Clinical outcomes of single-incision robotic cholecystectomy versus conventional 3-port laparoscopic cholecystectomy

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Background: Few studies have compared the surgical results of single-incision robotic cholecystectomy (SIRC) with those of conventional laparoscopic cholecystectomy (CLC). The purpose of this study was to evaluate the relative clinical efficacy of SIRC by comparing the number of postoperative days, pain level and complications between the 2 surgical methods.

Methods: We retrospectively collected demographic, perioperative and postoperative data for all patients who underwent SIRC or CLC performed by a single surgeon from June 2016 to May 2017. Operative time was recorded, divided into anesthesia time, docking time, console time and total operation time. Postoperative pain was measured with the Numerical Pain Rating Scale.

Results: A total of 121 patients underwent cholecystectomy during the study period, of whom 61 had SIRC and 60 had CLC. The mean total operation time of SIRC and CLC was 93.52 (SD 20.27) minutes and 37.67 (SD 19.73) minutes, respectively ($p < 0.001$). The total operation time excluding console time of SIRC was significantly longer than that of CLC (82.77 [SD 18.27] min v. 37.67 [SD 19.73] min) ($p < 0.001$). The mean Numerical Pain Rating Scale score was 4.73 (SD 1.23) (SIRC: 4.75 [SD 1.24]; CLC: 4.70 [SD 1.22]) ($p = 0.8$) within 1 hour after the operation; scores after 6 hours and 1 day decreased in a similar manner in the 2 groups ($p = 0.1$).

Conclusion: Postoperative pain, use of an additional port, complication rates, operation time and cost of SIRC were similar to or greater than those of CLC. Large randomized controlled trials are needed to examine the true benefits of SIRC.

Contexte : Peu d'études ont comparé les résultats chirurgicaux de la cholécystectomie robotique par incision unique (CRIU) à ceux de la cholécystectomie laparoscopique classique (CLC). Le but de la présente étude était d'évaluer l'efficacité clinique relative de la CRIU en comparant le nombre de jours postopératoires, l'intensité de la douleur et les complications avec les 2 méthodes chirurgicales.

Méthodes : Nous avons recueilli de manière rétrospective les données démographiques, périopératoires et postopératoires de tous les patients soumis à une CRIU ou à une CLC effectuée par un seul chirurgien entre juin 2016 et mai 2017. Le temps opératoire a été enregistré, subdivisé entre anesthésie, temps d'installation, temps à la console et durée totale de l'intervention. La douleur postopératoire a été mesurée au moyen d'une échelle numérique d'évaluation de la douleur.

Résultats : En tout, 121 patients ont subi une cholécystectomie durant la période de l'étude, dont 61, une CRIU et 60, une CLC. La durée opératoire totale moyenne des CRIU et des CLC a été de 93,52 (É.-T. 20,27) minutes et de 37,67 (É.-T. 19,73) minutes, respectivement ($p < 0{,}001$). La durée opératoire totale excluant le temps à la console a été significativement plus longue avec la CRIU qu'avec la CLC (82,77 [É.-T. 18,27] minutes c. 37,67 [É.-T. 19,73] minutes) ($p < 0{,}001$). Le score moyen à l'échelle numérique d'évaluation de la douleur a été de 4,73 (É.-T. 1,23) (CRIU : 4,75 [É.-T. 1,24]; CLC : 4,70 [É.-T. 1,22]) ($p = 0{,}8$) 1 heure suivant l'intervention; après 6 heures et après 1 jour, les scores avaient diminué de façon similaire dans les 2 groupes ($p = 0{,}1$).

Conclusion : La douleur postopératoire, l'utilisation d'un port additionnel, les taux de complication, le temps opératoire et le coût de la CRIU ont été similaires ou supérieurs à ceux de la CLC. Il faudra réaliser de plus grands essais randomisés et contrôlés pour analyser les bénéfices réels de la CRIU.

Gallbladder disease is one of the most common diseases requiring surgical treatment. In the United States, more than 500 000 people are reported to undergo gallbladder surgery annually.[1] Since laparoscopic cholecystectomy was first introduced as a viable replacement for open cholecystectomy, in 1985, it has been widely used and has become the gold standard method for the treatment of gallbladder disease. Surgeons' efforts to reduce invasiveness have led to the development of single-incision laparoscopic cholecystectomy (SILC), which has been reported to be safe and to have good clinical outcomes.[2–5] However, although the cosmetic results obtained with SILC are good, this technique has several limitations related to proper triangulation, instrument collisions, the surgeon's unstable ergonomic posture and damage to surrounding tissues.[6,7]

The da Vinci Single-Site robotic system (Intuitive Surgical) was developed to overcome these problems.[8,9] This system allows the robot arm to electronically manipulate the inverse surgeon's hand movements. The instrument inserted through the 2- to 3-cm umbilical incision is operated through an electrical reverse, minimizing interference between surgical instruments during operation. To adapt to this system, all surgeons learn the technique through animal and cadaver training before the first operation.

Good results, including quick healing time, less pain, reduced blood loss and good cosmetic results, have been reported with single-incision robotic cholecystectomy (SIRC).[9,10] The ability to obtain a good cosmetic effect with fewer port sites is an important advantage that cannot be refuted. However, SIRC is much more expensive than conventional 3-port laparoscopic cholecystectomy (CLC), even when considering only the disposable devices required for SIRC and not the base cost of the robot system.[11,12] In addition, few studies have directly compared SIRC with CLC. We performed a study to evaluate the relative efficacy of SIRC by comparing clinical results such as length of hospital stay, pain level and complications between SIRC and CLC.

Methods

The study was approved by the ethics review board of our hospital. We retrospectively collected clinical features and surgical outcomes for all patients who underwent SIRC or CLC performed by a single surgeon at our institute from June 2016 to May 2017 via review of the medical record. Both surgical methods were explained to patients, who decided which method was used. Patients aged 18–80 years with cholelithiasis, gallbladder polyps or chronic cholecystitis were included in this study. Patients with acute cholecystitis and associated inflammation of other organs such as cholangitis or pancreatitis were excluded.

Surgical procedure

For CLC, the patient was placed on the operating table in a supine position. Pneumoperitoneum was created through an anterior approach at the umbilicus, and an 11-mm trocar was inserted. Two 5-mm trocars were then inserted in the right subcostal region at the midclavicular line and subxiphoid under endoscopic view (Fig. 1). Cholecystectomy was performed by means of a routine method. The gallbladder was pulled out through the incision, which was closed with a 2–0 Vicryl suture.

For SIRC, the patient was prepared in the same way as for CLC. A 2- to 3-cm incision was made in the umbilicus, and the main port was inserted through the incision. At the main port, a camera, 2 robot arms and an assist trocar were inserted, and the patient was placed in a reverse Trendelenburg position. The operation cart was located for

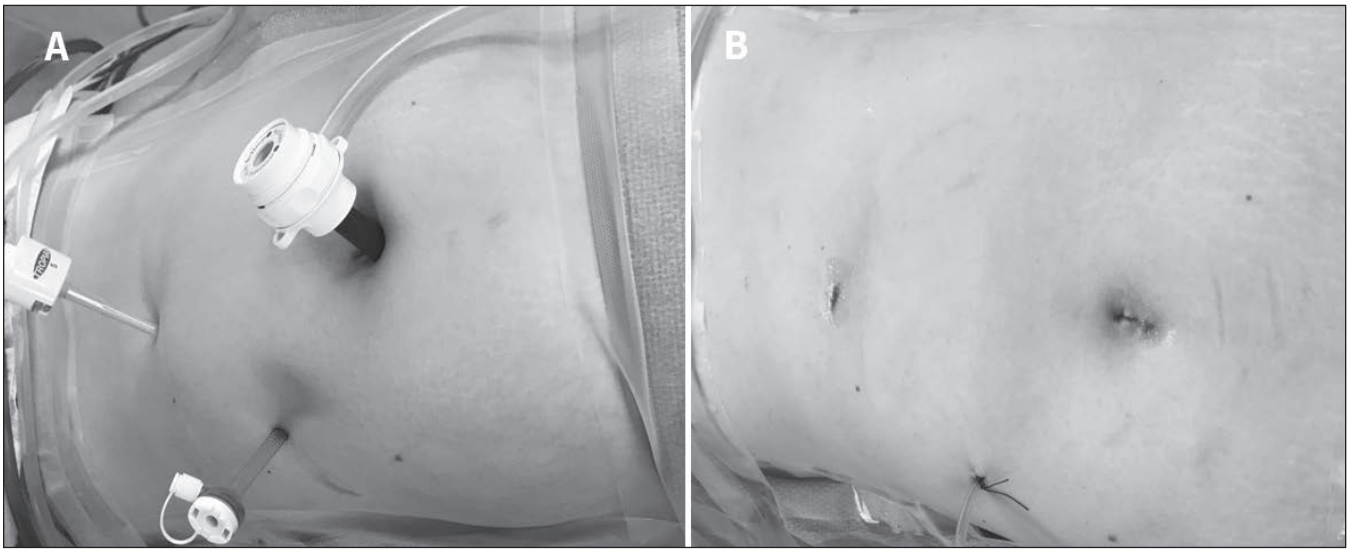

Fig. 1. Conventional laparoscopic cholecystectomy. (A): Standard 3-port insertion state. (B): Wound after skin closure of all 3 ports.

docking, and the camera was inserted through the port. The cannula was then located near the gallbladder, and the grasper and dissector were inserted through the cannula (Fig. 2). Cholecystectomy was performed by means of a routine method. The gallbladder was pulled out through the incision, which was closed with a 2–0 Vicryl suture.

Clinical features and surgical outcomes

Blood tests, ultrasonography and computed tomography were performed in all patients, and magnetic resonance cholangiopancreatography was performed when clinically necessary. Operative time was recorded, divided into anesthesia time (from induction to recovery), docking time (from port insertion until the start of intraperitoneal surgery), console time (time during which actual cholecystectomy was performed in the abdominal cavity) and total operation time (from incision to wound closure). We estimated the amount of blood loss by analyzing the anesthesia records of irrigation and suction volumes. Postoperative pain was measured with the Numerical Pain Rating Scale.[13,14] Nonsteroidal anti-inflammatory agents were routinely used to control the patients' pain.

Statistical analysis

We performed all statistical analyses with Stata version 14.0 (Stata Corp). A p value < 0.05 was considered statistically significant.

Results

A total of 121 cholecystectomy procedures were performed between June 2016 and May 2017, of which 61 (50.4%) were SIRC and 60 (49.6%) were CLC (Table 1). Body mass index, body surface area, American Society of Anesthesiologists Scale score and number of patients with symptomatic gallbladder were not significantly different between the SIRC and CLC groups. Patient age ranged from 28 to 79 years (mean 46.48 [standard deviation (SD) 11.64] yr). Patients in the SIRC group were significantly younger than those in the CLC group (mean age 42.69 [SD 8.95] yr v. 50.33 [SD 12.82] yr, $p < 0.001$). None of the patients had a previous history of upper abdominal surgery. However, 3 patients (5%) in the SIRC group and 5 patients (8%) in the CLC group had a history of lower abdominal surgery.

The most common indication for cholecystectomy was cholelithiasis (23 patients [38%] in the SIRC group and 46 [77%] in the CLC group). The incidence of cholelithiasis was significantly different between the 2 groups ($p < 0.001$). Some patients had medical comorbidity such as diabetes, hypertension and thyroid disease, but the incidence of these diseases was not significantly different between the 2 groups ($p > 0.05$). There was no difference in the American Society of Anesthesiologists Scale score between the 2 groups ($p = 0.05$).

The intraoperative and postoperative outcomes are summarized in Table 2. The mean docking time was 10.75 (SD 4.33) minutes (range 4–30 min), and the mean console time was 44.84 (SD 13.83) minutes (range 15–90 min). The mean total operation time for SIRC and CLC was 93.52 (SD 20.27) minutes and 37.67 (SD 19.73) minutes, respectively ($p < 0.001$). The total operation time excluding docking time for SIRC was significantly greater than that for CLC (82.77 [SD 18.27] v. 37.67 [SD 19.73]) ($p < 0.001$).

None of the patients had altered operative procedures or additional ports inserted because of bleeding or adhesion. The mean number of in-hospital postoperative days was 2.35 (SD 1.38) (SIRC: 2.26 [SD 0.92] d; CLC: 2.43 [SD 1.73] d) ($p = 0.5$). There were no intraoperative complications such as massive bleeding or common bile duct injury. There were also no postoperative complications such as incisional hernia, wound infection, complicated fluid collection, postoperative ileus, or postoperative bile leakage.

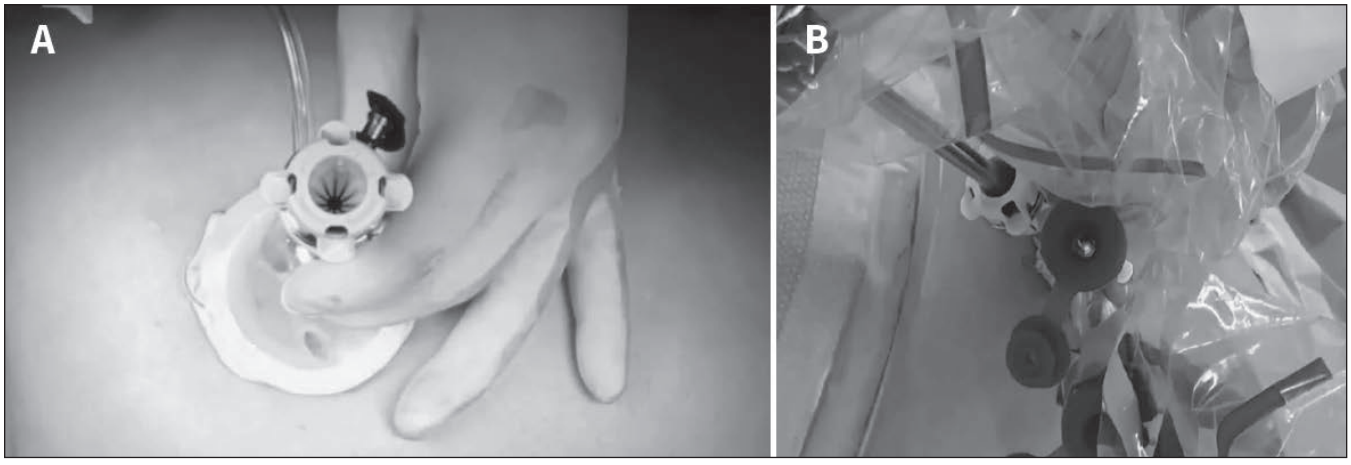

Fig. 2. Single-incision robotic cholecystectomy. (A) Single port insertion state. (B) Multichannel single port with an assistant port in the middle.

Table 1. Patient demographic and clinical characteristics

Characteristic	No. (%) of patients* Total $n = 121$	SIRC $n = 61$	CLC $n = 60$	p value
Sex				0.3
Male	62 (51.2)	34 (55.7)	28 (46.7)	
Female	59 (48.8)	27 (44.3)	32 (53.3)	
Age, yr, mean ± SD	46.48 ± 11.64	42.69 ± 8.95	50.33 ± 12.82	< 0.001
Body mass index, mean ± SD	25.00 ± 3.59	24.78 ± 3.62	25.23 ± 3.57	0.49
Body surface area, m^2, mean ± SD	1.76 ± 0.20	1.77 ± 0.21	1.75 ± 0.18	0.7
American Society of Anesthesiologists Scale score				0.05
1	85 (70.2)	38 (62.3)	47 (78.3)	
2	36 (29.8)	23 (37.7)	13 (21.7)	
Symptoms				0.3
No	58 (47.9)	32 (52.4)	26 (43.3)	
Yes	63 (52.1)	29 (47.5)	34 (56.7)	
Preoperative diagnosis				< 0.001
Chronic cholecystitis	18 (14.9)	14 (23.0)	4 (6.7)	
Gallbladder polyp	30 (24.8)	21 (34.4)	9 (15.0)	
Gallbladder adenomyosis	4 (3.3)	3 (4.9)	1 (1.7)	
Cholelithiasis	69 (57.0)	23 (37.7)	46 (76.7)	
Pathologic diagnosis				< 0.001
Chronic cholecystitis	48 (39.7)	36 (59.0)	12 (20.0)	
Gallbladder polyp	27 (22.3)	20 (32.8)	7 (11.7)	
Gallbladder adenomyosis	4 (3.3)	2 (3.3)	2 (3.3)	
Cholelithiasis	42 (34.7)	3 (4.9)	39 (65.0)	

CLC = conventional laparoscopic cholecystectomy; SD = standard deviation; SIRC = single-incision robotic cholecystectomy.
*Except where noted otherwise.

Table 2. Perioperative and postoperative outcomes

Outcome	Mean ± SD Total	SIRC	CLC	p value
Docking time, min	—	10.75 ± 4.33	—	—
Console time, min	—	44.84 ± 13.83	—	—
Total operation time, min	65.83 ± 34.40	93.52 ± 20.27	37.67 ± 19.73	< 0.001
Total operation time excluding docking time, min	—	82.77 ± 18.27	37.67 ± 19.73	< 0.001
Amount of bleeding, mL	36.28 ± 29.86	38.20 ± 27.05	34.33 ± 32.59	0.48
Numerical Pain Rating Scale score				
At 1 h	4.73 ± 1.23	4.75 ± 1.24	4.70 ± 1.22	0.8
At 6 h	2.69 ± 0.98	2.54 ± 0.59	2.85 ± 1.24	0.1
At 1 d	2.40 ± 1.08	2.25 ± 1.02	2.55 ± 1.12	0.1
No. of follow-up days	0.09 ± 0.28	0.16 ± 0.37	0.02 ± 0.12	0.005
No. of in-hospital postoperative days	2.35 ± 1.38	2.26 ± 0.92	2.43 ± 1.73	0.5

CLC = conventional laparoscopic cholecystectomy; SD = standard deviation; SIRC = single-incision robotic cholecystectomy.

The mean pain score at 1 hour after the operation was 4.73 (SD 1.23) (SIRC: 4.75 [SD 1.24]; CLC: 4.70 [SD 1.22]) ($p = 0.8$); scores at 6 hours and 1 day decreased in a similar pattern in the 2 groups ($p = 0.1$).

Discussion

In this retrospective study, we found that postoperative pain, use of an additional port, complication rates, operation time and cost of SIRC were similar to or greater than those of CLC. During SIRC, through the electrical inverse signal, the movement of the surgeon became ergonomic, and there was little collision between the instruments. This resulted in almost no damage to surrounding tissues and no delay of operation time.

In the study of Morel and colleagues,[15] the average total operation time for SIRC was 91.1 minutes, the mean console time was 50.9 minutes, and the mean docking time was 6.6 minutes. The corresponding values in the present study were 93.52 minutes, 44.84 minutes and 10.75 minutes.

However, SIRC required a significantly longer total operation time than CLC ($p < 0.001$), even when the operation time was compared without the docking time ($p < 0.001$).

Similar pain scores for SILC and CLC were reported in 2 previous studies.[16,17] Luna and colleagues[18] showed that the inflammatory reaction to surgery, as measured by interleukin 6 and C-reactive protein levels, was similar after SILC and CLC. The reason for this is that many manipulations in SILC have been reported, and pain may be reduced through decreased manipulation.[19] Based on these studies, it appears that SIRC may be less painful than CLC. However, we found no significant difference in pain scores between SIRC and CLC. Although there are few incision sites in SIRC, the length of the incision is long, many instruments are inserted into a single incision, and the operation time is relatively long. This may have contributed to the lack of difference in the degree of pain between the 2 groups.

Konstantinidis and colleagues[9] reported a mean of 23.84 (SD 10.27) postoperative hours with SIRC. Morel and colleagues[15] reported a mean of 2.4 postoperative days. In the current study, we noted a mean of 2.35 (SD 1.38) postoperative days for the overall group of patients (2.26 [SD 0.92] d for the SIRC group and 2.43 [SD 1.73] d for the CLC group). The length of the hospital stay after surgery was not significantly different between the 2 groups. The higher number of postoperative days after CLC was not due to complications but, rather, to the national insurance system, which has low admission charges. In addition, no patients required use of an additional port, there was no conversion to laparotomy or laparoscopy, and there were no postoperative complications. Overall, the perioperative and postoperative results were not significantly different between the 2 groups.

Limitations

This study had several limitations, including short-term analysis, a single hospital setting and its retrospective nature. Therefore, large randomized controlled trials are needed to examine the true benefits of SIRC.

Conclusion

Although the cosmetic outcomes of SIRC are excellent, postoperative pain, use of an additional port, complication rates, operation time and cost were similar to or greater than those of CLC.

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Competing interests: None declared.

Contributors: All authors designed the study. S. Lee acquired the data, which all authors analyzed. S. Lee wrote the article, which all authors reviewed and approved for publication.

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