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ORIGINAL ARTICLE

Comparison study of clinical outcomes between single-site robotic cholecystectomy and single incision laparoscopic cholecystectomy

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Summary *Background:* Multiport laparoscopic cholecystectomy is the standard surgical procedure for symptomatic gallbladder diseases. The latest evolution is single incision laparoscopic cholecystectomy (SILC). Single-site robotic cholecystectomy (SSRC) overcomes several limitations of manual SILC. The aim of this study is to present our initial experiences in SSRC and to compare its clinical outcomes with those of SILC.
Methods: This study retrospectively reviewed data for patients who received SSRC or SILC from February 2014 to September 2015. The following variables were analyzed: age, sex, body mass index, indications, pain scale, length of stay, and complications. The data were analyzed with Student *t* test or by Fisher exact test.
Results: The analysis included 51 SSRC (33 women, 18 men) and 63 SILC patients (40 women, 23 men). Patients in both groups had similar demographic features and indications for surgery. The SSRC group required no conversions to conventional laparoscopy and no additional trocars, whereas the SILC group had two (3.17%) cases. Length of stay did not significantly differ between the SSRC and SILC groups (4.29 ± 0.72 vs. 4.13 ± 0.93 days, respectively; $p = 0.823$). However, the SSRC group had shorter operative time (71.30 ± 48.88 vs. 74.70 ± 30.16 minutes; $p = 0.772$), less perioperative bile spillage (9.81% vs. 19.05%; $p = 0.189$), and less postoperative bile leakage (0% vs. 3.17%; $p = 0.501$). However, the parameters mentioned above were not statistically significant, whereas pain scale scores were significantly lower in the SSRC group (2.11 ± 0.76 vs. 3.98 ± 0.84; $p < 0.01$).

Conflicts of interests: None.

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Conclusions: Both SSRC and SILC are safe and feasible procedures for performing single incision cholecystectomy. SSRC, however, has the advantage of significantly decreased postoperative pain.

1. Introduction

Whereas laparoscopic cholecystectomy is considered the standard treatment for symptomatic gallstones, the latest evolution in cholecystectomy is single incision surgery. Single incision laparoscopic cholecystectomy (SILC), which was first introduced in 1995,[1] is considered an effective minimally invasive method of managing benign gallbladder diseases. It avoids scarring because the entry point is hidden in the umbilicus, and it does not cause substantial postoperative pain or reduction in postoperative quality of life.[2,3] However, SILC is not widely used by laparoscopic surgeons because the narrow working space markedly limits the movement of instruments and the number of instruments that can be used at one time.[4] Retraction or other assistance is often required.[5] Additional technical difficulties of SILC include loss of triangulation, poor ergonomic conditions, an unstable platform, a high learning curve, and counterintuitive instruments.

In 2011, the da Vinci Single-Site Instrumentation and Accessories (Intuitive Surgical, Inc., Sunnyvale, CA, USA) system was developed to overcome these limitations.[6–8] This novel computer-based platform incorporates a multichannel single port that accommodates two curved, robotic cannulae. These interchangeable semirigid instruments cross each other within the trocar such that the cannula entering from the left becomes the right-side operative instrument and *vice versa*.[9] The da Vinci platform triangulation problems occur when conventional laparoscopic instruments are used.[10]

This three-dimensional endoscope provides extremely fine visualization and avoids the problem of collisions between bedside surgeons or between intra-abdominal instruments. The da Vinci single-site platform performed equivalently to traditional multiport cholecystectomy.[7] Finally, the platform improves ergonomic comfort by enabling the surgeon to operate the endoscope while seated at the console.

To the best of our knowledge, the only reported use of the da Vinci platform for single-site robotic cholecystectomy (SSRC) in an Asian population is a 2015 study performed in a Korean population.[11] After our center implemented the da Vinci platform in February 2014, our surgical team was the first to use it.

The aim of this study was to evaluate the feasibility and efficacy of SSRC in 51 consecutive cases and to compare clinical outcomes between SSRC and SILC.

2. Methods and materials

Data were collected for all SSRC procedures performed at our institution from February 2014 to September 2015, which included 51 cases. The indications for cholecystectomy were symptomatic gallbladder stone (with or without acute cholecystitis) and gallbladder polyps. For comparison, the analysis included an additional 63 patients who had received SILC with the same surgical indications. Because of the high cost of instruments for both procedures, the inclusion criteria call for those who are willing to pay for the additional expense. The exclusion criteria include patients who cannot tolerate the laparoscopic surgery and those with previous major abdominal surgery.

The data analysis in this study included demographic data, comorbidities, and indications for surgery, complications, rate of conversion, average length of hospital stay (LOS), pain scale score, and total operative time. Data collected for both SSRC and SILC patients included age, sex, body mass index (BMI), diagnosis, operative outcome (operative time, conversion rate, and intraoperative complications), postoperative outcome (LOS, pain scale score, and postoperative complications), and total operative time (time from skin incision to skin closure). The pain scale score was measured at 8 hours after the surgery using the visual analog scale (VAS) method.

In the SSRC group, the da Vinci Single-Site surgical system (Intuitive Surgical, Inc, Sunnyvale, CA, USA) was used to perform cholecystectomy. The patients were placed in a supine position, and a vertical 2.5-cm incision was made through the umbilicus. The da Vinci Single-Site multichannel Port was introduced into the peritoneal cavity, and pneumoperitoneum was created by an injection of carbon dioxide gas under 15 mmHg intra-abdominal pressure. The patient was placed in a reverse Trendelenburg position with a 15° inclination and tilted to the left side. Curved cannulae and accessory trocars were inserted into the port under direct endoscopic visualization, and the docking procedure was performed. After the flexible da Vinci instruments were inserted through the curved cannulae, the robotic surgical system automatically established an association between the hands of the surgeon and the ipsilateral tip of the surgical instrument to enable intuitive control. The assistant then grasped and lifted the fundus of the gallbladder in a lateral upward direction to expose the subhepatic space. After safe retraction and visualization of the Calot's triangle, the surgeon could begin using the console for surgery. The cystic duct and cystic artery were skeletonized and dissected, and then clipped with Hemo-o-lok clips. Cholecystectomy was performed in a retrograde fashion. The excised gallbladder was extracted through the umbilicus with the port. The fascial defect and the skin incision were closed with absorbable sutures.

The SILC group received cholecystectomy with the assistance of Lagiport, a commercial kit made in Taiwan. The port had three attachments: wound retractor,

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attachment ring, and Lagiport top. A transverse skin incision was made in the subumbilical region, and the peritoneal cavity was approached by a longitudinal fascial dissection. A wound retractor was applied in the peritoneal cavity, and the dissection method described above was performed in a circular fashion to retract the wound defect. The attachment ring was then locked onto the wound retractor. The Lagi-Port top was housing onto the attachment ring. The multiple ports of the Lagiport system, including two 5-mm seals and two 12-mm seals, enabled a wide range of instrumentation. A camera system with a 5-mm elongated scope was introduced to visualize the peritoneal cavity. The gallbladder was manipulated with an Endograb retraction system, a 5-mm straight grasp, and a dissector. After cholecystectomy, the gallbladder was removed directly through the fascial defect while being protected by the wound retractor. The fascial defect and the skin incision were then closed in the same manner as in the SSRC group.

Continuous variables were expressed as means ± standard deviations, and categorical variables were expressed as frequencies and percentages. The Student *t* test for continuous variables and Fisher exact test were used to identify statistically significant parameters. A *p* value less than 0.05 was considered statistically significant.

3. Results

The SSRC group included 33 females (64.71%) and 18 males (35.29%). The mean age in the SSRC group was 53.64 ± 15.54 years (range, 23–83 years), and the mean BMI was 23.6 ± 3.8 kg/m^2 (range, 18–33 kg/m^2). The indications for surgery were symptomatic gallbladder stone in 33 patients (64.7%), gallbladder stone with acute cholecystitis in 10 patients (19.61%), and gallbladder polyps in eight (15.69%) patients. Of the 51 patients, 10 (19.61%) had omental adhesion to gallbladder that required adhesiolysis. No conversions were required, and all procedures were performed robotically. Bile juice spillage occurred during surgery in five (9.81%) cases. No patients in the SSRC group suffered bile juice leakage postoperatively. The mean operative time was 71.30 ± 48.88 minutes (range, 35–186 minutes). Operative time was significantly longer in patients with acute cholecystitis than in those without acute inflammation (96.42 ± 25.31 vs. 65.3 ± 23.2 minutes, respectively; $p = 0.0065$). The average LOS was 4.21 ± 0.72 days. The average VAS pain score was 2.11 ± 0.76 at 8 hours after the surgery.

Table 1 shows that preoperative demographic features were similar in the SILC and SSRC groups. Table 2 shows that the overall operative time in the SILC group was 74.70 ± 30.16 (range, 35–210) minutes. Operative time was significantly longer in patients with acute cholecystitis than in those without acute inflammation (92.57 ± 25.31 vs. 68.33 ± 29.02 minutes, respectively; $p = 0.008$). Two (3.17%) patients converted to two-port laparoscopic cholecystectomy. Twelve of 63 (19.05%) patients had bile spillage during surgery. Four of five cases bile spillage in SSRC and six of 12 in SSRC occurred in the initial 15 cases. Two (3.17%) patients suffered postoperative bile juice leakage that required external abdominal drainage and endoscopic biliary drainage.

Table 1 Comparison of demographic features and indications between SSRC and SILC.

	SSRC ($n = 51$)	SILC ($n = 63$)	p
Age (y), mean ± SD	53.64 ± 15.54	50.94 ± 13.79	0.742
Sex, *n* (%)			
Male	18 (35.29)	23 (36.51)	0.781
Female	33 (64.71)	40 (63.49)	
BMI (kg/m^2)	23.6 ± 3.8	24.6 ± 3.11	0.582
Indications, *n* (%)			
GB stone	33 (64.70)	37 (58.73)	0.751
GB stone with acute cholecystitis	10 (19.61)	15 (23.81)	
GB polyp	8 (15.69)	15 (23.81)	

BMI = body mass index; GB = gallbladder; SD = standard deviation; SILC = single incision laparoscopic cholecystectomy; SSRC = single-site robotic cholecystectomy; VAS = visual analogue scale.

Table 2 Comparison of clinical outcomes between SSRC and SILC.

	SSRC ($n = 51$)	SILC ($n = 63$)	p
Omental adhesion, *n* (%)	10 (19.61)	9 (14.29)	0.462
Conversion rate, *n* (%)	0 (0)	2 (3.17)	0.501
Bile spillage during surgery, *n* (%)	5 (9.81)	12 (19.05)	0.189
Operation time (min)	71.30 ± 48.88	74.70 ± 30.16	0.772
Pain scale (VAS)	2.11 ± 0.76	3.98 ± 0.84	0.001
Length of stay (d)	4.21 ± 0.72	4.13 ± 0.93	0.823
Postoperative bile leakage, *n* (%)	0 (0)	2 (3.17)	0.501
Cost (NTD)	196,543 ± 9001	76,387 ± 7247	0.001

NTD = new Taiwan dollar; SILC = single incision laparoscopic cholecystectomy; SSRC = single-site robotic cholecystectomy; VAS = visual analogue scale.

The SSRC and SILC groups did not significantly differ in patient-related factors, i.e., age, sex, BMI, and indications for surgery ($p > 0.05$). Additionally, the two groups did not significantly differ in total operative time or in average LOS ($p > 0.05$).

Compared to the SSRC group, the SILC group had higher rates of conversion, bile spillage during operation, and postoperative bile juice leakage. However, the differences did not reach statistical significance.

Table 2 shows that the pain scale score after the operation was the parameter that significantly differed between the SSRC group and the SILC group (2.11 ± 0.76 vs. 3.98 ± 0.84, respectively; $p < 0.001$).

SSRC and SILC patients pay an extra 150,000 and 30,000 New Taiwan dollars (NTD) in addition to the cost of the National Health Insurance. The medical costs of both procedures are significantly higher in the SSRC group (NTD 196,543 ± 9001 vs. 76,387 ± 7247; $p < 0.001$).

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4. Discussion

The two groups compared in this study did not significantly differ in demographic features, disease diagnoses, or indications for cholecystectomy ($p > 0.05$, Table 1). Additionally, operative time did not significantly differ ($p = 0.804$). In both groups, operative time was significantly longer in patients with acute cholecystitis compared to those without acute cholecystitis (96.42 $\pm$ 25.31 vs. 65.3 $\pm$ 23.2 minutes in the SSRC group, respectively, $p = 0.0065$; 92.57 $\pm$ 25.31 vs. 68.33 $\pm$ 29.02 minutes in the SILC group, respectively, $p = 0.008$). Operative time was affected by the severity of gallbladder inflammation. Some studies[10,12] have also reported longer operative time in patients with acute cholecystitis compared to those without acute cholecystitis. In the report of Vidovszky et al,[13] a prospective study of SSRC revealed that, in patients undergoing surgery for acute inflammation of the gallbladder, operative time was significantly increased in patients with intra-abdominal adhesion ($p = 0.0139$) and in patients with high BMI ($p = 0.003$).

In this study, perioperative bile juice spillage and postoperative bile leakage tended to be higher in SILC than in SSRC. The SILC group also had higher intraoperative bile juice spillage (19.05% vs. 9.81% in SSRC) and higher postoperative bile leakage (3.177% vs. 0% in SSRC), although the differences are not statistically significant. An earlier comparison by Lee et al[11] similarly showed more bile spillage during operation in SILC compared to SSRC (10% vs. 0%, respectively). Most of the bile spillage cases occurred in the initial 15 cases. Both the operators had experiences of traditional laparoscopic cholecystectomy for more than 1000 cases. The learning curve effects can be easily overcome by the experienced surgeons.

There were two conversion cases receiving SILC. The first one was a 54-year-old woman with a BMI of 31.58 kg/m^2. Owing to the difficulty in firing the clip for the cystic duct, an additional 11-mm trocar was introduced at the upper abdomen to apply the hemoclip. The second was a 50-year-old man with acute gangrenous cholecystitis. Because of the edematous change of the cystic duct stump, the hemoclip slipped after the cystic duct was transacted. Another 3-mm trocar was introduced at the right upper abdomen, a 3-mm grasper was used to pull up the cystic duct stump, and a hemolock was clipped on through the umbilical Lagiport.

Most of the previous studies on SSRC have reported no major complications. For example, reported rates of bile juice spillage during SSRC are low (range, 0—7%).[5,12,14,15] Another systematic review of SILC reported that only 42 out of 1166 patients had postoperative complications, including bile leakage, residual choledocholithiasis, intra-abdominal hematoma, biliary stricture, and wound complications.[16]

Robotic technology is a compensatory technique that can overcome the constraints and ergonomic limitations of SILC. Therefore, it may enable surgeons to realize the full potential of the single-access approach.[17] However, major limitations of manual SILC include visualization, triangulation with the target anatomy, and ergonomics. Current SILC instruments are designed to enter the abdomen parallel to the umbilicus, which can cause a loss of triangulation with the target anatomy. The parallel approach and the resulting lack of space between instruments impair visualization and increase the risk of collisions between instruments or between an instrument and the camera. In this approach, retraction of the target anatomy may also result in suboptimal tissue exposure. Because of the retrospective nature of the study, an objective assessment of muscle straining to the surgeons cannot be achieved.

In an analysis of 100 consecutive cases, Pietrabissa et al[15] reported that SSRC patients have less postoperative pain compared to SILC patients. In the current study, the mean pain score was significantly lower in the SSRC group compared with the SILC group (2.11 $\pm$ 0.76 vs. 3.98 $\pm$ 0.84, respectively; $p < 0.001$). Pain scores reported in the literature range from 2.2 $\pm$ 1.51 to 2.5 $\pm$ 1.4 for SSRC[7,10,11,18] and from 2.62 to 4.3 $\pm$ 1.5 for SILC.[11,18] The reduced pain in the SSRC group in our study may have resulted from the use of a remotely operated robotic platform combined with the different forces applied by the system. For example, remote operation ensures that all instruments and robotic cameras rotate around a fixed point marked on the material, which should theoretically minimize torque on the abdominal wall if the system is precisely docked. Most of the patients in both groups stated that the pain centered around the umbilicus. It is reasonably postulated that the pain sensation is not related to the gallbladder inflammation nor bile spillage during operation.

5. Conclusions

This study showed that SSRC and SILC yielded similar clinical results for most of the measured parameters. Although SSRC was superior in terms of surgical complications, significant differences were not found. Cost utility analysis would be needed in further advanced study between cost and quality of life. In conclusion, although both SSRC and SILC are effective and safe for single-incision cholecystectomy, SSRC has the advantage of significantly decreased postoperative pain.

References

1. Paganini A, Lomonto D, Navordino M. *One port laparoscopic cholecystectomy in selected patients. Third International Congress on New Technology in Surgery, Luxemburg*. 1995.
2. Gumbs AA, Milone L, Sinha P, et al. Totally transumbilical laparoscopic cholecystectomy. *J Gastrointest Surg*. 2009;13:533—534.
3. Langwieler TE, Nimmesgern T, Back M. Single-port access in laparoscopic cholecystectomy. *Surg Endosc*. 2009;23:1138—1141.
4. Hua J, Gong J, Yao L, Song Z. Single-incision versus conventional laparoscopic cholecystectomy: a systematic review and meta-analysis. *Open Sci J Clin Med*. 2014;2:103—118.
5. Morel P, Buchs NC, Iranmanesh P, et al. Robotic single-site cholecystectomy. *J Hepatobiliary Pancreat Sci*. 2014;21:18—25.
6. Morel P, Pugin F, Bucher P, Buchs NC, Hagen ME. Robotic single-incision laparoscopic cholecystectomy. *J Robot Surg*. 2012;6:273—274.

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7. Wren SM, Curet MJ. Single-port robotic cholecystectomy: results from a first human use clinical study of the new da Vinci single-site surgical platform. *Arch Surg*. 2011;146:1122—1127.
8. Balaphas A, Hagen ME, Buchs NC, Pugin F, Volonte F, Inan I. Robotic laparoendoscopy single-site surgery: a transdisciplinary review. *Int J Med Robot*. 2013;9:1—11.
9. Kroh M, El-Hayek K, Rosenblatt S, et al. First human surgery with a novel single-port robotic system: cholecystectomy using the da Vinci Single-Site platform. *Surg Endosc*. 2011;25:3566—3573.
10. Konstantinidis MK, Hirides P, Hirides S, et al. Cholecystectomy using a novel single-site robotic platform: early experience from 45 consecutive cases. *Surg Endosc*. 2012;26:2687—2694.
11. Lee SH, Jung MJ, Hwang HK, Kang CM, Lee WJ. The first experiences of robotic single-site cholecystectomy in Asia: a potential way to expand minimally-invasive single-site surgery? *Yonsei Med J*. 2015;56:189—195.
12. Gonzalez AM, Rabaza JR, Donkor C, et al. Single-incision cholecystectomy: a comparative study of standard laparoscopic, robotic, and SPIDER platforms. *Surg Endosc*. 2013;27:4524—4531.
13. Vidovszky TJ, Carr AD, Farinholt GN, Ho HS, Smith WH, Ali MR. Single-site robotic cholecystectomy in a broadly inclusive patient population. *Ann Surg*. 2014;260:134—141.
14. Ayloo S, Choudhury N. Single-site robotic cholecystectomy. *JSLS*. 2014;18:115—119.
15. Pietrabissa A, Sbrana F, Morelli L, et al. Overcoming the challenges of single-incision cholecystectomy with robotic single-site technology. *Arch Surg*. 2012;147:709—714.
16. Antoniou SA, Pointner R, Granderath FA. Single-incision laparoscopic cholecystectomy: a systematic review. *Surg Endosc*. 2011;25:367—377.
17. Tang B, Hou S, Cuschieri. Ergonomics of and technologies for single-port laparoscopic surgery. *Minim Invasive Ther Allied Technol*. 2011;21:46—54.
18. Prasad A, Mukherjee KA, Kaul S, Kaur M. Postoperative pain after cholecystectomy: conventional laparoscopy versus single-incision laparoscopic surgery. *J Minim Access Surg*. 2011;7:24—27.

Please cite this article in press as: Su W-L, et al., Comparison study of clinical outcomes between single-site robotic cholecystectomy and single incision laparoscopic cholecystectomy, Asian Journal of Surgery (2016), http://dx.doi.org/10.1016/j.asjsur.2016.03.005