

# Single-Port Laparoscopic and Robotic Cholecystectomy in Obesity (> 25 kg/m<sup>2</sup>)

Eun Jeong Jang, MD, Young Hoon Roh, MD, PhD, Chang Moo Kang, MD, PhD,  
Dong Kyun Kim, MD, PhD, Ki Jae Park, MD, PhD

## ABSTRACT

**Background and Objectives:** Single-port cholecystectomy has emerged as an alternative technique to reduce the number of ports and improve cosmesis. Few previous studies have assessed obesity-related surgical outcomes following single-port cholecystectomy. In this study, technical feasibility and surgical outcomes of single-port laparoscopic cholecystectomy (SPLC) and robotic single-site cholecystectomy (RSSC) in obese patients were investigated.

**Methods:** We conducted a two-center collaborative study and retrospectively reviewed initial experiences of RSSC and SPLC in patients whose body mass index was over 25 kg/m<sup>2</sup>. Medical records of patients were reviewed. Clinical characteristics and short-term oncologic outcomes were considered and compared between SPLC and RSSC groups.

**Results:** RSSC and SPLC were performed in 39 and 78 patients, respectively. In comparative analysis, the total operative time was longer in the RSSC group (109.92 minutes vs. 60.99 minutes;  $P < .001$ ).

However, requiring additional port for completion of surgical procedure was less frequent in the RSSC group (0%

vs. 12.8%;  $P = .029$ ). Immediate postoperative pain score was not significantly different between the two groups (4.95 vs. 5.00;  $P = .882$ ). However, pain score was significantly lower in the RSSC group at the time of discharge (1.79 vs. 2.38;  $P = .010$ ). Conversion to conventional multiport cholecystectomy, intraoperative bile spillage, or complication rate was not significantly different between the two groups ( $P > .05$ ).

**Conclusions:** SPLC and RSSC could be safely performed in selected patients with high body mass index, showing no significant clinical differences.

**Key Words:** Single-port laparoscopic cholecystectomy; Robotic single-site Cholecystectomy; Body mass index.

## INTRODUCTION

Laparoscopic cholecystectomy has been regarded as a first-choice treatment option for benign gallbladder disease.<sup>1</sup> Surgical procedures in general are becoming less invasive due to preferences of both patients and surgeons for reduced surgical scar with improved cosmetic outcomes attributable to minimized incisions. In line with this trend, single-port cholecystectomy by laparoscope and robot has emerged.

Despite its advantages, such as faster recovery and cosmetic results, single-port cholecystectomy has a limitation in that it requires skilled techniques. Those who have severe acute cholecystitis, those who have received previous upper abdominal surgery, and those who are obese are regarded as contraindications in single-port cholecystectomy.<sup>2</sup> In addition, since both hands move within one port, movement is restricted in single-port cholecystectomy. Crossing hands is unnatural to perform the operation. To become familiar with this operation technique, a sufficient learning curve is needed. To overcome this limitation, robotic single-site cholecystectomy (RSSC) has emerged. This operative method seems to overcome technical constraints of traditional single-port laparoscopic cholecystectomy by offering enhanced visualization as a three-dimensional image with improved triangulation and ergonomics.<sup>3</sup> In today's society, obesity is becoming in-

Department of Surgery, Dong-A University College of Medicine, Busan, Korea (Drs Jang, Roh, and Park).

Department of Surgery, Yonsei University College of Medicine, Seoul, Korea (Dr. Kang).

Department of Internal Medicine, Dong-A University Medical center, Busan, Korea (Drs Kang and Kim).

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Address correspondence to: Young Hoon Roh, MD, PhD, Department of Surgery, Dong-A University College of Medicine, 26 Daesingongwon-Ro, Seo-Gu, Busan 49201, Korea. Telephone: 82-51-240-2619, Fax: 82-51-247-9316, E-mail: gsryh@dau.ac.kr or to Chang Moo Kang, MD, PhD, Department of Surgery, Yonsei University College of Medicine 50-1 Yonsei Ro, Seodaemun gu, Seoul, 03722, Korea, Tel: 82-10-8944-9601 Fax: 82-51-247-9316, E-mail: cmkang@yuhs.ac

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creasingly prevalent because of changes in diet and lifestyle. Moreover, surgeons and patients desire for more minimally invasive surgery to improve quality of life and medical safety. This has propelled single-port cholecystectomy to become a new standard operative method.<sup>4</sup> Therefore, outcome of single-port cholecystectomy in obese patients is becoming an important health issue.<sup>5</sup>

Several studies have described the outcome of cholecystectomy in obese patients. Boweling et al<sup>6</sup> have shown obese patients, including morbidly obese patients, have no increased risk of conversion to open surgery or complications compared to normal-weight patients. Readmission rate or length of hospital stay is not significantly influenced by body mass index (BMI) either. However, other studies have suggested that high BMI is directly correlated with longer operative time.<sup>7-9</sup> In addition, obesity itself increases the risk of surgery such as increased morbidity and mortality. It also increases the difficulty of securing vision during surgery. However, no studies have reported outcomes of single-port cholecystectomy by laparoscope (SPLC) and RSSC in patients with high BMI. Therefore, the objective of this study was to retrospectively compare results of SPLC and RSSC in patients with high BMI to determine their technical feasibility and safety in high-BMI patients.

## METHODS

We conducted a two-center collaborative study and retrospectively reviewed medical records of 39 patients who received RSSC at Severance Hospital (Seoul, Korea) between December 2013 and May 2015 and 78 patients who underwent SPLC at Dong-A University Hospital (Busan, Korea) between January 2011 and December 2011. All patients had BMI over 25 kg/m<sup>2</sup>. This criterion was defined using World Health Organization classification cutoff value of obesity for Asian populations. For each group (SPLC or RSSC) of patients, the surgery was performed by one surgeon, respectively. Demographic and clinical information included patient sex, age, BMI, and American Society of Anesthesiologists score. Operative information consisted of the following: preoperative symptoms, preoperative diagnosis, previous abdominal surgery, operative time, console time, estimated blood loss, rate of conversion to open procedure, bile spillage during operation, additional port use, postoperative complications, postoperative pain score, and hospital stay. Pain score was measured with visual analogue scale.

## Surgical-Technique SPLC

A 2.5-cm transumbilical vertical skin incision was made and a multichannel port was used. The laparoscopic camera was then inserted through a 5–10-mm port. The surgeon who performed all procedures was more accustomed to single-port surgery using straight instruments as opposed to dedicated single-port laparoscopic instruments. Therefore, flexible electric hook was the only instrument additionally required. All instruments were the same as those used for conventional laparoscopic cholecystectomy, including a 30° angle rigid laparoscope of 5 mm in diameter. The cystic duct and artery were dissected with a flexible electric hook and a 10-mm Hem-O-Lok clip (Weck Closure System Research Triangle Park, NC, USA) made with Prolene material was used to ligate the cystic duct. The proximal and distal ends of cystic duct were clipped. The cystic artery was ligated with a 5-mm Hem-O-Lok clip and sheared with laparoscopic scissors. Gallbladder was retracted in cephalic dissection, separated from liver bed, and removed directly through the port site. The peritoneum, fascia, and subcutaneous tissue were sutured. However, skin sutures were not required after skin edge was approximated because only a 5-mm vertical incision was visible.<sup>10</sup>

## RSSC

A 2.5–3-cm transumbilical vertical skin incision was made through the midpoint of the umbilicus. The reversed port that had been prepared already was inserted into the abdomen and CO<sub>2</sub> gas was infused via the insufflations port. Initially, an 8.5-mm endoscope was introduced through the camera port. With the guidance of this endoscope, two curved 5-mm cannulas were introduced via the port access and placed at the appropriate position near the gallbladder. After docking was completed, a 5-mm assistant cannula was introduced through the accessory port access which was located on the right side of camera port access in the reverse port. The operator then moved to the surgical console while the assistant surgeon took position on the left side of the patient—an exact mirror image of the conventional technique. At the beginning of the operation, the assistant held the fundus of the gallbladder using a long straight grasper forceps via the assistant port access. Then the operator changed the position of endoscope to below the assistant grasper forceps and advanced, resulting in retraction of the gallbladder in a cephalic and right lateral direction. The operator performed the cholecystectomy using several da Vinci robot instruments, including Maryland dissector, mono-

polar cautery, crocodile grasper, scissors, and Hem-o-Lok clip (Weck Closure System, Research Triangle Park, NC, USA). During the operation, the operator checked the anatomy of the biliary tree using intraoperative infrared fluorescent cholangiography. After the gallbladder was detached from the liver, the gallbladder was removed via the umbilical incision with a 5-mm specimen bag. The fascia defect was closed with continuous absorbable suture and the skin was approximated with subcuticular continuous suture.<sup>11</sup>

### Statistical Analysis

Continuous variables are presented as mean ± SD while categorical variables are described as frequency (%). Student-*t* test and  $\chi^2$  were used for comparative analysis between two groups. All statistical analyses were performed using SPSS 20.0 for Windows (SPSS Inc, Chicago, IL, USA). *P*-values <.05 were considered statistically significant.

## RESULTS

### Demographic Characteristics

A total of 117 patients were included, including 58 males and 59 females. Overall, patient's BMI was estimated as mean kg/m<sup>2</sup>. The most frequent diagnosis was gallbladder stone (86 patients, 73.5%).

In comparative analysis, the proportion of female patients was much higher in the RSSC group than SPLC group (64.1% vs. 43.6%; *P* = .036). Patients in RSSC group was also much younger (42.03 ± 10.72 years vs. 49.76 ± 12.95 years; *P* = .002). BMI was found to be higher in the RSSC group with marginal significance (28.17 kg/m<sup>2</sup> vs. 27.17 kg/m<sup>2</sup>; *P* = .072). In addition, patients with low American Society of Anesthesiologists score were more frequently found in the RSSC group (*P* = .003). However, there were no significant differences in terms of diagnosis of operation history (*P* > .05; **Table 1**).

**Table 1.**  
Demographic Characteristics and Preoperative Data of Patients

	Total	RSSC (N = 39)	SPLC (N = 78)	<i>P</i> -Value
Gender				.036
Male	58 (49.6%)	14 (35.9%)	44 (56.4%)	
Female	59 (50.4%)	25 (64.1%)	34 (43.6%)	
Age (mean ± SD)		42.03 ± 10.720	49.76 ± 12.949	.002
BMI (mean ± SD)		28.17 ± 2.972	27.17 ± 2.278	.072
ASA score				.003
1	36 (30.8%)	20 (51.3%)	16 (20.5%)	
2	63 (53.8%)	15 (38.5%)	48 (61.5%)	
3	18 (15.4%)	4 (10.3%)	14 (17.9%)	
Preoperative diagnosis				.237
Chronic cholecystitis	4 (3.4%)	0	4 (5.1%)	
Acute cholecystitis	4 (3.4%)	0	4 (5.1%)	
GB polyp	15 (12.8%)	4 (10.3%)	11 (14.1%)	
GB adenomyomatosis	3 (2.6%)	2 (5.1%)	1 (1.3%)	
GB stone	86 (73.5%)	32 (82.1%)	54 (69.2%)	
Adenomyomatosis with GB stone	5 (4.3%)	1 (2.6%)	4 (5.1%)	
Previous operative history				.810
Yes	23 (19.7%)	7 (17.9%)	16 (20.5%)	
No	94 (80.3%)	32 (82.1%)	62 (79.5%)	

ASA, American Society of Anesthesiologists; BMI, body mass index; GB, gallbladder; RSSC, robotic single-site cholecystectomy; SPLC, single-port laparoscopic cholecystectomy.

## Postoperative Outcomes

The total operative time was longer ( $P < .001$ ) in the RSSC group (109.92 minutes) than that in the SPLC group (60.99 minutes). These two groups showed significant difference in the use of additional robotic arm or port (0% vs. 12.8%;  $P = .029$ ). Conversion rate, bile spillage during operation, or complication was not significantly different between the two groups. Complication was mostly wound infection. Immediate postoperative pain score between the two groups showed no significant difference (4.95 vs. 5.00;  $P = .882$ ). However, at the time of discharge, pain score showed statistically significant difference between the two groups (1.79 vs. 2.38;  $P = .010$ ), although such difference was not clinically significant (**Table 2**).

## Relationship Between BMI and Surgical Outcomes

High-BMI patients were evenly distributed according to operation sequence regardless of surgical approach. This suggests that cholecystectomy by laparoscope and robot is safe. It can be performed by surgeons with initial experience as long as they are sufficiently trained for each operative technique. Operation sequence and BMI are not correlated ( $P = .302$  and  $P = .940$ , respectively; **Figure 1**). There was no significant correlation between operation sequence and operation time in either group ( $P = .506$  and  $P = .491$ , respectively; **Figure 2**). There was no significant correlation between BMI and operation time in RSSC group either ( $P = .529$ ). On the other hand, higher BMI was correlated with longer operation time in the SPLC group ( $P = .025$ ; **Figure 3**).

## DISCUSSION

Recently, outcomes of single-port cholecystectomy by laparoscopy and robot have been studied in many papers due to preference of surgeons and patients for minimally invasive surgery. Papers comparing SPLC and RSSC have also been published.

Among these papers, Gustafson et al<sup>12</sup> have shown that there is no major difference between the two groups, although operation with a robot is more costly and time-consuming. Gonzalez et al<sup>13</sup> have also stated that both SPLC and single-incision robotic cholecystectomy can be feasible and safe alternatives except that robot surgery takes longer time.

However, no studies have reported their outcomes in patients with high BMI. The present study is the first one that reports results of SPLC and RSSC in high-BMI patients. In addition, a greater number of patients were enrolled through collaborative research between two hospitals. Results of this study provide important implications for the society where obese patients are increasing due to recent changes in eating habits and life styles.

Review of studies on outcomes of each single-port cholecystectomy according to BMI revealed controversial findings. Yilmaz et al<sup>14</sup> have reported that SPLC is associated with prolonged operative time, a high level of additional port requirements, and increased wound complication rates. However, a recent study<sup>15</sup> and our previous study<sup>4</sup> have revealed that postoperative outcomes of obese patients after SPLC are not inferior to those of nonobese patients. Wakasugi et al<sup>16</sup> have re-

**Table 2.**  
Operative Outcomes

	RSSC (N = 39)	SPLC (N = 78)	P-Value
Total operation time (min, mean ± SD)	107.92 ± 24.950	60.99 ± 17.810	<.001
Estimated blood loss (≥30 mL/>30 mL)	35/2	78/0	.102
Conversion rate (to laparoscopy or open)	2 (5.1%)	2 (2.6%)	.600
Use of additional robotic arm or port	0	10 (12.8%)	.029
Bile spillage during operation	6 (15.4%)	9 (11.5%)	.568
Complication	0	5 (6.4%)	.168
Pain score after immediate surgery	4.95 ± 1.905	5.00 ± 1.405	.882
Pain score at discharge (VAS)	1.92 ± 0.900	2.35 ± 1.209	.007
Length of postoperative hospital stay	1.79 ± 1.031	2.38 ± 1.209	.010

VAS, visual analogue scale; RSSC, robotic single-site cholecystectomy; SPLC, single-port laparoscopic cholecystectomy.

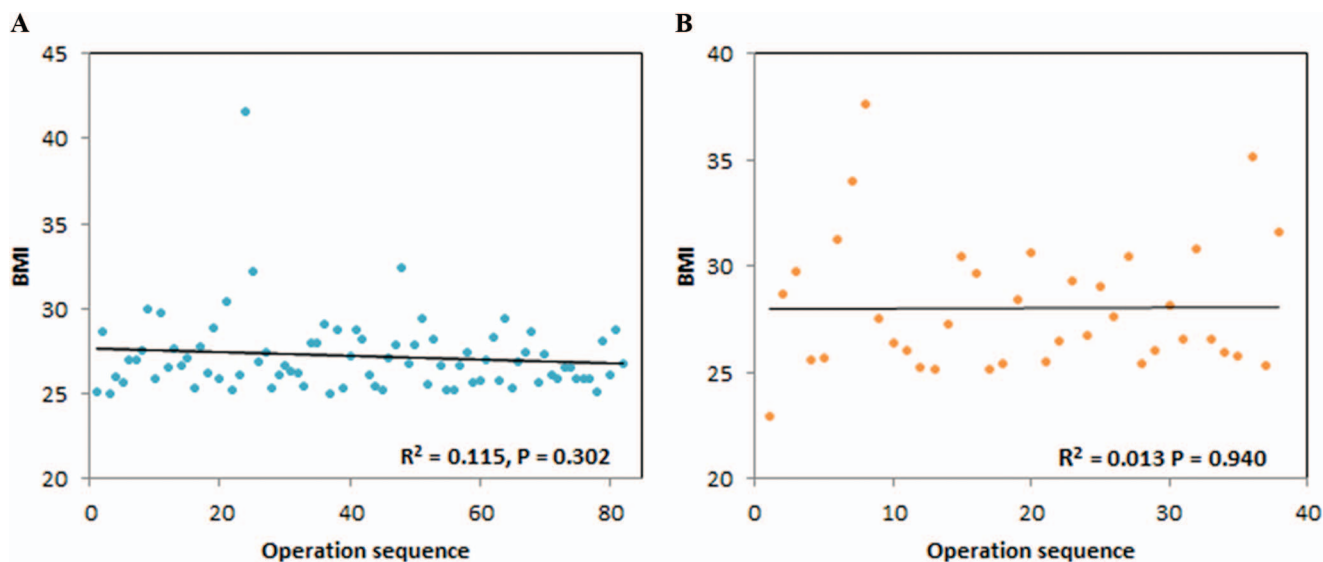


Figure 1. A and B, Correlation between operation sequence and BMI.

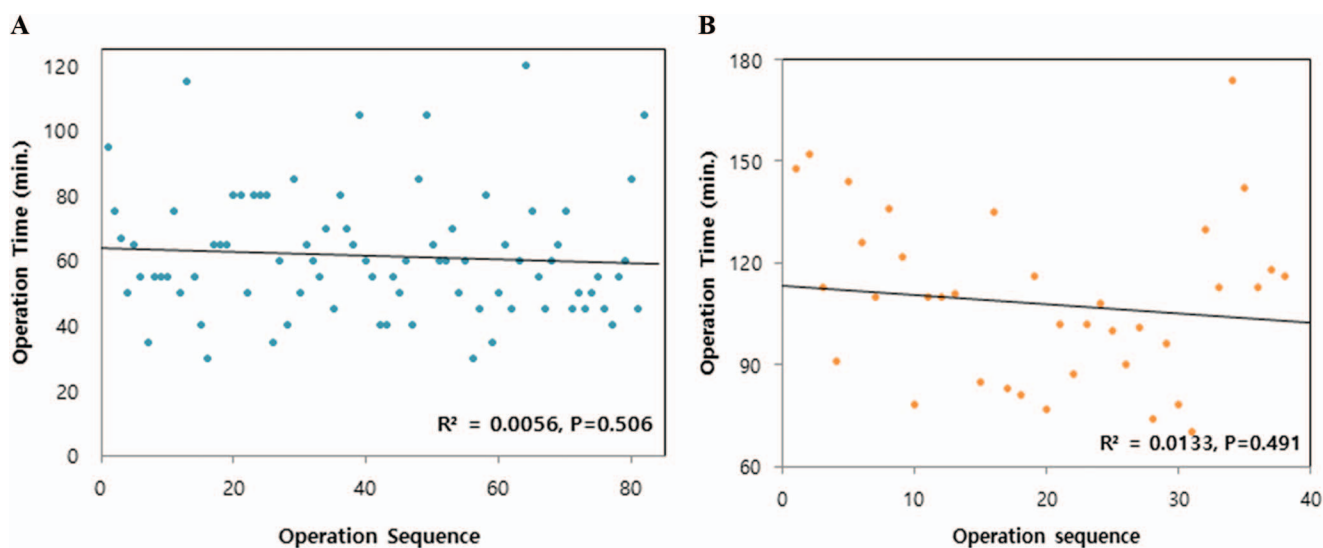


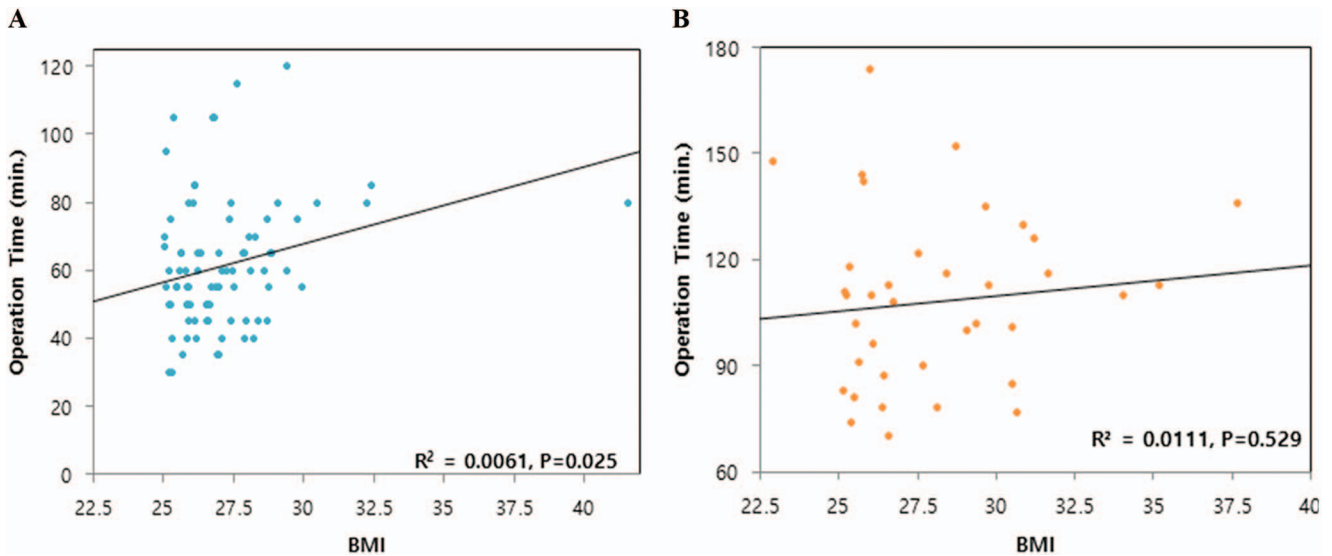
Figure 2. A and B, Correlation between operation sequence and operation time.

ported that SPLC seems to be feasible and safe in obese patients, offering good cosmetic outcomes, although obese patients are at significantly higher risk for the operation with longer operative time. Obuchi et al<sup>17</sup> have shown that obesity does not have an adverse impact on technical difficulty or postoperative outcomes of SPLC. Thus, BMI is not considered a key criterion in patient selection for SPLC.<sup>15</sup>

Although many studies have reported outcomes of SPLC, few studies have reported outcomes and possibility of RSSC. Vidovszky et al<sup>18</sup> have shown that RSSC is safe with

manageable learning curve. They found that obesity did not significantly affect conversion rate or operative time. Chung et al<sup>19</sup> have also reported that RSSC is safe to perform in inner city academic hospital setting.

In our study, different periods of time were used to enroll patients. Results were obtained after each operator passed a certain learning curve. Although there were differences in demographic characteristics between the two groups of patients, such differences were not statistically significant. Total operative time was longer in the RSSC group than that in the SPLC group (109.92 minutes vs. 60.99 minutes).



**Figure 3.** A and B, Correlation between BMI and operation time.



**Figure 4.** Methods of single-port laparoscopic cholecystectomy.

However, if only the console time was considered, it was significantly shorter in RSSC than that in SPLC ( $P = .031$ ). Although there were significant differences in the time of discharge and pain score, these differences were not clinically meaningful considering that that was a collaboration study.

As can be seen from results of our study, for patients with high BMI, RSSC can be safely performed without using an additional port. Compared to SPLC, RSSC has some advantages, including free use of robotic arms, comfort during suture, and low incidence of common bile duct injury using indocyanine green test.<sup>20</sup> Unlike SPLC, which has to overcome ergonomics, RSSC provides an opportunity for less experienced surgeons to try. To overcome the limitation of learning curve and carry out safe operation of SPLC in obese patients, we used 4-channel port and a laparoscopic fan retractor to press the omentum and duodenum,

allowing clear view of Calot triangle and cystic duct.<sup>4</sup> And also we used long-length laparoscopic instruments as a reverse (**Figure 4**). Recently, fluorescent cholangiography has been introduced as a useful tool for intra-operative visualization of biliary tree during laparoscopic cholecystectomy.<sup>21</sup>

The major difference between RSSC and SPLC is cost effectiveness when selecting an operative modality. RSSC is about 3 or 4 times more expensive than SPLC in Korea because of medical insurance policies. Only the Da Vinci-Si system enables surgeons to perform RSSC. This system will add a big cost to the hospital. If we can overcome the cost effectiveness of RSSC, it will be a good choice for cholecystectomy. We believe that RSSC is not only a final destination, but also a middle process to get single-port operation for most biliary diseases. Ultimately, SPLC and RSSC can be safely applied to high BMI patients. It is important to search for appropriated surgical methods based on patient's condition and surgeon's technique skills and experience.

One of the limitations of our study was that we used BMI cutoff values of obesity based on world health organization classification for Asian populations. Mean BMI values for patients in RSSC and SPLC groups were 28.17 kg/m<sup>2</sup> and 27.17 kg/m<sup>2</sup>, respectively. Recently, in Japan there had been published a paper that there was no difference in surgical outcomes over BMI 30 kg/m<sup>2</sup>.<sup>17</sup> However, if we used World Health Organization classifications of obesity (BMI of 30 kg/m<sup>2</sup> or greater), we would only have 9 and 4 obese patients in RSSC and SPLC groups, respectively.

Therefore, a BMI of 25 kg/m<sup>2</sup> was more suitable as the criteria for the present study.

## CONCLUSION

Results of this study showed that single-port cholecystectomy could be done safely in obese patients with robotic or laparoscopic technique. Robotics surgery has its own limitation because of its cost. However, it provides a variety of surgical method choices. This study contributes to wider performance of single-port laparoscopic and robotic cholecystectomy to benefit more patients by giving clinical evidence of their merits for obese patients.

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