

Minimally Invasive Single-Site Cholecystectomy in Obese Patients: Laparoscopic vs. Robotic

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Purpose: Laparoscopic cholecystectomy is treatment method for management of benign gallbladder diseases. Further attempts are made to operate single-port laparoscopic cholecystectomy. However, single-port laparoscopic cholecystectomy, the procedure remains technically difficult, especially in obese patient. Recently, a robotic surgical system for minimal invasive surgery was introduced to overcome the limitations of conventional laparoscopic surgery.

Methods: From April 2009 to August 2017, we retrospectively reviewed the medical records of patients with single-site, minimally invasive (laparoscopic and robotic) cholecystectomy with high BMI (>25 kg/m²). We analyzed general characteristics and perioperative outcomes between the single-fulcrum laparoscopic cholecystectomy group and the robotic single-site cholecystectomy (RSSC) group.

Results: Operation time (57.56±11.10 vs 98.5±12.28 $p<0.001$) was significantly longer and postoperative pain score (3.61 vs 5.15 $p=0.000$) was significantly higher in the robotic single-site cholecystectomy (RSSC) group, but the actual dissection time (25.85±11.09 vs 25.79±13.35 $p=0.978$) was not significantly different between the two approaches. Iatrogenic gallbladder perforation, (13 vs 6 $p=0.005$), patients undergoing RSSC showed a significantly smaller amount than did those undergoing single-fulcrum laparoscopic cholecystectomy (SFLC).

Conclusion: It is difficult to say for certain that RSSC is clearly better than SFLC in obese patients. However, because of the technical convenience and efficiency of surgery with RSSC, RSSC can be practically worthwhile. Further study is mandatory.

Keywords: Obesity, Cholecystectomy, Laparoscopy, Robotic surgical procedures

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Received March 14, 2019

Revised May 24, 2019

Accepted June 18, 2019

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INTRODUCTION

In the management of benign gallbladder diseases, such as cholelithiasis and gallbladder polyp, cholecystectomy has been recognized as the ultimate treatment method. Since the first laparoscopic cholecystectomy was performed by French obstetrician Philippe Mouret in 1987,¹ laparoscopic cholecystectomy

has become the gold standard due to its reduced operation time, better cosmetic effect, reduced pain, and earlier postoperative recovery compared with open cholecystectomy.^{1,2} More recently, additional surgical techniques have been developed to reduce access injury. Finally, single-port laparoscopic cholecystectomy was introduced as an effort to reduce the extent of procedural invasiveness.^{2,3} However, despite the introduction

of various methods and devices for single-port laparoscopic cholecystectomy,^{4,5} the procedure remains technically difficult.

Recently, a robotic surgical system for single-port laparoscopic surgery was introduced to overcome the limitations of conventional laparoscopic surgery.⁶ Unlike in manual laparoscopic surgery, this robot system can provide the surgeon with a reconstructed anatomical image in three dimensions and re-allocate the movement of surgical instruments so that surgeons can ergonomically control them through a single surgical site via a surgical console. In addition, there is no unnecessary movement caused by hand shaking or the leverage principle, and movement in the abdominal cavity can occur much more freely. Unlike in laparoscopy, there is also no unnecessary screen movement.⁷ Therefore, it is believed that robot single-port surgery is easier to perform than laparoscopic single-port surgery.^{8,9}

Surgical patients with obesity represent a challenge in minimally invasive surgery and, considering the increasing number of obese patients,¹⁰ difficult cases are expected to increase in number. It is thought to be even more difficult to perform laparoscopic single-port cholecystectomy in patients with high body mass index (BMI). In fact, it has been reported that, in patients with high BMI, laparoscopic cholecystectomy necessitates a longer operative time, shows a higher probability of requiring additional ports, and presents a higher percentage of complications than that performed in normal BMI patients.^{11,12}

The World Health Organization (WHO) previously published guidelines that Asian patients with high BMI ($> 25 \text{ kg/m}^2$).¹³ In this study, we investigated the potential role of the aforementioned robotic surgical system in performing single-port cholecystectomy in patients with high BMI ($> 25 \text{ kg/m}^2$) by comparing outcomes with those achieved using our technique of single-fulcrum laparoscopic cholecystectomy (SFLC)¹⁴ for treating benign gallbladder diseases.

MATERIALS AND METHODS

Patient selection

From April 2009 to August 2017, medical records of patients who underwent single-site, minimally invasive (laparoscopic and robotic) cholecystectomy at Severance Hospital (Sincheon, Seoul) were reviewed. Among them, patients with high BMI ($>25 \text{ kg/m}^2$) were enrolled for this study. Patient demographics collected were sex, age, symptoms, history, BMI, diagnosis, and American Society of Anesthesiologists (ASA) score, while perioperative outcomes data were operation time, actual dissection time, blood loss, bile spillage during operation, and conversion to open or laparoscopic surgery. Operation time was defined as the full operation time, including docking,

actual dissection, and console time. Actual dissection time was defined as the time from the beginning of the dissection of Calot's triangle to the end of gallbladder removal from the liver bed. We analyzed general characteristics and intraoperative features between the SFLC group and the robotic single-site cholecystectomy (RSSC) group. This retrospective study was approved by the Institutional Review Board (IRB) of Severance Hospital (2018-2507-002). Because of the retrospective nature of this study, the need for patient informed consent was waived per IRB direction.

Surgical technique

In the SFLC group, after a 2-cm transumbilical vertical skin incision was made, subcutaneous fat tissue was dissected, the fascia layer was exposed, and a 10-mm trocar was inserted. A conventional 10 mm, 30° laparoscope was inserted into the 10-mm trocar. After insertion into the peritoneum, a 5-mm trocar was inserted in the lower part of the fascia, and a 2-mm trocar was inserted into the same fulcrum level of the 5-mm trocar. This provided a large space for movement without impacting the working instruments. The surgeon stood on the left side of the patient as in conventional laparoscopic cholecystectomy (LC) and handled the working instruments. The assistant stood on the right side of the operator and controlled the laparoscopic equipment.¹⁴

Separately, in the RSSC group, after a 2.5- to 3-cm transumbilical vertical skin incision was made, subcutaneous fat tissue was dissected to expose the fascia layer. Then, a port was inserted into the abdominal cavity. After the pneumoperitoneum state, the reverse Trendelenburg position (15~20°) was established, the axis was moved to the right by 30°, and the da Vinci robot was placed. At this point, an 8.5-mm endoscope was inserted into the camera port, and two curved cannulas were inserted with the guidance of this endoscope and placed near the gallbladder. After docking of the robot, an additional 5-mm assistant port was inserted. The operator controlled the console during the procedure, while the assistant controlled the equipment on the left side of the patient.¹⁵

Statistics

Categorical variables are expressed as frequency with percentage, and continuous variables are expressed as mean value \pm standard deviation. The chi-square test for categorical variables and Student's t-test for continuous variables were used to evaluate statistical significance between parameters. Statistical significance was established at a *p*-value less than 0.05. The cumulative method was used for learning curve analysis and takes a quantitative approach, which is a cumulative sum of

the difference between individual data and the average of all the data.

RESULTS

Change of surgical approach to cholecystectomy in patients with high BMIs

During the study period, the total number of patients who underwent single-port minimally invasive (SFLC and RSSC) cholecystectomy was 401, of which 113 (28.2%) were high BMI patients. The total number of patients who underwent SFLC was 141 and of which 41 (29.1%) were high BMI patients, who underwent RSSC was 260 and of which 72 (27.7%) were high BMI patients. Of the total number of patients, 42 were males and 69 were females. The mean age was 46.1 years and the mean BMI was 27.5 kg/m². Additionally, of the 113 patients, 41 patients underwent SFLC and 72 patients underwent RSSC. Patients underwent surgery with SFLC from 2009 to 2012. However, since 2012, when the introduction of robotic single-site surgical system occurred, most patients underwent surgery with the RSSC approach.

Perioperative comparative analysis (SFLC vs. RSSC)

General characteristics and perioperative data are shown in Table 1. All patients underwent surgery for benign gallbladder disease. There were no significant differences in sex ($p=0.365$), BMI ($p=0.217$), symptoms ($p=0.816$), or ASA score ($p=0.443$) between the two groups. There was, however, a significant difference in age ($p=0.008$) and diagnosis ($p=0.015$).

Intraoperative surgical outcomes were compared between the two groups (Table 2). Operation time ($p<0.001$, Fig. 1) was significantly longer for RSSC, but the actual dissection time ($p=0.978$, Fig. 2) was not significantly different between the

two approaches. For estimated blood loss, both RSSC and SFLC were observed to be minimal loss, and there was no significant difference between the two groups. In cases of intraoperative bile leakage (iatrogenic gallbladder perforation, $p=0.005$), patients undergoing RSSC showed a significantly smaller amount than did those undergoing SFLC. There were no cases of open conversion in either group, but both included one case of laparoscopic conversion. Postoperative data showed that postoperative pain score (base on NPIS) ($p=0.000$) was significantly higher in the RSSC group versus the SFLC

Table 2. Intraoperative & postoperative outcomes of patients with single-port minimally invasive cholecystectomy

Variables	SFLC (n=41)	RSSC (n=72)	p-value
Operation time (min.)	57.56±11.10	98.5±12.28	<0.001
Actual dissection time (min.)*	25.85±11.09	25.79±13.35	0.978
Conversion to OC	0	0	
Conversion to LC	1	0	
EBL (mL)	Minimum	Minimum	NA
Intraoperative bile spillage (iatrogenic gallbladder perforation)	13	6	0.005
Pain score			
Immediate postoperatively	3.61	5.15	0.000
At discharge	1.63	1.88	0.227
LOH	1.32	1.58	0.062

LC = laparoscopic cholecystectomy; OC = open cholecystectomy; EBL = estimated blood loss; Actual dissection time = the time from the beginning of dissection of Calot's triangle to the end of gallbladder removal from the liver bed.

Table 1. General characteristics and perioperative results of patients in whom SFLC or RSSC was attempted

Variables	SFLC (n=41)	RSSC (n=72)	p-value
Age (years)*	50.1±11.1	43.8±12.3	0.008
Male/female	13/28 (31.7/69.3)	29/22 (73.4/26.6)	0.365
BMI (kg/m ²)	27.1±1.68	27.7±2.83	0.217
Symptom (yes /no)	22/19 (53.7/46.3)	37/35 (51.4/48.6)	0.816
GB stone /GB polyp	40/1 (97.5/2.5)	59/13 (81.9/18.1)	0.015
ASA score	1.34±0.575	1.43±0.601	0.443

SFLC = laparoscopic single-fulcrum cholecystectomy; RSSC = robot single-site cholecystectomy.

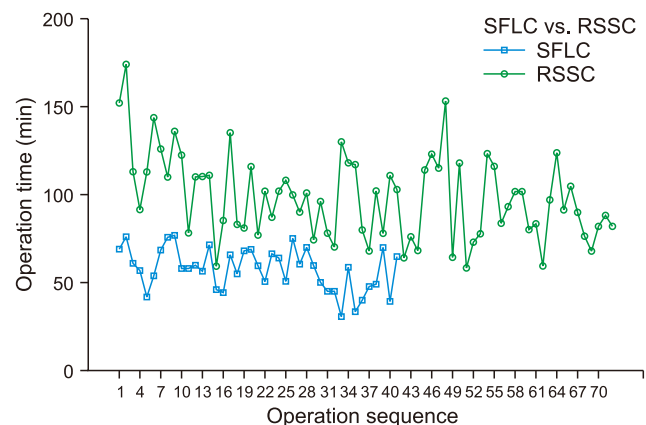


Fig. 1. Operation sequence over operation time.

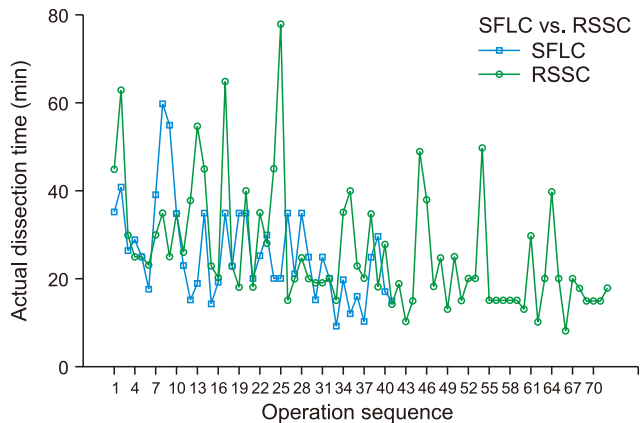


Fig. 2. Actual dissection time over operation sequence.

group, but there was no significant difference between the two groups regarding discharge pain score ($p=0.272$) or postoperative hospital stay length ($p=0.062$, Table 2).

DISCUSSION

We conducted this study to investigate the difference between intraoperative and postoperative outcomes of RSSC and SFLC in high-BMI patients ($>25 \text{ kg/m}^2$). Usually, obesity is defined as $\text{BMI} \geq 30 \text{ kg/m}^2$ according to the WHO criteria.¹³ However, Asian people are more likely to have a higher risk of diabetes mellitus than Westerners at the same BMI, and the population density of high BMI is also different in these two populations. Therefore, in this study, we included patients with $\text{BMI} 25 \text{ kg/m}^2$ or more according to the Asian criteria.¹³

In preoperative comparative analysis, there was a difference in age and diagnosis in the two patient groups. It is presumed that the young patients prefer robotic surgery. Intraoperative data showed that operation time was significantly longer in the SFLC group compared with in the SFLC group. This finding suggests that docking should be performed for robotic surgery. However, actual dissection time was not significantly different between the two groups ($p=0.978$), suggesting that intraoperative movement for effective dissection of Calot's triangle seems to be comparable. In cases of bile spillage during gallbladder dissection, the amount in the RSSC group was significantly smaller than that of the SFLC group, which is probably due to the better visual field of operation and fine movement in the former. This outcome is due to the inefficient movements in LSFC than RSSC, because of the limitation of movement. In addition, by using the ICG technology, the dissection plane between the liver bed and gallbladder appears as a gray zone with no ICG signal, which can be visual guidance and make it easier to dissect. But there is a controversy as to whether this finding is clinically meaningful, because additional com-

plications related to bile spillage from gallbladder perforation do not occur in those patients. However, in case of gallbladder polyp, unexpected gallbladder carcinoma can be detected in final pathologic diagnosis. Gallbladder perforation can be critical in those patients. Potential role of RSSC in terms with less gallbladder perforation need to be further investigated.

Considering the postoperative data, RSSC patients demonstrated a significantly higher immediate postoperative pain score than those in the SFLC group; this result may be due to the larger length of the incision in the former. However, there was no significant difference in length of hospital stay or discharge pain score between the two groups. Clinically, this finding would be of no great significance if the immediate postoperative pain was properly controlled.

Previous studies have shown that, when comparing RSSC and LSSC, RSSC is safer, easier to learn, less stressful, and technically easier for the operator to perform.^{7,9,16,17} Also, other investigations have detailed that the rates of major complications and open conversion are lower in patients with high BMI compared with cases of RSSC and standard laparoscopic cholecystectomy.¹⁸ Therefore, when comparing RSSC and SFLC in high-BMI patients, RSSC seems to be a safer procedure associated with less morbidity.

However, when comparing RSSC and SFLC, RSSC showed a lower incidence of gallbladder perforation rate but no difference in postoperative outcome, incidence of other complications, or length of operation time. Postoperative pain was higher with RSSC but was managed at a similar level to those with SFLC at discharge.

The annual Korean costs of laparoscopic surgery and laparoscopic surgery are 2.2 million won and five million won, respectively. In terms of cost-benefit analysis, robotic surgery is not more advantageous than laparoscopic surgery.

Notably, our study was conducted using data from a single institution and involved only a single surgeon. Also, operation timing is different for SFLC and RSSC. Further studies will proceed of multicenter data in normal BMI patients or whole patients.

In conclusion, based on the above results, it is difficult to say for certain that RSSC is clearly better than SFLC. However, because of the convenience and efficiency of surgery with RSSC, which cannot be clinically measured, we have switched from LSFC to RSSC. Though the rising cost of this procedure is controversial, our patients are receiving safer and more efficient surgical treatment.

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AUTHORS' CONTRIBUTIONS

Conceptualization: CMK. Formal analysis: KML. Methodology: DHH, KML. Writing—original draft: KML, Writing—review and editing: DHH, HKH, SYR, WJL, CMK.

CONFLICT OF INTEREST

None.

FUNDING

None.

ACKNOWLEDGMENTS

None.

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