Benefit of Single-Incision Laparoscopic Cholecystectomy
—A Comparison to the 4-Port Method—

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Abstract

Objective: We performed a comparative analysis of single-incision laparoscopic cholecystectomy (SILC) and 4-port laparoscopic cholecystectomy (LC) to clarify the usefulness of SILC in treating cholecystopathy.

Subjects and Methods: Subjects were 77 patients who underwent LC prior to the introduction of SILC at our hospital and 182 patients who subsequently underwent SILC. We obtained patient data retrospectively and compared operation time, bleeding volume, length of postoperative hospital stay, and postoperative use of analgesic drugs between the 2 groups.

Results: There was no significant difference between the SILC group and the LC group in terms of operation time, bleeding volume, or complications. However, postoperative stay averaged 6.44 days in the SILC group vs. 7.9 days in the LC group, and postoperative analgesic use averaged 1.32 times in the SILC group vs. 1.72 times in the LC group, and these differences were statistically significant.

Conclusion: At our institution, SILC and LC provided equivalent surgical outcomes, however, SILC proved to be less invasive as evaluated by the duration of postoperative hospital stay and the use of analgesics. These findings confirm the usefulness and increased benefit of SILC.

Key words
Laparoscopic cholecystectomy, single-incision laparoscopic cholecystectomy

Introduction

Laparoscopic cholecystectomy (LC) was first described in 1989 by Preissat et al.¹ and Reddick et al.² The first clinical report in Japan appeared in 1990.³ LC spread rapidly from that time and is currently the standard surgical technique for benign cholecystopathy. Navarra et al.⁴ first reported the use of single-incision laparoscopic cholecystectomy (SILC) in 1997. According to the Nationwide Survey of Endoscopic Surgery in Japan that was conducted in 2012,⁵ SILC was used in 4042 patients during 2011, and the technique is expected to continue to increase in popularity. SILC requires fewer ports sites than LC, and this, of course, is cosmetically advantageous. However, there are very few reports comparing the therapeutic outcomes of SILC and LC. SILC was introduced at our hospital in March 2009. Thus, we were able to review and compare therapeutic outcomes of SILC and LC from our surgical practices. Our findings are reported herein.

Subjects and Methods

Included in our study were 182 patients who underwent SILC between March 2009 and March 2013 and 77 patients who underwent LC before March 2009. Data pertaining to all of these patients was used for comparative analysis. Among these patients were 45 patients who were admitted for antibiotic treatment of mild cholecystitis but underwent elective SILC (n=34) or LC (n=11), and the data pertaining to these patients was included in a comparative subgroup analysis. According to treatment guidelines,⁶ SILC is not indicated for patients with

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acute cholecystitis requiring emergency surgery or if there is a preoperative suspicion of gallbladder cancer.

We obtained patients’ records and reviewed and analyzed operation time, bleeding volume, length of postoperative hospital stay, and postoperative use of analgesics.

The study received the approval of the St. Marianna University School of Medicine Life Ethics Committee (no. 2493).

The SILC technique involves placing the patient in a supine split-leg reverse Trendelenburg position with the right side elevated as in LC, and establishing a pneumoperitoneal pressure of 12 mm Hg. The surgeon stands between the patient’s legs, and the scopist stands to the patient’s left. A longitudinal incision of approximately 20 mm is made in the umbilicus, and a SILSTM Port with 3 access channels (Covidien Ltd., Tokyo) is introduced by the open method. The scope is flexible and has a diameter of 5 mm. The surgeon holds the Roticator™ Endo Grasp™ II (Covidien Ltd.) in his or her left hand and a straight hook-type electric scalpel in the right hand. Surgery is performed by means of the cross-hand technique. A 2-mm mini-loop retractor II (Covidien Ltd.) is inserted below the right costal arch to elevate the gallbladder. The working space is secured by inserting the flexible scope along the abdominal wall and observing the forceps from above. Adjustable forceps are used to grasp tissues distal to the intended area of dissection and avoid interference between the forceps. The critical view is achieved in the same way as in LC surgery.

The resected gallbladder is removed with an Endo Catch™ Gold specimen pouch (Covidien Ltd.). Drains are not generally inserted during SILC, but they are generally inserted during LC at our hospital. Intraoperative cholangiography was not performed during either SILC or LC in any of the patients included in the study. Umbilical reconstruction was achieved with 2-0 absorbable suture material after closure of the abdominal wall. The skin was then closed with 4-0 monofilament absorbable suture material. All patients underwent general anesthesia only; epidural anesthesia was not administered for pain management. Perioperative management is generally the same as for LC.

Statistical analyses

Values are shown as mean (range) unless otherwise indicated. Between-group differences in continuous data were analyzed by unpaired t-test, and between-group differences in categorical data were analyzed by χ² test. P < 0.05 was considered statistically significant.

Results

Overall patient characteristics (Table 1)

Mean age was 53.4 years (26–82 years) in the SILC group and 59.9 years (23–89 years) in the LC group, and the difference was significant. No significant difference in any other patient characteristic was noted between the 2 groups. Both groups included patients who received a postoperative histopathologic

<table>
<thead>
<tr>
<th>Patient Characteristics Per Study Group (Table 1)</th>
<th>SILC</th>
<th>LC</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>182</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>53.4 (26 - 82)</td>
<td>59.9 (23 - 89)</td>
<td>0.002048*</td>
</tr>
<tr>
<td>Male to Female ratio</td>
<td>94/88</td>
<td>47/30</td>
<td>0.149394</td>
</tr>
<tr>
<td>BMI</td>
<td>23.5 (15.5 - 40.7)</td>
<td>24.2 (16.8 - 39.7)</td>
<td>0.210863</td>
</tr>
<tr>
<td>Previous upper abdominal surgery</td>
<td>1</td>
<td>2</td>
<td>0.211613</td>
</tr>
<tr>
<td>History of choledocholithiasis</td>
<td>15</td>
<td>12</td>
<td>0.117097</td>
</tr>
<tr>
<td>Gallbladder polyps</td>
<td>21</td>
<td>5</td>
<td>0.263312</td>
</tr>
<tr>
<td>Gallbladder cancer (postoperative histopathology)</td>
<td>1</td>
<td>1</td>
<td>0.507018</td>
</tr>
<tr>
<td>Post-cholecystitis (in-patient treatment)</td>
<td>34</td>
<td>11</td>
<td>0.500300</td>
</tr>
</tbody>
</table>

*P < 0.05
Benefit of SILC
diagnosis of gallbladder cancer.

Overall surgical outcomes (Table 2)

In the SILC group, the mean operation time was 90.8 minutes (28–250 minutes), and the mean bleeding volume was 8.91 mL (1–220 mL). Intraoperative bile leakage occurred in 15 patients (8%) in this group. In the LC group, the mean operation time was 84.43 minutes (30–128 minutes), mean bleeding volume was 11.25 mL (1–80 mL), and intraoperative bile leakage occurred in 6 patients (7%). No significant difference was noted between the 2 groups. The postoperative hospital stay was 6.44 days (3–10 days) for the SILC group and 7.9 days (4–24 days) for the LC group, and analgesics were given postoperatively 1.32 times (0–5 times) in the SILC group and 1.72 times (0–7 times) in the LC group. The hospital stay was significantly shorter, and analgesics were given significantly less often, in the SILC group.

One or more drains were placed in 23 (13%) patients in the SILC group via the mini-loop retractor insertion site either because of intraoperative bile leakage or because the patient was under long-term treatment with anticoagulants. One or more drains were placed in 76 (98%) patients in the LC group. Nine patients (5%) in the SILC group required an additional port, SILC was converted to LC in 8 patients (4%), and SILC was converted to laparotomy in 1 patient (0.5%). LC was converted to laparotomy in 2 patients (2%). For all 3 of these patients, conversion was necessary because adhesiolysis proved to be difficult; each had undergone a previous gastrectomy via an epigastric midline incision. The rate of conversion to laparotomy did not differ significantly between the 2 groups.

The postoperative complications in the SILC group were surgical wound infections in 3 patients (1%) and incisional hernia in 1 patient (0.5%). The surgical wound infections healed with conservative treatment; the incisional hernia required repeat surgery. Postoperative complications in the LC group were surgical wound infections in 3 patients (3%) and bile duct injury in 2 patients (2%). All of these complications were resolved with conservative treatment. The incidence of complications did not differ significantly between the 2 groups.

Patient characteristics and surgical outcomes in cases of cholecystitis (Table 3)

There were no significant differences in patient characteristics between the 34 SILC patients and 11 LC patients who were treated for mild cholecystitis. There was also no significant difference between these 2 groups in operation time, bleeding volume, length of postoperative stay, or postoperative use of analgesics. No significant difference was noted in intraoperative bile leakage, and no postoperative complications were noted in either group. Dissection was difficult due to extensive adhesions in all 3 SILC patients who required addition of a port and in all 3 SILC patients who underwent conversion to LC.
Laparoscopic surgery has become the standard surgical technique for cholecystectomy because of its reduced invasiveness and because technical advances allow the surgeon to secure a good visual field. SILC has been performed in Japan since 2008. The indications for single-incision surgery have been broadened, and an increasing number of institutions are applying the technique in the surgical treatment of colonic and gastric disease. SILC for cholecystopathy was introduced at our hospital in May 2009, and the surgical procedures have been standardized. As of October 2013, SILC has been performed in 282 patients at our hospital. However, securing the surgical field and manipulating the scopes can be more challenging in SILC than in LC; there is a much greater chance of interference between the scopes and between the forceps and scopes.

These technical difficulties have led to discussion of various SILC strategies, including (1) the use of adjustable forceps with flexible tips and (2) the insertion of 3 trocars through a single incision to maintain distance between the forceps. However, techniques differ between hospitals, and there is currently no consensus on standard practice. Forceps are operated by the parallel method or the cross method. The parallel method can be used in the same way as during LC, but the lack of distance between the forceps makes surgery difficult. The cross method maintains greater distance between the forceps. Some time is required to master this method. Here, also, no consensus has been reached on the superiority of either the parallel or the cross method. Kawaguchi et al. emphasize facilitating a clear visual field that is easy to work in, regardless of whether the parallel or cross method is preferred. Some surgeons emphasize the parallel method because the cross method is considered to be more challenging. However, we have adopted the cross method. We use an SILS port, and we hold the adjustable forceps in the left hand and the electric scalpel in the right hand. By inserting a 5-mm flexible laparoscope along the abdominal wall, we have been able to obtain a critical view from directly above and to avoid instrument interference. We standardized this procedure and then began collecting surgical data.

Ito reported insertion of an additional port in 4 out of 55 SILC patients (7%), and Hirano et al. reported conversion to LC in 14 of 252 (5%) SILC patients. Rivas et al. reported favorable results, with a conversion rate of 0% in 110 patients. Nine of our SILC patients (5%) required an additional port. In 7 (78%) of these patients, dissection was difficult because of extensive adhesions, in 1 (11%) patient, obesity prevented us from securing the visual field (body mass index [BMI] was 36.2), and in 1 (11%) patient, hemostasis was necessary. Among the 8 patients who underwent conversion to LC, dissection was difficult because of extensive adhesions in 5 patients (62.5%), and we encountered difficulty securing the visual field due to obesity (BMI 40.7) in

### Discussion

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### Table 3

<table>
<thead>
<tr>
<th>Characteristics and Outcomes of Patients with Cholecystitis</th>
<th>SILC</th>
<th>LC</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>34</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>56 (24 - 72)</td>
<td>54 (26 - 82)</td>
<td>0.819112</td>
</tr>
<tr>
<td>Male to Female ratio (male/female)</td>
<td>11/23</td>
<td>5/6</td>
<td>0.21061</td>
</tr>
<tr>
<td>BMI</td>
<td>23.8 (18.9 - 36.2)</td>
<td>24.7 (22.2 - 28.7)</td>
<td>0.323377</td>
</tr>
<tr>
<td>Operation time (minutes)</td>
<td>100 (39 - 180)</td>
<td>120 (49 - 160)</td>
<td>0.104735</td>
</tr>
<tr>
<td>Bleeding volume (mL)</td>
<td>17.7 (1 - 220)</td>
<td>22.5 (3 - 105)</td>
<td>0.680263</td>
</tr>
<tr>
<td>Postoperative hospital stay (days)</td>
<td>7.29 (4 - 18)</td>
<td>6.9 (5 - 10)</td>
<td>0.680263</td>
</tr>
<tr>
<td>Postoperative use of analgesic drugs (times)</td>
<td>1.8 (0 - 5)</td>
<td>1.5 (0 - 4)</td>
<td>0.548971</td>
</tr>
<tr>
<td>Intraoperative bile leakage</td>
<td>5</td>
<td>3</td>
<td>0.625236</td>
</tr>
<tr>
<td>Need for an additional port</td>
<td>3</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Conversion to LC</td>
<td>3</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

*p < 0.05*
1 (12%) patient and difficulty securing a critical view due to an impacted calculus in the neck of the gallbladder in 1 (12%) patient. These potential complications during surgery mean that the surgical team should constantly be ready to reassess the situation and to create an additional port or convert to LC if necessary.

Our study revealed a significant difference between the SILC and LC patients in terms of the length of hospital stay and the postoperative use of analgesics. Prasad et al.\textsuperscript{12}) reported no significant difference between SILC and LC when patients’ pain was assessed subjectively on a visual analog scale, and Tsutsui et al.\textsuperscript{13}) reported no significant difference between SILC and LC when patients’ pain was assessed subjectively on a numeric rating scale. Our study did not include subjective assessment of pain. However, there was a significant between-group difference in the frequency of analgesic use up to the time of discharge. Reduced postoperative use of analgesics may also have contributed to the shorter postoperative hospital stay in our SILC group.

Conversion to laparotomy is one of the major factors contributing to a relatively long hospital stay. Our study included 1 case of SILC and 2 cases of LC that were converted to laparotomy; the SILC case required 10 days of hospitalization, and the LC cases required 22 and 24 days, respectively. Moreover, in the LC group, there were 2 cases of biliary tract damage and the resulting postoperative stays were 10 and 11 days. Drain insertion may also be a factor affecting hospital stay. Drain insertion was performed significantly more often in our LC group; however, it must be noted that drain insertion was an LC requirement during the time period covered by the study. The surgical protocol calls for withdrawal of the drain 1 day after surgery, whether for SILC or LC, so we do not consider drain insertion to be directly connected to the length of hospital stay.

Podolsky et al.\textsuperscript{14}) and Kawaguchi et al.\textsuperscript{8}) reported no SILC- or LC-related postoperative complications, including incisional hernia. Our study included 3 SILC patients with surgical wound infections and 1 SILC patient with an incisional hernia. The incisional hernia was attributed to insufficient closure of the abdominal wall in an obese patient with a BMI of 30. Notably, all complications occurred in patients treated soon after we introduced SILC at our hospital. We now ensure subcutaneous irrigation of the umbilical incision and pay special attention to complete closure of the peritoneum, and we have not since encountered such complications.

The greatest advantage of SILC is the cosmetic outcome; the scar is hidden within the umbilicus. It is, however, necessary to pay particular attention to the prevention of complications such as wound infection and incisional hernia.

For adequate comparison of elective operations for mild cholecystitis that require inpatient treatment, an accumulation of cases is needed. Some such cases require exfoliation of inflammatory adhesions, which may extend the operation time. One would think that extensive exfoliation would increase the invasiveness of the procedure; however, there was no significant difference in the length of hospital stay for mild cholecystitis treated by SILC or by LC. Therefore, even for cholecystitis, we came to the conclusion that surgery can be performed safely by single-incision laparoscopy. Clarifying the usefulness of SILC for treatment of cholecystitis or even urgent SILC for treatment of acute cholecystitis is our future task.

**Conclusion**

We compared SILC and LC to determine the usefulness of SILC. There was no significant difference in operation time or bleeding volume between the 2 procedures. The length of the hospital stay and the need for postoperative analgesia were significantly improved with SILC, suggesting that SILC is less invasive than conventional LC.

SILC is a single-incision technique. Even though the surgical team must constantly consider the potential need to convert to conventional LC or to use an additional port or other method to deal with difficulties during surgery, we anticipate continued developments in this area and look forward to further standardization of the best practices.

**References**