Solo Three-incision Laparoscopic Cholecystectomy Using a Laparoscopic Scope Holder for Acute Cholecystitis

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Purpose: Laparoscopic cholecystectomy (LC) is a commonly performed procedure for the management of acute cholecystitis. The presence of an inexperienced scopist or a shortage of manpower could be problematic in emergency surgical cases. To overcome these potential problems while ensuring a stable surgical view during LC, we performed solo surgery.

Methods: We retrospectively reviewed the results of 22 patients who underwent solo three-incision LC (S-TILC) and 31 patients who underwent the conventional three-incision LC (C-TILC) from March 1, 2015, to August 31, 2015. We compared the two groups with respect to the patients' clinical characteristics, and intraoperative and postoperative results; and severity grade as defined by the updated Tokyo guidelines 2013 (TG13) criteria.

Results: No significant differences in baseline characteristics were found between the two groups. The intraoperative perforation rates were higher in the C-TILC group than in the S-TILC group ($p=0.016$). Two cases were converted to human-assisted LC in the S-TILC group because of severe adhesions and the scope holder breaking down. No significant differences were found between the groups with respect to length of hospital stay; postoperative diet habit; or rates of post-cholecystectomy diarrhea, abdominal pain, wound complication, or complication according to the Clavien-Dindo grade.

Conclusion: S-TILC and C-TILC were comparable in terms of results, and this solo surgery in LC could be performed for cases of acute cholecystitis during shortage of skilled manpower.

Keywords: Laparoscopic cholecystectomy, Acute cholecystitis, Solo surgery

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INTRODUCTION

Laparoscopic cholecystectomy (LC) has been a standard procedure for the elective management of benign gallbladder (GB) diseases, and its indications have been expanded to include acute inflammation of the GB. Until the first half of the 1990s, surgeons were ambivalent about performing LC for acute cholecystitis, but given the comparable, and often more

favorable, results of this technique with those of open surgery with respect to duration of hospital stay and postoperative morbidity, it has grown in popularity and is now generally considered the first option for acute cholecystitis.¹

The proportion of patients with gallstones who subsequently develop acute cholecystitis ranges from 3.8% to 12%,² and the complication rate of LC for acute cholecystitis ranges from 9% to 16%,³ which is higher than that for elective LC. To add to

this, Korean surgeons sometimes have to work with inexperienced scopists or an inadequate number of surgical assistants when managing cases of acute cholecystitis. This situation could lead to intraoperative or postoperative complications, and operator fatigue.

We performed solo surgery by using a laparoscopic scope holder to maintain a stable surgical view, comparable with that provided by an experienced scopist in conventional LC, and replaced the inexperienced scopist with an inexhaustible machine in a group of patients who required emergency surgery for acute cholecystitis. We compared patient outcomes after acute cholecystitis between a group treated with solo LC and a group treated with conventional LC with a scopist.

MATERIALS AND METHODS

Fifty-three patients underwent LC for acute cholecystitis between March 1, 2015, and August 31, 2015, at a single center. Among these patients, 22 underwent solo three-incision LC (S-TILC) and 31 underwent conventional three-incision LC (C-TILC). These two groups were retrospectively analyzed. This study was approved by our institutional review board (approval no. B-1608-359-102).

The patients' clinical characteristics included age; sex; height; weight; body mass index (BMI); a history of abdominal operation, including upper abdominal surgery; American Society of Anesthesiology (ASA) score; preoperative biliary drainage; percutaneous transhepatic gallbladder drainage (PTGBD); interval between symptom onset and operation; and severity grade according to the updated Tokyo Guidelines 2013 (TG13) criteria.⁴

Intraoperative results of interest included 1) conversion rate to conventional LC involving a scopist; 2) the utilization of an additional port; 3) rate of conversion from laparoscopic to open surgery; 4) operation time; 5) estimated blood loss (EBL); 6) rates of biliary complications, including intraoperative bile leak and incidental bile duct injury; 7) rates of bowel injury; 8) rates of intraoperative GB perforation during dissection; and 9) need for an indwelling drain catheter.

Postoperative outcomes of interest included 1) the length of hospital stay; 2) changes in dietary habits, classified as good, mild (I, suboptimal appetite), moderate (II, digestives are required), and severe (III, abdominal discomfort with digestives); 3) rates of post-cholecystectomy diarrhea, classified as mild (I, relieved within 3 days), moderate (II, relieved within 7 days), and severe (III, requiring an anti-diarrhea drug); 4) the degrees of abdominal and shoulder pains, classified as mild (I, pain relieved within 3 postoperative days), moderate (II, pain relieved within 7 days), or severe (III, pain relieved over 7 days); 5) postoperative wound status, classified as grade I

(clear), grade II (erythematous or presence of induration and pain), or grade III (presence of pus drainage at first visit 2 weeks after discharge); and 6) rates of postoperative complications according to the Clavien-Dindo classification.⁵

Solo three-incision cholecystectomy procedure

The patient was placed in the supine position with the right arm abducted. The laparoscopic scope holder (Lapatostat™ CIVICO, Coralville, IA, USA) was mounted on the left side rail of the patient's bed. After general anesthesia, an 11-mm port was inserted in the abdominal cavity through the umbilicus, and then a rigid laparoscopic camera was inserted in the abdominal cavity and fixed with a scope holder. A 5-mm port was inserted in subxiphoid, and another 5-mm port was inserted midway between the two previous ports. Pneumoperitoneum was maintained at 12 mm Hg. The patient's position was changed to reverse Trendelenburg, and the patient's right side was elevated. The LC procedure was the same as the conventional cholecystectomy procedure. The surgical wound was closed in layers, and an aseptic dressing was applied (Fig. 1).

Statistical analysis

Nonparametric continuous variables were analyzed by using the Mann-Whitney *U* test, and categorical variables were analyzed by using Fisher's exact test. All statistical analyses were performed by using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA). A *p* value of <0.05 was considered statistically significant.

Fig. 1. View of solo three-incision laparoscopic cholecystectomy.

Table 1. Baseline patient characteristics

	S-TILC (n=22)	C-TILC (n=31)	p value
Age (years)	61.41 ± 15.09	66.93 ± 14.80	0.19
Sex (M:F)	11 (50.0):11 (50.0)	17 (54.8):14 (45.2)	0.728
Ht (cm)	161.96 ± 7.28	162.32 ± 8.75	0.875
Wt (kg)	63.7 ± 13.40	67.01 ± 14.87	0.409
BMI (kg/m ²)	24.13 ± 3.88	25.25 ± 4.26	0.335
Abdominal operation history N (%)	8 (36.4)	7 (22.6)	0.272
Upper abdominal operation history	2 (9.1)	2 (6.5)	1
ASA (1:2:3)	9 (40.9):12 (54.5):1 (4.5)	7 (22.6):19 (61.3):5 (16.1)	0.235
Combined diseases N (%)			
Acute cholangitis	0 (0)	1 (3.2)	
Liver abscess	1 (4.5)	0 (0)	
Acute pancreatitis	1 (4.5)	0 (0)	
Common bile duct stone	0 (0)	1 (3.2)	
Gallbladder perforation	0 (0)	3 (9.7)	
Preoperative biliary drainage N (%)			
ERCP, ERBD, ERPD	4 (18.2)	3 (9.7)	0.431
CBD stone removal			
PTGBD	7 (31.8)	18 (58.1)	0.059
Emergency operation N (%)	10 (45.5)	11 (35.5)	0.465
Interval between onset to operation (hours)	76.05 ± 76.69	67.52 ± 47.18	0.877
TG13 severity grading of acute cholecystitis N (%)			0.397
Grade I	12 (57.1)	15 (48.4)	
Grade II	9 (42.9)	13 (41.9)	
Grade III	0 (0)	3 (9.7)	

Values presented are mean ± standard deviation. S-TILC = Solo three-incision laparoscopic cholecystectomy; C-TILC = conventional three-incision laparoscopic cholecystectomy; M = male; F = female; Ht = height; Wt = weight; BMI = body mass index; ASA = American Society of Anesthesiology classification; ERCP = endoscopic retrograde cholangio-pancreatography; ERBD = endoscopic retrograde biliary drainage; EPBD = endoscopic pancreatobiliary drainage; CBD = common bile duct; PTGBD = percutaneous transhepatic gallbladder drainage; TG13 = Tokyo guidelines for the management of acute cholangitis and cholecystitis 2013.

RESULTS

No significant differences were found between the groups with respect to the patients' preoperative baseline characteristics and severity grade according to TG13 ($p=0.397$). The mean age of the study population was 61.41 ± 15.09 years in the S-TILC group and 66.93 ± 14.80 years in the C-TILC group ($p=0.190$). The proportion of male patients did not differ significantly ($p=0.728$) between the two groups (50.0% and 54.8%, respectively). Two patients each in the S-TILC (9.1%) and C-TILC groups (6.5%) had a history of upper abdominal surgery

($p=1.000$). Only one patient (4.5%) in the S-TILC group and 5 (16.1%) in the C-TILC group had an ASA score of 3.

The associated diseases were liver abscess, symptomatic gallbladder stone, acute acalculous cholecystitis, and acute pancreatitis in the S-TILC group, and acute cholangitis, acute acalculous cholecystitis and common bile duct stone, and gallbladder perforation in the C-TILC group. Seven patients (31.8%) in the S-TILC group and 18 (58.1%) in the C-TILC group underwent PTGBD ($p=0.431$; Table 1).

Table 2 shows the details in the TG13 diagnostic criteria and the differences in histological diagnosis between the two

Table 2. TG13 diagnostic criteria of acute cholecystitis in patients

	S-TILC (n=22)	C-TILC (n=31)	p value	
TG13 diagnostic criteria for acute cholecystitis				
Local signs of inflammation N (%)				
Murphy's sign	14 (63.6)	14 (45.2)	0.184	
RUQ mass/pain/tenderness	0 (0)/20 (90.9)/20 (90.9)	0 (0)/29 (93.5)/29 (93.5)		
Systemic signs of inflammation				
Fever (C°)	37.77±0.77	37.65±0.82	0.596	
Elevated CRP (mg/dl)	10.65±9.00	12.46±8.90	0.506	
Elevated WBC count (/μl)	14,751.9±10,897.92	15,490.32±6,589.28	0.318	
Imaging finding modality				
CT:US:EUS:MRCP:HIDA scan	22 (100.0):5 (22.7):3 (13.6):2 (9.1):0 (0)	31 (100.0):3 (9.7):3 (9.7):0 (0):0 (0)	0.008	
Histologic diagnosis N (%)				
Acute cholecystitis	10 (45.5)	4 (12.9)		
Acute and chronic cholecystitis	3 (4.6)	8 (25.8)		
Acute suppurative cholecystitis	0 (0)	1 (3.2)		
Acute gangrenous cholecystitis	3 (13.6)	14 (45.2)		
Chronic cholecystitis	6 (27.3)	3 (9.7)		
Transmural necrosis	0 (0)	1 (3.2)		

S-TILC = Solo three-incision laparoscopic cholecystectomy; C-TILC = conventional three-incision laparoscopic cholecystectomy; RUQ = right upper quadrant; CRP = C-reactive protein; WBC = white blood cell; CT = computed tomography; US = ultrasonography; EUS = endoscopic ultrasonography; MRCP = magnetic resonance cholangiopancreatography; HIDA = hepatobiliary iminodiacetic acid.

groups. Local and systemic signs of inflammation, and imaging modality findings were not significantly different. Histological findings showed that acute cholecystitis, which included acute with chronic cholecystitis, suppurative cholecystitis, gangrenous cholecystitis, and transmural necrosis, occurred in 16 patients (63.7%) in the S-TILC group and 28 patients (90.3%) in the C-TILC group ($p=0.008$). The C-TILC group included 14 cases of histologically confirmed gangrenous cholecystitis, and its percentage was higher in the C-TILC group than in the S-TILC group.

Intraoperative outcomes

The operation time did not differ significantly ($p=0.459$) between the S-TILC and C-TILC groups (50 min [range, 30~110 min] and 55 min [range, 40~260 min], respectively). No significant difference ($p=0.896$) in EBL was found between the two groups (trace [range, trace~300 ml] for the S-TILC group and trace ml [range, trace~400 ml] for the C-TILC group).

Two cases (9.1%) were converted to human-assisted LC in the S-TILC group because of the presence of severe adhesions

and a scope holder breakdown in the middle of the operation. One case (3.2%) of intraoperative bile leak occurred in the C-TILC group. It was managed via surgical exploration of the common bile duct with T-tube insertion and primary repair of the bile duct injury site. One case (3.2%) of jejunal perforation occurred during adhesiolysis in the C-TILC group. The proportion of patients with intraoperative GB perforation was higher in the C-TILC group than in the S-TILC group (2 [9.1%] versus 12 [38.3%], respectively; $p=0.016$). No significant difference in the number of patients who required an indwelling drain catheter was found between the two groups ($p=0.097$; Table 3).

Postoperative results

The length of hospital stay was comparable between the S-TILC and C-TILC groups (2.2 ± 1.51 and 3.00 ± 1.78 days, respectively; $p=0.11$). At the 2-week follow-up visit, no significant differences in the rates of changes in dietary habits ($p=0.602$), new onset diarrhea ($p=0.266$), abdominal pain ($p=0.691$), or wound complication ($p=0.476$) were found be-

Table 3. Intraoperative characteristics

	S-TILC (n=22)	C-TILC (n=31)	p value
Operation time (min) (n=21/31)	60.71 ± 25.21	68.39 ± 41.60	0.459
EBL (ml)	trace (range trace – 300)	trace (range trace – 400)	0.896
Conversion (human assist) N (%)	2 (9.1)		
Additional port use N (%)	0 (0)	2 (6.5)	0.505
Open conversion N (%)	0 (0)	0 (0)	
Biliary complications N (%)			
Intraoperative bile leak	0 (0)	1 (3.2)	1
Small bowel injury N (%)	0 (0)	1 (3.2)	1
Intraoperative perforation N (%)	2 (9.1)	12 (38.2)	0.016
Drain catheter insertion N (%)	7 (31.8)	17 (54.8)	0.097

S-TILC = Solo three-incision laparoscopic cholecystectomy; C-TILC = conventional three-incision laparoscopic cholecystectomy; EBL = estimated blood loss.

tween the two groups.

With respect to the postoperative complications according to the Clavien–Dindo criteria, one case (4.5%) was a grade IIIa complication and 2 cases (9.1%) were grade IIIb complications in the S-TILC group, and 2 cases (6.5%) were grade IIIa complications, 1 case (3.2%) was a grade IIIb complication, and 1 case (3.2%) was a grade IVa complication in the C-TILC group ($p=0.866$).

In the S-TILC group, the grade IIIa complication was a case of postoperative bile leak from the sutured cystic duct site, which was managed with endoscopic retrograde biliary drainage. The grade IIIb complications were a case of myocardial infarction that required a coronary artery bypass graft and a case of adhesive ileus that required exploratory laparotomy.

In the C-TILC group, the group IIIa complications were a liver function abnormality requiring endoscopic ultrasonography and an intravenous site injury during stay in the intensive care unit. The grade IIIb complication was an adhesive ileus that required exploratory laparotomy, and the grade IVb complication was a seizure event on the day of discharge (Table 4).

DISCUSSION

A stable surgical view is essential for good surgical outcomes in laparoscopic surgery. An unstable surgical field is an inevitable consequence in cases where the surgical assistant is fatigued and is more likely to occur when an inexperienced scopist is holding the camera. Many surgeons experience this situation when operating on emergency cholecystectomy cases in patients presenting with acute cholecystitis.

A stable surgical view in LC can be obtained by using the

passive laparoscopic scope holder because the GB is a small organ; thus, the surgical field is limited to the subhepatic area. This means that not a lot of endoscopic movement is required in order to obtain a good surgical view. In addition, an unexhausted scope holder makes the surgical view clear and allows the surgeons to concentrate on the operation rather than on educating an inexperienced and fatigued scopist.

In this study, we evaluated patient outcomes after solo surgery using a scope holder in lieu of an inexperienced scopist during emergency LC surgery, and found that intraoperative results were comparable between the groups, with the exception of higher rates of intraoperative GB perforation in the patients treated with C-TILC than in those treated with S-TILC. Postoperative results did not differ significantly between the S-TILC and C-TILC groups. Given the comparable results between the two surgical approaches, S-TILC appears to be a useful alternative to C-TILC in the current era of surgical human resource deficiency. However, the S-TILC group had two cases of conversion to a human scopist. One was due to scope holder breakdown, and the other was due to the presence of severe adhesions. The latter case occurred during an early phase. Broad adhesiolysis in a narrow surgical field demands a wide surgical view, which makes an operator difficult to operate the camera and proceed with adhesiolysis simultaneously. In that case, the operator needed a camera operator, even though operator's surgical procedure was all the same. In addition, an assistant with whom the surgeon can discuss the procedure was needed sometimes. A potential disadvantage of this solo surgery is that it may affect the surgical training of residents and clinical fellows, but in the era of readily available surgical simulation programs, this problem can be curtailed by

Table 4. Postoperative results

	S-TILC (n = 22)	C-TILC (n = 31)	p value
Hospital stay (days)	2.2 ± 1.51	3.00 ± 1.78	0.110
Diet (I:II:III)	16 (76.2):3 (14.3):2 (9.5)	25 (89.2):1 (7.1):1 (3.6)	0.602
Diarrhea (I:II:III)	19 (90.5):0 (0):2 (9.5)	24 (92.3):1 (3.8) :1 (3.8)	0.266
Abdominal pain (I:II:III)	21 (100):0 (0):0 (0)	23 (92.0):1 (4.0):1 (4.0)	0.691
Shoulder pain (I:II:III)	5 (100.0):0 (0):0 (0)	No record	
Wound (grade I:II:III)	20 (100):0 (0)	22 (100.00):0 (0):0 (0)	0.476
Postoperative complications N (%)			
Clavien-Dindo grade	7 (31.8)	7 (22.6)	0.866
I	11 (50.0)	17 (54.8)	
II	1 (4.5)	3 (9.7)	
IIIa	1 (4.5)	2 (6.5)	
IIIb	2 (9.1)	1 (3.2)	
IVa	0 (0)	1 (3.2)	
IVb	0 (0)	0 (0)	

S-TILC = Solo three-incision laparoscopic cholecystectomy; C-TILC = conventional three-incision laparoscopic cholecystectomy; Wound: grade I = clear; grade II = erythematous or with induration and pain; grade III = with pus drainage. Diet: good = mild (I) with a suboptimal appetite; moderate (II) = digestives required; severe degree (III) = with abdominal discomfort even with digestives. Diarrhea: mild (I) = relieved within 3 days; moderate (II) = relieved within 7 days; severe (III) = an anti-diarrhea drug is needed. Post-cholecystectomy abdominal and right shoulder pain was classified as mild (I) = pain relieved within 3 postoperative days; moderate (II) = pain relieved within 7 days; severe (III) = pain relieved after 7 days.

providing trainees with access to well-organized educational video programs and lectures.

Many reports on solo surgery have emerged. This technique has been utilized in single-port laparoscopic appendectomy, LC with a robotic camera holder or joystick-guided camera device, stomach surgery, endoscopic thyroidectomy, and nephrectomy.^{6–11} It is particularly utilized in surgeries in which the surgical view is limited. With advances in surgical techniques and the development of robot-assisted surgery, we can reasonably expect that the field of solo surgery will continue to expand.

This study has a number of limitations, which should be noted, including its small sample size, selection bias, and retrospective design. Solo surgery was considered especially in the presence of a shortage of manpower and when the baseline characteristics of the two groups did not differ significantly. As more severely ill patients were included in the C-TILC group, the complication rates in the group were higher. In addition, we did not record the stability of the surgical view objectively and did not show the advantage in terms of human resource with a statistical index. The safety of this surgical approach should be continually assessed in future studies involving larger sample sizes. Nevertheless, our results have

shown that solo surgery can be performed in cases of acute cholecystitis and that the results of this surgical technique are comparable with those obtained with C-TILC. Therefore, S-TILC using a laparoscopic camera holder could potentially replace a scopist in C-TILC for the management of acute cholecystitis in cases of manpower shortage.

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