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Early Outcomes of Robotic Single Site Cholecystectomy Using the DaVinci Xi® System

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ABSTRACT

Purpose: Robotic surgery has become an established alternative to conventional laparoscopy or single site laparoscopy by solving the problems of angulation, improving the ergonomics of single-incision technology, and overcoming the intrinsic limitations of single-incision laparoscopy. Although the robotic single site technology is non-wristed and, unlike other conventional robotic instruments, only provides rotation, the ergonomics are nevertheless excellent. Therefore, the objective of this study is to present our initial experience in robotic single site cholecystectomy (RSSC) by a surgeon. Through this, we suggest that RSSC could be a feasible and safe procedure for overcoming the shortcomings of single incision laparoscopic cholecystectomy (SILC).

Methods: This study is a retrospective data review of 74 patients who underwent RSSC between April 2019 and August 2020 at our institution. The demographic, pre-, and postoperative data were retrospectively collected.

Results: A total of 74 patients underwent RSSC. The mean age of patients was 44.7 ± 9.5 years, and their mean body mass index was $24 \pm 3\,kg/m^2$. Symptomatic gallbladder stone (56.8%) was the most common pre-operative diagnosis. Mean of total operation and docking times was 39.3 ± 12.5 (20 – 85) and 7.6 ± 3.1 (4 – 20) minutes, respectively. There was no conversion, additional port insertion, bleeding, or intra-operative complication; however, one patient had wound seroma.

Conclusions: RSSC for uncomplicated gallbladder disease may serve as an excellent alternative to SILC or conventional laparoscopic cholecystectomy because of its low complication rates, good cosmesis, and ease of reproducibility without a substantial learning curve.

Key Words: Robotic cholecystectomy, Single site, Gallbladder.

INTRODUCTION

General surgical procedures are becoming less invasive because of esthetic results, less postoperative pain, and quicker convalescence. In line with this trend, laparoscopic and robotic single site cholecystectomy (RSCC) has emerged.[1] In the case of single incision laparoscopic cholecystectomy (SILC), studies have demonstrated several limitations such as collision between the laparoscopic instruments, problems in manipulating tissues or in delicate movements, the long learning curve, improper triangulation, and ergonomics.[2,3] RSSC, as a counterpart of SILC, is on the rise in minimally invasive surgery.

Thus far, advantages and disadvantages of RSSC are controversial compared to those of conventional laparoscopic cholecystectomy (CLC) or SILC. Zhang et al.[4] showed that RSSC does not decrease the risk of intra-operative and postoperative complication, it rather takes a longer operation time, more cost, and increases the risk of wound infection with incisional hernia.[5] However, RSSC has cosmetic results, reduces postoperative pain, and improves quality of life.[6] Concomitantly, it preserves proper triangulation (the critical view) and stable 3D view of the operation field.[6] These features reduce the surgeon's mental and physical workload.[6] Although SILC has several advantages, it also has disadvantages that are difficult to overcome. As a result, surgeons are reluctant to approach SILC and we think that this is why it has not become popular.

As reported by Kroh et al.,[7] robotic surgery has become an established alternative to conventional laparoscopy by solving the problems of angulation, improving the ergonomics of single-incision technologies, and overcoming the intrinsic limitations of single-incision laparoscopy. Although the robotic single-site technology is non-wristed, and unlike other conventional robotic instruments, only provides rotation, the ergonomics are nevertheless excellent.[2,8]

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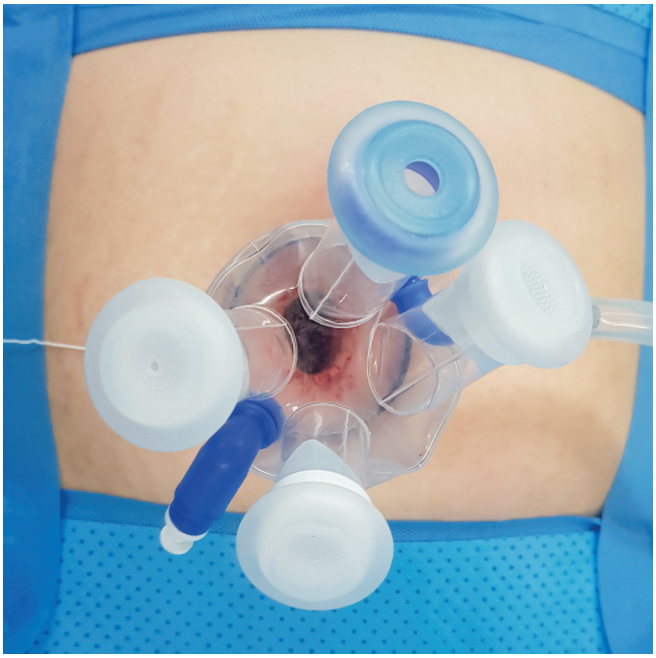


Figure 1. Glove Port.

Therefore, the objective of this study is to present our initial experience in RSSC by a surgeon without any experience of SILC. Through this, we suggest that RSSC could be a feasible and safe procedure to overcome the shortcomings of SILC by an experienced surgeon, while maximizing robotic advantages.

METHODS

This study is a retrospective data review of 74 patients who underwent RSSC between April 2019 and August 2020 at our institution. All patients who underwent RSSC for various gallbladder diseases in this period were included. Initial exclusion criteria for selection to do RSSC were 1) severe acute cholecystitis; 2) suspicious malignancy; 3) history of major abdominal surgery; and 4) refusal of RSSC due to cost. All operations were conducted by one surgeon, who was highly experienced in laparoscopic surgery, but for whom this was the first time conducting robotic surgery. Since April 2019, various robotic surgeries of hepatobiliary-pancreas have been performed: 74 RSSC, 5 live donor modified right hepatectomy, 2 right hepatectomy, 3 wedge resection of liver, 1 left lateral sectionectomy of liver, 2 choledochal cyst excision, 2 extended cholecystectomy for early gallbladder cancer and 5 distal pancreatectomy.

The demographic, pre, and postoperative data were retrospectively collected, and the postoperative pain score (24 hours later), based on the Numerical Pain Rating Scale, was also collected retrospectively by an independent nurse.

Results are expressed as mean ± standard deviation. SPSS Statistics 230.0 (SPSS Inc., Chicago, IL, USA) was used to evaluate all the statistical analysis.

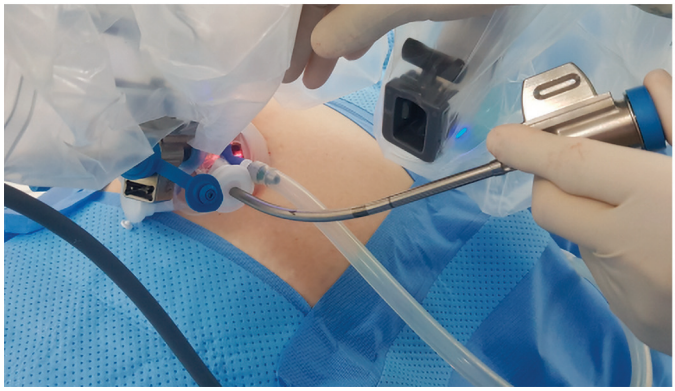
The requirement for informed consent from patients was waived due to the retrospective nature of this study. This study was conducted according to the principles of the Declaration of Helsinki.

SURGICAL TECHNICS

The patients were prepared as CLC. They were placed in the supine and reverse Trendelenburg position with both arms secured at the side of the body. A 2–20.5 cm transumbilical incision was made. Through this incision, glove port (NELIS, Bucheon, Korea) was inserted (**Figure 1**). When pneumoperitoneum was established, the DaVinci ξ® system (Intuitive Surgical, Sunnyvale, CA) was set at the right upper

Figure 2. Three Cannulas. (8 mm Camera Cannula, 5 x 250 Millimeters Curved Cannulas).

A



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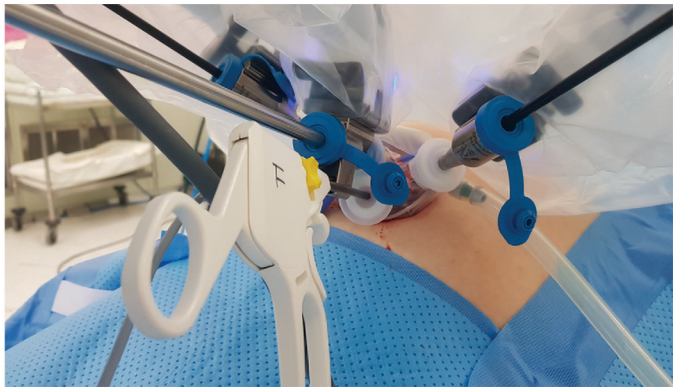

Figure 3. (A). Multichannel Single Port With an Assistant Port. (B). Multichannel Single Port With an Assistant Port.

section. We inserted an 8 mm camera cannula in the blue channel and targeted the gallbladder. Next, on the right, a 5 × 250 mm curved cannula was inserted in the white channel for permanent cautery hook. Under the hook, on the left, the same cannula was inserted for the Crocodile grasper **(Figures 2, 3A,** and **3B)**. At last, the first assistant retracted the gallbladder cranially using the laparoscopic grasper through the other white channel. From skin incision to this point is the docking time.

Once all ports were in, the cystic duct and artery were ligated by robotic Hem-o-lok clips (Weck Closure System, Research Triangle Park, NC, USA). Finally, the gallbladder was dissected from gallbladder fossa and retrieved with a glove port. Fascia was closed by interrupted suture.

Table 1.
Patient Demographic Data and Pre-operative Diagnosis

Demographics	Number / Range
Mean age, year, range	44.7 ± 9.5 (20 – 62)
Sex, male/female (%)	20/54 (27/73)
Mean Body Mass index, kg/m^2	24 ± 3 (18.7 – 31.2)
ASA status, n (%)	
I	41 (55.4)
II	32 (43.2)
III	1 (1.4)
Pre-operative diagnosis, n (%)	
Adenomyomatosis	11 (14.9)
Symptomatic GB stone	42 (56.8)
GB polyp	17 (23)
Gallstone pancreatitis	2 (2.7)
Acute cholecystitis	2 (2.7)

Values are presented as mean ± standard deviation, number (%) or median (range).
ASA, American Society of Anesthesiologists; GB, gallbladder.

RESULTS

A total 74 patients underwent RSSC during this period. The mean age of patients was 440.7 ± 90.5 years, and their body mass index (BMI) was 24 ± 3 kg/m^2. Of these total, 20 patients were male. Most of patients' American Society of Anesthesiology classification was class I (55.4%) and II (43.2%). Symptomatic gallbladder stone (56.8%) was the most common pre-operative diagnosis, followed by gallbladder polyp (23%), adenomyomatosis (14.9%), acute cholecystitis (20.7%), and gallstone pancreatitis (20.7%) (**Table 1**).

As shown in **Table 2**, mean of total operation and docking time was 39.3 ± 12.5 (20 – 85) and 7.6 ± 3.1 (4 – 20) minutes, respectively. In our study, operation time was defined as either 1) total operation time: the time from skin incision to skin closure; or 2) docking time: the time from skin incision to installation of the second robotic arm in cannula. There was no conversion, additional port insertion, and bleeding. There was also no intra-operative complication, but one patient had wound complication that required antibiotics and dressing. Mean of hospital stay was 2.5 ± 0.9 (1 – 6) days and mean pain score after one day was numerical rating scale 3.1 ± 0.9 (2 – 7). Lastly, postoperative pathological diagnosis was not significantly different from prediagnosis. Chronic cholecystitis (59.5%) was most common, followed by cholesterol polyp (16.2%), adenomyomatosis (10.8%), acute cholecystitis (6.8%), and adenoma (6.8%).

Table 2.
Postoperative Outcomes and Pathological Diagnosis

Outcomes	Number / Range
Total operation time, min	39.3 ± 12.5 (20 –85)
Docking time, min	7.6 ± 3.1 (4–20)
Conversion, n (%)	0 (0)
Additional port, n (%)	0 (0)
Bleeding, n (%)	0 (0)
Complication, Clavien-Dindo classification	
I	1 (1.4)
II	0 (0)
IIIa, IIIb	0 (0)
IVa, IVb	0 (0)
V	0 (0)
Hospital stay, day	2.5 ± 0.9 (1–6)
Pain after Day 1, Numerical Rating Scale	3.1 ± 0.9 (2–7)
Pathological diagnosis	
Adenomyomatosis	8 (10.8)
Chronic cholecystitis	44 (59.5)
Cholesterol polyp	12 (16.2)
Adenoma	5 (6.8)
Acute cholecystitis	5 (6.8)

Values are presented as mean ± standard deviation, number (%) or median (range).

DISCUSSION

In order to become a new surgical procedure for benign disease, SILC must be feasible and safe for all surgeons, and must have a suitable learning curve. Above all, it should have advantages over previous surgical procedures. SILC has not been introduced in the area of minimally invasive surgery until now, but one of the reasons why it was not popularized is that it was not more feasible and safer than CLC or other methods. Rather, the fatigue of the surgeon was increased by the long learning curve, long operation time, and collision of the instrument and person. For those reasons, the surgeon in this study who performed large number of CLC experiments did not perform SILC.

We aimed to compare the initial experience of RSSC with the results of other studies to determine the relative advantages of this procedure.

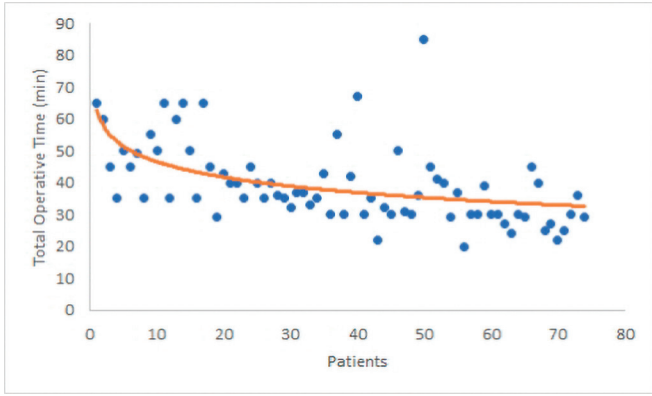

Figure 4. Correlation between Operation Sequence and Total Operative Time.

In this retrospective study of RSSC, we analyzed total operative time, docking time, conversion rate, use of additional port, bleeding, complication, hospital stay, and pain after 1 day. Among them, total operative and docking times were prominent results compared with other studies. Recent studies showed that the means of total operative and docking time were 101.6[9]/86.5[3]/93.5[10] and 11.5[3]/10.8[10] minutes, respectively. In another systemic review[11] that compared 13 papers, mean of total operative time was 77.29 minutes. Among the comparative papers, the minimum mean of total operative time was 530.8 minutes and maximum value was 107 minutes. Our study has proven that total operative and docking time was only 39.3 ± 12.5 (20–85) and 7.6 ± 3.1 (4–20) minutes, respectively. This result implies that the surgeon, who had lots of experience, did not have limitations when performing robot surgery. Additionally, the mean of time except docking time to total operative time was 310.8 ± 100.8 (14 – 77) minutes. Although, there is no significant difference in comparison with CLC outcomes, the mean

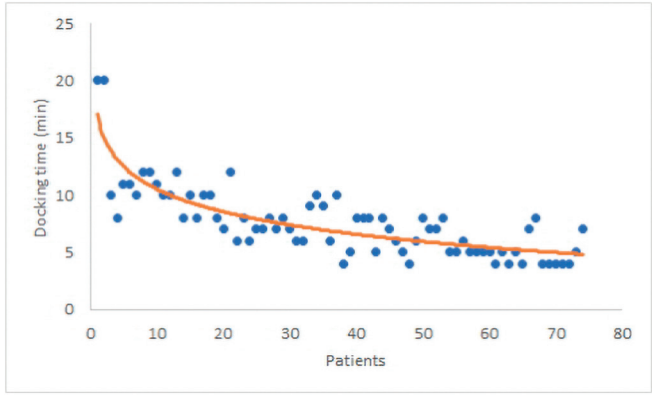

Figure 5. Correlation between Operation Sequence and Docking Time.

Table 3.
Single Incision Laparoscopic Cholecystectomy Mean Operative Time in Other Studies

Reference	Year	Sample Size (N)	Mean Age (y)	Body Mass Index (kg/m^2)	Operation Time (min)
Han, et al.[9]	2020	104	46.7 ± 11.8	23.5 ± 2.9	56.7 ± 13.7
Jang, et al.[1]	2019	78	49.8 ± 12.9	27.2 ± 2.3	61 ± 17.8
Boram Lee, et al.[17]	2019	591	53.52	24.83	59.9 ± 25.8
Ye-ji Lee, et al.[18]	2018	1000	51.9 ± 14.6	24.7 ± 3.5	53.7 ± 19.1
Su, et al.[15]	2016	63	50.9 ± 13.8	24.6 ± 3.1	74.7 ± 30.6

Values are presented as mean ± standard deviation.

of operative time of this study's surgeon for CLC was 300.9 ± 60.3 minutes.[12] However, the mean of operative time for CLC in other studies was 370.7 ± 19.7mintures,[3] 640.5 ± 220.2 minutes,[13] 370.2 ± 100.2 minutes.[14] This means, the longer operative time that was one of the major limitations of RSSC, could be overcome.

In addition, we analyzed the pattern of total operative and docking time as operation sequence increased. **Figures 4** and **5** showed that the operation and docking time decrease significantly as the number of operations increase. It has a stronger correlation at docking time than at total operative time (operation time: $\rho = -0.51$. $P < .001$, docking time: $\rho = -0.74$, $P < .001$). Docking time was halved after two cases, which indicates that docking time is not a hindrance to performing RSSC for the first time. On our results (**Figures 4** and **5**), the robotic technique seems to be more intuitive and does not a require long and specific learning curve.[11]

Recent comparison studies between RSSC and SILC were published.[4,6,15] Most of the papers support that RSSC are safe and feasible procedure, and surgical outcomes are superior to SILC except for cost and operation time. These surgical outcomes included intra-operative complication, ergonomics, preserving triangulation within operative field, and surgeon's mental and physical stress. About operation time, they cannot reach agreement; when comparing our study with other large cohort studies about SILC, we can observe that there is no difference in operation time. **Table 3** summarizes the data from other studies about SILC's operation time. Surely, these comparisons have bias, but we could estimate

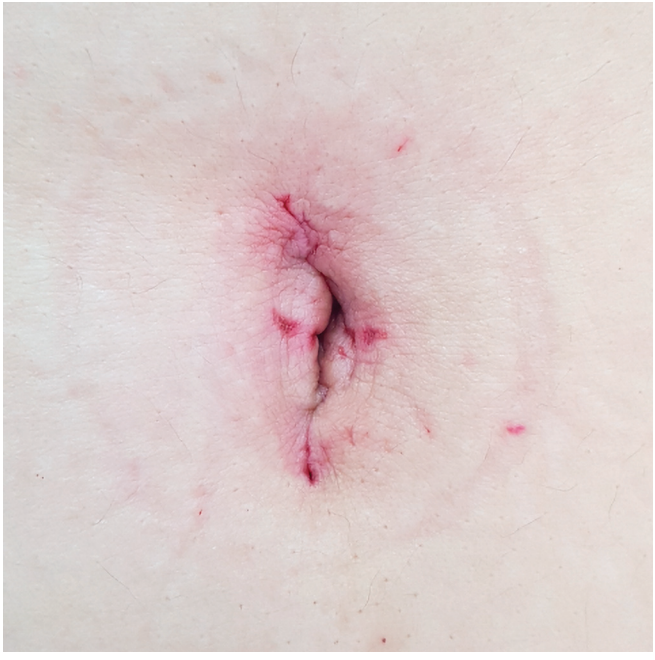

Figure 6. Postoperative wound.

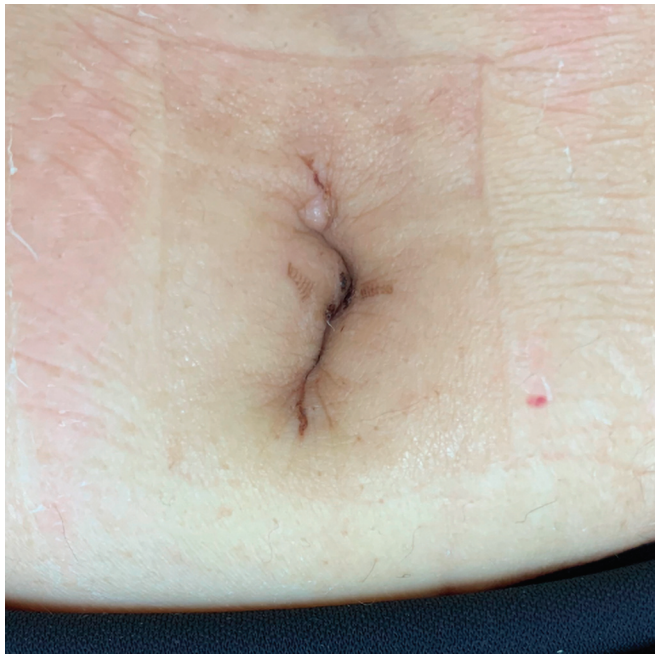

Figure 7. Wound after one week post-operative.

putative advantages. Intuitively, these results support that the operation time is no longer a limitation to do RSSC.

We had just one postoperative complication as wound problem; these complication rates (10.4%) are lower than those in other studies. The patient was routinely discharged but visited the outpatient clinic after 1 day because of wound seroma; antibiotics and dressing were needed for 2 weeks. Usually, our hospital stay of cholecystectomy patients was 2 days regardless of surgical method. However, in this study, the range of hospital stay was from 1 to 6 days, this is because one patient had suffered from nonspecific abdominal pain after surgery, so we checked CT that was no problem and discharged on postoperative day six without any symptoms.

It has been established that despite the robotic single site technology being non-wristed and, unlike other conventional robotic instruments, only provides rotation,[2,8] the ergonomics are excellent. Thus, preserving proper triangulation (the critical view) and stable 3D view of the operation field. We think this is why RSSC can be more secure than SILC. Moreover, it has one of the important advantages that SILC does not overcome. Thanks to the merits described above, in our study, there was no need for additional laparoscopic arm, robotic arm, open conversion, or conversion to laparoscopic cholecystectomy (**Table 2**). Therefore, we can say that this result also indicates that RSSC could be a safe procedure for benign gall bladder disease.

From the perspective of feasibility and safety as mentioned so far, RSSC could be a good procedure for benign gallbladder disease compare with SILC. These features would help reduce surgeon's mental and physical workload, which will increase the surgeon's satisfaction.

Moreover, a recent study showed that RSSC is attainable to not only experienced operators, but also to novice operators. In the aspect of the learning curve, RSSC has a lower threshold than does SILC.[16] However, for emergency cases like bleeding, severe inflammation, and common bile duct injury, beginners will find it hard to deal with this situation in RSSC. Nevertheless, with the attending physician providing supervision, it could be feasible and safe even for beginners, with low complication and no adverse effect.[16]

Finally, **Figures 6** and **7** shows the incision scar on postoperative day one. In this study, although the patient's satisfaction of the cosmetic result was not assessed, the patient's subjective satisfaction was very high, which may be comparable to SILC.

However, the issue of cost is still a major limitation of RSSC, as we can only recommend to the patients who have private insurance in Korea. If these practical problems are solved, RSSC could be applied in more cases because RSSC could increase both the satisfaction of surgeons and patients, as mentioned earlier.

This study was a retrospective study that involved small cases, which is a limitation. The putative advantages of RSCC can only be estimated because of the comparison with previous studies. Therefore, in the near future, the benefits of RSSC with high-grade evidence through randomized controlled trials will be confirmed.

CONCLUSION

In our study, we demonstrated that RSSC for uncomplicated gallbladder disease may serve as an excellent alternative to SILC or CLC because of its low complication rates, good cosmesis and ease of reproducibility without a substantial learning curve; it may also increase, both, the surgeons' and patients' satisfaction with the outcomes. However, the cost is an issue that needs to be solved in the near future.

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