicago, IL, United States).

Results

Of 409 patients who were initially treated with SPLA for acute appendicitis, 65 (15.9%) underwent laparoscopic appendectomy with additional port insertion. There was no case converted to open surgery. The reasons for additional port insertion were the following: severe inflammation in 59 (90.8%) patients, adhesion in 3 (4.6%) patients, and extended surgery in 3 (4.6%) patients. Age, sex, body mass index, underlying comorbidities, and complicated appendicitis were different between the SPLA and conversion groups (Table I). Single-port laparoscopic appendectomy was often performed in younger and female patients (75.0% vs. 56.1%, respectively). In terms of preoperative laboratory results, lymphocyte count and C-reactive protein level were significantly higher in the SPLA group.

Table II presents the operative data and surgical outcome between the SPLA and conversion groups. Cecectomy and colectomy were usually performed...
### Table I. Clinical characteristics between the SPLA and conversion groups

| Characteristics                        | SPLA (n = 344) | Conversion (n = 65) | P-value |
|----------------------------------------|----------------|--------------------|---------|
| Age, mean ± SD [years]:                |                |                    | < 0.001 |
| < 40, n (%)                            | 258 (75.0)     | 35 (53.8)          | 0.001   |
| ≥ 40, n (%)                            | 86 (25.0)      | 30 (46.2)          |         |
| Sex, n (%):                            |                |                    | 0.004   |
| Male                                   | 151 (43.9)     | 41 (63.1)          |         |
| Female                                 | 193 (56.1)     | 24 (36.9)          |         |
| ASA, n (%):                            |                |                    | 0.067*  |
| 1, 2                                   | 343 (99.7)     | 63 (96.9)          |         |
| ≥ 3                                    | 1 (0.3)        | 2 (3.1)            |         |
| BMI, n (%):                            |                |                    | 0.004   |
| < 25 kg/m²                             | 278 (80.8)     | 42 (64.6)          |         |
| ≥ 25 kg/m²                             | 66 (19.2)      | 23 (35.4)          |         |
| Underlying comorbidities, n (%):       |                |                    | < 0.001 |
| No                                     | 249 (72.4)     | 30 (46.2)          |         |
| Yes                                    | 95 (27.6)      | 35 (53.8)          |         |
| Previous laparotomy, n (%):            |                |                    | 0.929   |
| No                                     | 303 (88.1)     | 57 (87.7)          |         |
| Yes                                    | 41 (11.9)      | 8 (12.3)           |         |
| Delayed appendectomy, n (%):           |                |                    | 0.308*  |
| No                                     | 339 (98.5)     | 63 (96.9)          |         |
| Yes                                    | 5 (1.5)        | 2 (3.1)            |         |
| Complicated appendicitis, n (%):       |                |                    | 0.001*  |
| No                                     | 330 (95.9)     | 54 (83.1)          |         |
| Yes                                    | 14 (4.1)       | 11 (16.9)          |         |
| WBC, mean ± SD [/μl]:                  |                |                    | 0.911   |
| < 10000/μl, n (%)                      | 90 (26.2)      | 20 (30.8)          | 0.442   |
| ≥ 10000/μl, n (%)                      | 254 (73.8)     | 45 (69.2)          |         |
| Segment neutrophil, mean ± SD [/μl]†   | 9805 ±4074     | 9969 ±4339         | 0.768   |
| Lymphocyte, mean ± SD [/μl]            | 1818 ±791      | 1597 ±685          | 0.036   |
| Hemoglobin, mean ± SD [g/dl]           | 13.7 ±1.6      | 13.9 ±1.6          | 0.413   |
| Platelet, mean ± SD [10³/μl]           | 259 ±65        | 241 ±74            | 0.042   |
| C-reactive protein, mean ± SD [mg/l]*   | 21.0 ±36.7     | 57.0 ±65.1         | < 0.001 |
| < 5 mg/l, n (%)                        | 151 (43.9)     | 11 (16.9)          | < 0.001 |
| ≥ 5 mg/l, n (%)                        | 190 (55.2)     | 53 (81.5)          |         |

*Fisher’s exact test, †1 case was missing, ‡4 cases were missing. SPLA – single-port laparoscopic appendectomy, ASA – American Society of Anesthesiologists, BMI – body mass index, WBC – white blood cells.
in the conversion group. The overall complication rate was 1.5% in each group, of which 1 patient developed superficial SSI and 4 patients developed deep SSI in the SPLA group. The patients who had deep SSI in the conversion group needed intensive care unit admission. There was no mortality 30 days postoperatively in each group. The duration of the operation, amount of estimated blood loss, and postoperative hospital stay were significantly longer in the conversion group.

In the multivariate analysis model with the significant variables in the univariate analysis, old age (OR = 1.031; 95% CI: 1.014–1.049; p < 0.001), male sex (OR = 2.119; 95% CI: 1.131–3.971; p = 0.019), increased serum C-reactive protein level (OR = 2.944; 95% CI: 1.433–6.047; p = 0.003), and complicated appendicitis (OR = 3.330; 95% CI: 1.304–8.503; p = 0.012) were significant risk factors for conversion to CLA (Table III).

Discussion
This study successfully determined the risk factors for conversion to CLA. There are many studies about the comparison between SPLA and CLA. However, there are few studies about conversion risk factors. Our study is unique in this light and demonstrated that severe inflammation (C-reactive protein...
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and complicated appendicitis) could be a significant risk factor.

C-reactive protein is well known as one of the acute-phase inflammatory proteins [13]. Increased serum C-reactive protein level suggested more intense local inflammatory reaction and severe appendicitis. Increased serum C-reactive protein level has also been reported as a risk factor for conversion to open surgery during laparoscopic appendectomy [14]. In this study, complicated appendicitis was defined as gangrenous or perforated appendicitis. As inflammation proceeded in acute appendicitis, the tissue became edematous and friable with increasing risk of bleeding, and adhesion with the surrounding tissue developed. Studies have reported that complicated appendicitis was a risk factor for conversion to laparotomy in laparoscopic appendectomy [14–16].

Single-port laparoscopic appendectomy has several technical issues. Triangulation with multiple instruments is difficult, and maintenance of the traction-countertraction of the target organ is challenging due to parallel entry of straight instruments and the occasional collision between handles of different instruments [10]. These basic technical issues and severe inflammation might increase the possibility of additional port insertion. In this study, appendectomy was often performed and more perforated appendicitis and abscess formation were identified in the conversion group than the SPLA group. Moreover, the operation time and amount of blood loss were also significantly longer and greater, respectively, in the conversion group.

As seen in previous studies on single-incision operations, the transumbilical single-incision approach is feasible and safe, and there is no greater incidence of complications [4, 17, 18]. One of the advantages of the single-port approach was greater comfort and less pain for patients. This might be achieved by reducing the size of the skin incision and not perforating the aponeurosis in the muscle. The umbilicus, located in the thinnest part of the abdominal wall, makes it easier to insert the multi-entry port, move in all directions, and then close the orifice under direct vision to avoid the possibilities of incisional hernia.

Male sex and old age were the significant risk factors of this study. There are studies reporting that male sex and old age were independent predictive factors for open conversion in laparoscopic appendectomy [14, 15, 19]. Gupta et al. reported that several risk factors including old age, male sex, longer duration of symptoms, and severe inflammation in computed tomography scan were present in combination [16]. In real practice, the operator might have a tendency to keep on performing single-port surgery in young female patients for cosmetic reasons. Moreover, older male patients tend to think that when they first experience abdominal pain, they are more likely to endure abdominal pain than younger women. Therefore, the delayed diagnosis was possible to associate with severe inflammation and conversion to CLA.

In this study, the overall rate of conversion to CLA was 15.9%. Several randomized trials concerning SPLA have reported rates of 8.2–11.1% for additional port insertion [7, 8, 20]. Because our institution was a tertiary referral center and teaching hospital, the overall conversion rate of this study was higher than those of other trials. The staff surgeon performed more conversions to CLA. It means that the resident performed SPLA in relatively easier cases, and the operator was replaced with a staff surgeon in difficult cases.

Obesity has been considered as a difficulty in laparoscopic surgery. However, body mass index was

### Table III. Multivariable analysis of predictive risk factors for conversion to CLA

| Variables                  | Odds ratio | 95% confidence interval | P-value |
|----------------------------|------------|-------------------------|---------|
| Age                        | 1.031      | 1.014–1.049             | < 0.001 |
| Male                       | 2.119      | 1.131–3.971             | 0.019   |
| Body mass index ≥ 25 kg/m² | 1.410      | 0.727–2.733             | 0.309   |
| Lymphocyte                 | 1.000      | 0.999–1.000             | 0.101   |
| Platelet                   | 1.001      | 0.996–1.006             | 0.788   |
| C-reactive protein ≥ 5 mg/l| 2.944      | 1.433–6.047             | 0.003   |
| Complicated appendicitis   | 3.330      | 1.304–8.503             | 0.012   |

CLA – conventional laparoscopic appendectomy.
not a risk factor for conversion to CLA in this study. The bulky mesenteric fat itself did not seem to interfere with the operation field because the appendix located on the right lower quadrant can be easily exposed by a position change of patients. This study indicates that severe inflammation rather than obesity influences the difficulty in completion of SPLA.

The limitation of this study was its retrospective nature. The postoperative complications of this cohort might have been underestimated because our institution had the policy that patients are required to be followed up only once, 1 week after discharge. The rate of complicated appendicitis was lower than that in another large cohort study [21]. Our institution is a tertiary referral center from other clinics, and patients were referred from other clinics with low quality images (CT or USG). Also, ambiguous microperforation that is suspicious discontinuity of appendiceal mucosa and tiny periappendiceal fat stranding might be missed. This study was conducted on a small, single-center, retrospective cohort. Several variables including laboratory results were missing.

Conclusions

Many patients with acute appendicitis are able to undergo SPLA. However, some of them also require conversion to CLA with additional ports. In our study, the conversion rate to CLA was 15.9%. Furthermore, increased serum CRP level and complicated appendicitis were strong predictive factors for conversion to CLA from SPLA in acute appendicitis.

Conflict of interest

The authors declare no conflict of interest.

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