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Optimal indication of single-incision laparoscopic cholecystectomy using Konyang Standard Method in benign gallbladder diseases

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Purpose: The optimal indications for single-incision laparoscopic cholecystectomy (SILC) have not yet been established.

Methods: This single-center retrospective study included consecutive patients who underwent SILC between April 2010 and June 2020. Difficult surgery (DS) (conversion to multiport or open cholecystectomy, adjacent organ injury, operation time of ≥90 minutes, or estimated blood loss of ≥100 mL) and poor postoperative outcome (PPO) (postoperative hospital stay ≥ 7 days or Clavien-Dindo grade ≥ II postoperative complications) were defined to comprehensively evaluate surgical difficulty and postoperative outcomes, respectively.

Results: Of 1,405 patients (mean age, 51.2 years; 802 female [57.1%]), 427 (grade I, n = 358; grade II/III, n = 69) underwent SILC for acute cholecystitis (AC), 34 (2.4%) needed conversion to multiport (n = 33) or open cholecystectomy (n = 1), 7 (0.5%) had adjacent organ injury during surgery, and 49 (3.5%) developed postoperative complications. Of the patients, 89 and 52 had DS and PPO, respectively. In the multivariate analysis, grade I AC, grade II/III AC, and body mass index of ≥30 kg/m^2 were significant predictors of DS. Age of ≥70 years and DS were significant predictors of PPO. In a subgroup analysis of patients with AC, DS (9.5% vs. 27.5%, p < 0.001) and PPO (5.0% vs. 15.9%, p = 0.001) were more frequent in patients with grade II/III AC than in those with grade I AC.

Conclusion: SILC is not recommended in patients with grade II/III AC and should be carefully performed by experienced and well-trained surgeons.

Keywords: Laparoscopy, Cholecystectomy, Acute cholecystitis

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INTRODUCTION

Laparoscopic procedures are considered a standardized approach for the treatment of benign gallbladder diseases [1]. With the development of surgical techniques and instruments and the accumulating experience in laparoscopic surgery, many surgeons have attempted to reduce the number of incisions. Single-incision laparoscopic cholecystectomy (SILC), which emerged as a result of these efforts, has been widely accepted since it was first introduced in 1997 [2]. Initially, SILC was performed only in highly selected patients; however, the indications were gradually expanded as the surgeons' experience accumulated. Nevertheless, no definite indications for SILC have been established thus far. Although previous studies have reported the safety and feasibility of SILC in patients with acute cholecystitis (AC) [3–5], some controversies remain about the safety of SILC for AC. Several systematic reviews have cautioned that attention should be paid to the application of SILC in patients with AC, obesity (body mass index [BMI] of ≥30 kg/m^2), and advanced age [6–8].

At our institution, SILC has been performed for benign gallbladder diseases since 2010. We have reported the evolution of our surgical method for SILC [9,10], as well as the risk factors for conversion to conventional multiport laparoscopic cholecystectomy (CMLC) [11] and prolonged operation time [12]. The current study aimed to identify the optimal indications for SILC by analyzing the difficulty of surgery and postoperative outcomes from our experience of >10 years.

MATERIALS AND METHODS

Patients and indications for single-incision laparoscopic cholecystectomy

We evaluated patients with benign gallbladder diseases who underwent SILC performed by three hepatobiliary surgeons at Konyang University Hospital between April 2010 and June 2020. A total of 1,405 patients were included in this study. Initially, when we selected candidates for SILC, we excluded patients aged >70 years and those with systemic disease, variation of bile duct, or complications of AC. After 50 cases, SILC was applied to all patients with benign gallbladder diseases except when malignancy was suspected. After reporting the risk factors for conversion and prolonged operation time [11,12], we carefully performed SILC in patients with complicated AC.

Surgical technique of single-incision laparoscopic cholecystectomy

Our surgical methods have evolved over time and cautiously expanded indications. In the first period, SILC was performed with a handmade three-channel port using surgical gloves. We named this the Konyang Standard Method (KSM). In the second period, SILC was performed using a handmade four-channel port with a snake liver retractor to expose the Calot triangle. We referred to this method as the modified KSM. In the third period, SILC was performed using a commercial four-channel port (Glove port; Nelis, Bucheon, Korea), which is the final version of our standardized SILC method. We referred to this method as the commercially modified KSM. For the commercially modified KSM, a 20-mm transumbilical incision was made and a glove port was inserted. The flexible laparoscope was inserted into the left lower channel, the snake retractor into the right lower channel below the laparoscope, and the grasper into the left upper channel located on the right side of the laparoscope. Meanwhile, the dissector, scissors, and electrocautery suction–irrigation device were inserted into the right upper channel below the grasper. The detailed surgical technique has been described in our previous study [10].

Definitions of demographics and treatment outcomes

The diagnosis of AC was based on the 2018 Tokyo Guidelines (TG18) [13]. Imaging findings were confirmed using abdominal ultrasonography, computed tomography, or magnetic resonance cholangiopancreatography. The severity of AC was classified according to TG18 [13]. The general condition and physical fitness of each patient were evaluated using the American Society of Anesthesiologists physical status (ASA PS) classification [14]. Postoperative complications were graded according to the Clavien-Dindo classification [15]. The length of hospital stay after surgery was defined as the number of days of hospital stay after the SILC procedure. Operation time was calculated as the time from skin incision to skin closure. Blood loss estimates were obtained from surgical records. Bile duct injury was defined as damage to the biliary tract, excluding the cystic duct and gallbladder, and was classified according to the timing of recognition. Adjacent organ injury recognized during surgery was defined as damage to adjacent organs, such as the duodenum, colon, and hepatic artery, excluding the bile duct. Bile duct injury and adjacent organ injury recognized during surgery were not included as postoperative complications.

An incisional hernia was defined as a hernia at the umbilical incision site that was postoperatively confirmed with physical examination and imaging studies.

Definitions of difficult surgery and poor postoperative outcome

We evaluated the surgical difficulty and postoperative outcomes to confirm the safety and feasibility of SILC. We defined difficult surgery (DS) as the occurrence of the following intraoperative outcomes: conversion to multiport or open cholecystectomy, adjacent organ injury during surgery, operation time of ≥90 minutes, or estimated blood loss of ≥100 mL. We defined poor postoperative outcome (PPO) as postoperative hospital stay of ≥7 days or postoperative complications of Clavien-Dindo grade ≥II. Operation time of ≥90 minutes, estimated blood loss of ≥100 mL, and postoperative hospital stay of ≥7 days, which are the criteria for DS and PPOs, were all determined based on 95% of the study population.

Statistical analysis

Categorical variables are presented as counts and percentages and were compared using the chi-square test. Continuous variables are summarized as means and standard deviations and were compared using Student *t* test. Multivariate analyses of the significant factors identified in the univariate analyses were performed using a logistic regression model. All tests were two-sided, and statistical significance was set at $p < 0.05$. Analyses were performed using IBM SPSS version 24 (IBM Corp., Armonk, NY, USA).

RESULTS

Study population

The patient demographics, disease characteristics, and surgical outcomes are listed in Table 1. The mean age at surgery was 51.2 years, and 802 patients (57.1%) were female. Of the 1,405 patients, 338 (24.1%) underwent SILC for gallbladder stones, 121 (8.6%) for gallbladder polyps, 474 (33.7%) for chronic cholecystitis, and 427 (30.4%) for AC. According to the TG18 classification of AC sever-

Table 1. Demographics, disease characteristics, and surgical outcomes in the study population

Variable	Data
No. of patients	1,405
Sex	
Male	603 (42.9)
Female	802 (57.1)
Age (yr)	51.2 ± 14.4
Body mass index (kg/m^2)	24.7 ± 3.5
<30	1,300 (92.5)
≥30	105 (7.5)
Preoperative diagnosis	
Gallbladder stone	338 (24.1)
Gallbladder polyp	121 (8.6)
Acute cholecystitis, TG18 grade	427 (30.4)
I	358 (25.5)
II/III	69 (4.9)
Chronic cholecystitis	474 (33.7)
Others	45 (3.2)
Prior abdominal surgery	
Yes	324 (23.1)
No	1,081 (76.9)
ASA PS classification	
<III	1,308 (93.1)
≥III	97 (6.9)
Preoperative laboratory finding	
White blood cell (×10^3/mm^3)	8.2 ± 3.6
Hemoglobin (g/dL)	13.6 ± 1.6
Platelets (×10^3/mm^3)	245.5 ± 96.2
PT (INR)	1.03 ± 0.09
Creatinine (mg/dL)	0.81 ± 0.23
AST (IU/L)	81.0 ± 207.1
ALT (IU/L)	76.0 ± 167.3
Total bilirubin (mg/dL)	1.13 ± 1.38
Preoperative EST	132 (9.4)
Preoperative PTGBD	137 (9.8)
Operation time (min)	51.8 ± 17.9
Estimated blood loss (mL)	14.8 ± 34.2
Intraoperative transfusion	0 (0)
Bile duct injury	3 (0.2)
Recognized during surgery	2 (0.1)
Recognized during the postoperative period	1 (0.1)
Adjacent organ injury recognized during surgery	4 (0.3)
Duodenum	2 (0.1)
Hepatic artery	2 (0.1)
Conversion	34 (2.4)
Insertion of one additional port	6 (0.4)
Insertion of two additional ports	27 (1.9)
Open conversion	1 (0.1)
Postoperative complication, CD grade	49 (3.5)
I	21 (1.5)
II	19 (1.4)
IIIa	6 (0.4)
IIIb	3 (0.2)
Postoperative hospital stay (day)	2.5 ± 1.7
Pathology	
Chronic cholecystitis	1,128 (80.3)
Acute cholecystitis or empyema	188 (13.4)
Polyp and adenoma	81 (5.8)
Cancer	5 (0.4)
Others	3 (0.2)
Incisional hernia	5 (0.4)
30-Day mortality	0 (0)

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

TG18, 2018 Tokyo Guidelines; ASA PS, American Society of Anesthesiologists physical status; PT, prothrombin time; INR, international normalized ratio; AST, aspartate transaminase; ALT, alanine transaminase; EST, endoscopic sphincterotomy; PTGBD, percutaneous transhepatic gallbladder drainage; CD, Clavien-Dindo classification.

ity, 358 patients (83.8%) had grade I AC and 69 patients (16.2%) had grade II/III AC. A total of 105 patients (7.5%) had a BMI of ≥30 kg/m^2, and 97 patients (6.9%) had an ASA PS classification of ≥III. In addition, 324 patients (23.1%) had a history of prior abdominal surgery. Preoperative percutaneous transhepatic gallbladder drainage (PTGBD) was performed in 137 patients (9.8%). Preoperative endoscopic sphincterotomy for common bile duct stones was performed in 132 patients (9.4%).

The mean operation time was 51.8 minutes, and the mean estimated blood loss was 14.8 mL. One additional port was inserted in six of the 1,405 patients (0.4%), two additional ports were inserted in 27 patients (1.9%), and open conversion was performed in only one patient (0.1%). Bile duct injury occurred in three patients, which was recognized during surgery in two patients and during the postoperative period in one patient. Four adjacent organ injuries (0.3%) were recognized during surgery, two in the duodenum and two in the hepatic arteries (one in the left hepatic artery and one in the right hepatic artery). No intraoperative transfusions were performed. Postoperative complications occurred in 49 patients (3.5%). The mean length of postoperative hospital stay was 2.5 days. Pathologic examination revealed that 1,128 (80.3%) patients had chronic cholecystitis, 188 (13.4%) had AC (emphysematous or gangrenous cholecystitis), and five (0.4%) had gallbladder cancer. Postoperative incisional hernia at the umbilical site was observed in five patients (0.4%). No postoperative 30-day mortality occurred.

Difficult surgery

According to the definition of DS, the study population was divided into two groups: non-DS (NDS) and DS. Table 2 shows a comparison of patient demographics between the two groups. No significant sex differences were observed between the two groups (p = 0.084). The DS group included more patients aged ≥70 years (10.0% vs. 20.2%, p = 0.002), patients with BMI of ≥30 kg/m^2 (7.1% vs. 14.6%, p = 0.009), and patients with an ASA PS classification of ≥III (6.2% vs. 16.9%, p < 0.001) than the NDS group. The proportion of patients with AC was also higher in the DS group than in the NDS group (28.4% vs. 59.6%, p < 0.001). Preoperative PTGBD was performed more frequently (8.5% vs. 28.1%, p < 0.001) in the

Table 2. Comparison of patient characteristics according to surgical difficulty and postoperative outcomes

Characteristic	Surgical difficulty		*p* value	Postoperative outcomes		*p* value
	Non-DS (n = 1,316)	DS (n = 89)		Non-PPO (n = 1,353)	PPO (n = 52)	
Female sex	759 (57.7)	43 (48.3)	0.084	774 (57.2)	28 (53.8)	0.631
Age, ≥70 yr	131 (10.0)	18 (20.2)	0.002	130 (9.6)	19 (36.5)	<0.001
Body mass index (kg/m^2)						
≥30	93 (7.1)	13 (14.6)	0.009	101 (7.5)	5 (9.6)	0.564
<20	100 (7.6)	3 (3.4)	0.139	99 (7.3)	4 (7.7)	0.919
Preoperatively diagnosed AC	374 (28.4)	53 (59.6)	<0.001	398 (29.4)	29 (55.8)	<0.001
Grade I	324 (24.6)	34 (38.2)		340 (25.1)	18 (34.6)	
Grade II/III	50 (3.8)	19 (21.3)		58 (4.3)	11 (21.2)	
Prior abdominal surgery, +	1,013 (77.0)	68 (76.4)	0.901	315 (23.3)	9 (17.3)	0.316
ASA PS classification ≥III	82 (6.2)	15 (16.9)	<0.001	87 (6.4)	10 (19.2)	<0.001
Preoperative laboratory findings						
WBC (×10^3/mm^3), >10.4 or <4.0	239 (18.2)	39 (43.8)	<0.001	261 (19.3)	17 (32.7)	0.017
AST (IU/L), >36	345 (26.2)	34 (38.2)	0.014	359 (26.5)	20 (38.5)	0.057
ALT (IU/L), >38	373 (28.3)	33 (37.1)	0.078	387 (28.6)	19 (36.5)	0.215
Total bilirubin (mg/dL), >1.3	220 (16.7)	26 (29.2)	0.003	231 (17.1)	15 (28.8)	0.028
Preoperative EST, +	119 (9.0)	13 (14.6)	0.082	121 (8.9)	11 (21.2)	0.003
Preoperative PTGBD, +	112 (8.5)	25 (28.1)	<0.001	121 (8.9)	16 (30.8)	<0.001
DS	NA	NA	NA	73 (5.4)	16 (30.8)	<0.001

Values are presented as number (%).

DS, difficult surgery; PPO, poor postoperative outcome; AC, acute cholecystitis; ASA PS, American Society of Anesthesiologists physical status; WBC, white blood cell; AST, aspartate transaminase; ALT, alanine transaminase; EST, endoscopic sphincterotomy; PTGBD, percutaneous transhepatic gallbladder drainage; NA, not applicable.

DS group than in the NDS group. With respect to preoperative laboratory findings, leukocytosis or leukopenia (18.2% vs. 43.8%, $p < 0.001$), elevated aspartate transaminase level (26.2% vs. 38.2%, $p = 0.014$), and hyperbilirubinemia (16.7% vs. 29.2%, $p = 0.003$) were more common in the DS group than in the NDS group.

In the multivariate logistic regression model that included the significant factors identified in the univariate analysis, grade I AC (odds ratio [OR], 2.157), grade II/III AC (OR, 5.108), and BMI of ≥30 kg/m^2 (OR, 2.163) were significant predictors of DS (Table 3).

Poor postoperative outcome

According to the definition of PPO, the study population was divided into two groups: non-PPO and PPO. Table 2 shows a comparison of patient demographics between the two groups. No significant sex differences were found between the two groups ($p = 0.631$). The PPO group included more patients aged ≥70 years (9.6% vs. 36.5%, $p < 0.001$) and patients with an ASA PS classification of ≥III (6.4% vs. 19.2%, $p < 0.001$) than the non-PPO group. The proportion of patients with AC was also higher in the PPO group than in the non-PPO group (29.4% vs. 55.8%, $p < 0.001$). Preoperative PTGBD (8.9% vs. 30.8%, $p < 0.001$) and endoscopic sphincterotomy (8.9% vs. 21.2%, $p = 0.003$) were performed more frequently in the PPO group than in the non-PPO group. With respect to preoperative laboratory findings, leukocytosis or leukopenia (19.3% vs. 32.7%, $p = 0.017$) and hyperbilirubinemia (17.1% vs. 28%, $p = 0.028$) were more common in the PPO group than in

Table 3. Multivariate analysis of predictors of difficult surgery in single-incision laparoscopic cholecystectomy

Factor	Multivariate analysis	
	OR (95% CI)	*p* value
Age (yr)		
<70	1 (Reference)	
≥70	1.044 (0.524–2.080)	0.903
BMI (kg/m^2)		
<30	1 (Reference)	
≥30	2.163 (1.119–4.181)	0.022
ASA PS classification		
<III	1 (Reference)	
≥III	1.452 (0.691–3.050)	0.325
WBC (×10^3/mm^3)		
≥4.0 or ≤10.8	1 (Reference)	
<4.0 or >10.8	1.635 (0.935–2.860)	0.085
AST (IU/L)		
≤36	1 (Reference)	
>36	1.211 (0.703–2.085)	0.491
Total bilirubin (mg/dL)		
≤1.3	1 (Reference)	
>1.3	1.112 (0.606–2.041)	0.731
Preoperative PTGBD		
No	1 (Reference)	
Yes	1.137 (0.563–2.294)	0.720
Acute cholecystitis		
No	1 (Reference)	
Grade I	2.157 (1.247–3.733)	0.006
Grade II/III	5.108 (2.063–12.648)	<0.001

OR, odds ratio; CI, confidence interval; BMI, body mass index; ASA PS, American Society of Anesthesiologists physical status; WBC, white blood cell; AST, aspartate transaminase; PTGBD, percutaneous transhepatic gallbladder drainage.

Table 4. Multivariate analysis of predictors of poor postoperative outcome in single-incision laparoscopic cholecystectomy

Factor	Multivariate analysis	
	OR (95% CI)	*p* value
Age (yr)		
<70	1 (Reference)	
≥70	3.496 (1.692–7.226)	0.001
ASA PS classification		
<III	1 (Reference)	
≥III	0.927 (0.367–2.339)	0.873
WBC (×10^3/mm^3)		
≥4.0 or ≤10.8	1 (Reference)	
<4.0 or >10.8	0.592 (0.256–1.371)	0.221
Total bilirubin (mg/dL)		
≤1.3	1 (Reference)	
>1.3	0.929 (0.433–1.993)	0.849
Preoperative EST		
No	1 (Reference)	
Yes	1.916 (0.820–4.479)	0.133
Preoperative PTGBD		
No	1 (Reference)	
Yes	2.230 (0.874–5.689)	0.093
Acute cholecystitis		
No	1 (Reference)	
Grade I	1.282 (0.597–2.752)	0.525
Grade II/III	2.208 (0.643–7.581)	0.208
Difficult surgery		
No	1 (Reference)	
Yes	5.681 (2.820–11.444)	<0.001

OR, odds ratio; CI, confidence interval; ASA PS, American Society of Anesthesiologists physical status; WBC, white blood cell; EST, endoscopic sphincterotomy; PTGBD, percutaneous transhepatic gallbladder drainage.

the non-PPO group. Furthermore, DS was more common in the PPO group than in the non-PPO group (5.4% vs. 30.8%, $p < 0.001$).

In multivariate analysis, age of ≥70 years (OR, 3.496) and DS (OR, 5.681) were statistically significant predictors of PPO, and the severity of AC was not statistically related to PPO (Table 4).

Patients with acute cholecystitis

A subgroup analysis of patients with AC was conducted according to the TG18 classification of AC severity; grade I AC group vs. grade II/III AC group. Table 5 shows the comparison of patient demographics, disease characteristics, and surgical outcomes between the two groups. The patients in the grade II/III AC group were older than those in the grade I AC group (53.1 years vs. 63.5 years, $p < 0.001$). More patients with an ASA PS classification of ≥III were included in the grade II/III AC group than in the grade I AC group (8.9% vs. 31.9%, $p < 0.001$). Preoperative PTGBD was performed more frequently (23.2% vs. 78.3%, $p < 0.001$) in the grade II/III AC group than in the grade I AC group. DS (9.5% vs. 27.5%, $p < 0.001$) and PPO (5.0% vs. 15.9%, $p = 0.001$) were more common in the grade II/III AC group than in the grade I AC group. The grade II/III AC group showed poorer outcomes than the grade I AC group in terms of operation time (57.1 minutes vs. 67.4 minutes, $p < 0.001$), conversion to multiport or open cho-

Table 5. Demographics, disease characteristics, and surgical outcomes in patients with acute cholecystitis according to disease severity

Variables	Acute cholecystitis (n = 427)	TG18 grade I (n = 358)	TG18 grade II/III (n = 69)	*p* value
Sex				0.131
Male	212 (49.6)	172 (48.0)	40 (58.0)	
Female	215 (50.4)	186 (52.0)	29 (42.0)	
Age (yr)	54.7 ± 15.5	53.1 ± 15.0	63.5 ± 15.3	<0.001
Body mass index (kg/m^2)	24.7 ± 3.5	24.8 ± 3.3	24.6 ± 4.0	0.802
Prior abdominal surgery				0.329
Yes	73 (17.1)	64 (17.9)	9 (13.0)	
No	354 (82.9)	294 (82.1)	60 (87.0)	
ASA PS classification				<0.001
<III	373 (87.4)	326 (91.1)	47 (68.1)	
≥III	54 (12.6)	32 (8.9)	22 (31.9)	
Preoperative laboratory findings				
WBC (×10^3/mm^3)	10.7 ± 4.5	9.7 ± 3.4	16.4 ± 5.3	<0.001
Hemoglobin (g/dL)	13.7 ± 1.6	13.7 ± 1.6	13.5 ± 1.7	0.355
Platelets (×10^3/mm^3)	234.3 ± 74.6	236.8 ± 72.6	221.4 ± 83.6	0.157
PT (INR)	1.06 ± 0.11	1.04 ± 0.09	1.13 ± 0.15	<0.001
Creatinine (mg/dL)	0.86 ± 0.29	0.84 ±0.26	0.98 ± 0.39	<0.001
AST (IU/L)	138.4 ± 313.6	143.5 ± 329.3	111.6 ±214.5	0.307
ALT (IU/L)	116.2 ± 226.9	122.4 ± 238.7	84.0 ± 148.0	0.198
Total bilirubin (mg/dL)	1.63 ± 1.89	1.56 ± 1.75	2.00 ± 2.47	0.160
Preoperative EST	80 (18.7)	69 (19.3)	11 (15.9)	0.516
Preoperative PTGBD	137 (32.1)	83 (23.2)	54 (78.3)	<0.001
Operation time (min)	58.8 ± 21.5	57.1 ± 20.4	67.4 ± 25.0	<0.001
Estimated blood loss (mL)	22.6 ± 55.3	21.6 ± 58.9	27.8 ± 29.6	0.194
Drain insertion	17 (4.0)	8 (2.2)	9 (13.0)	<0.001
Bile duct injury	2 (0.5)	2 (0.6)	0 (0)	
Adjacent organ injury recognized during surgery	1 (0.2)	0 (0)	1 (1.4)	
Conversion	25 (5.9)	14 (3.9)	11 (15.9)	<0.001
Insertion of one additional port	4 (0.9)	3 (0.8)	1 (1.4)	
Insertion of two additional ports	20 (4.7)	11 (3.1)	9 (13.0)	
Open conversion	1 (0.2)	0 (0)	1 (1.4)	

Table 5. Continued

Variables	Acute cholecystitis (n = 427)	TG18 grade I (n = 358)	TG18 grade II/III (n = 69)	*p* value
Difficult surgery	53 (12.4)	34 (9.5)	19 (27.5)	<0.001
Postoperative complication, CD grade	27 (6.3)	16 (4.5)	11 (15.9)	<0.001
I	6 (1.4)	5 (1.4)	1 (1.4)	
II	13 (3.0)	6 (1.7)	7 (10.1)	
IIIa	6 (1.4)	3 (0.8)	3 (4.3)	
IIIb	2 (0.5)	2 (0.6)	0 (0)	
Postoperative hospital stay (day)	2.8 ± 2.2	2.7 ± 2.1	3.7 ± 2.9	0.001
Poor postoperative outcome	29 (6.8)	18 (5.0)	11 (15.9)	0.001
Pathology				0.017
Acute cholecystitis	174 (40.7)	137 (38.3)	37 (53.6)	
Chronic cholecystitis and others	253 (59.3)	221 (61.7)	32 (46.4)	
Incisional hernia	3 (0.7)	2 (0.6)	1 (1.4)	0.417

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

TG18, 2018 Tokyo Guidelines; ASA PS, American Society of Anesthesiologists physical status; WBC, white blood cell; PT, prothrombin time; INR, international normalized ratio; AST, aspartate transaminase; ALT, alanine transaminase; PTGBD, percutaneous transhepatic gallbladder drainage; EST, endoscopic sphincterotomy; CD, Clavien-Dindo classification.

lecystectomy (3.9% vs. 15.9%, $p < 0.001$), postoperative complications (4.5% vs. 15.9%, $p < 0.001$), and postoperative hospital stay (2.7 vs. 3.7 days, $p = 0.001$).

DISCUSSION

Although minimally invasive surgery has been widely accepted in many surgical fields, it remains highly technically challenging in the field of hepatobiliary surgery. Nevertheless, laparoscopic cholecystectomy is performed in 1.2 million patients per year worldwide [16] and is considered the treatment of choice for benign gallbladder diseases. To improve the attendant benefits of minimally invasive surgery with CMLC using three to four ports, SILC was developed, which is recently increasing in popularity. As SILC cannot yet be considered a standard treatment, careful decision making is required when selecting patients suitable for SILC. However, few studies have investigated the optimal indications for SILC. The present study is meaningful because it analyzed a large number of patients who underwent SILC at a single institution and suggested the optimal indications for SILC.

To determine the optimal indications for SILC, both the difficulty of surgery and postoperative surgical outcomes need to be evaluated. Various factors including operation time, estimated blood loss, adjacent organ injury, postoperative complications, and length of hospital stay should also be considered. Evaluating each of the various factors in one study to determine the optimal indications for a procedure is challenging, and the factors need to be evaluated in an integrated manner. Therefore, we defined DS and PPO for a comprehensive evaluation of surgical difficulty and outcomes. In addition, since the decision of the surgical method whether to apply SILC or CMLC is made before surgery, this study evaluated the optimal indication for preoperative factors rather than intraoperative factors.

Although the safety of SILC in patients with AC remains controversial, its application in clinical practice is gradually expanding [17]. Patients with AC may have severe inflammation in the porta hepatis, which greatly distorts the anatomy. In addition, the gallbladder is often distended, friable, and difficult to grasp, and persistent oozing of blood often obscures the surgical field. All of these factors may impede the safety of SILC. Several previous case-controlled studies on SILC in patients with AC reported a 3.6% to 18.3% rate of postoperative complications, 2.7% to 60.0% rate of additional port insertion, 0.4% to 18.3% rate of open conversion, and 5.7 to 9.4 days of postoperative hospital stay [3,4,18,19]. Despite a large number of patients with AC compared with previous studies, the surgical outcomes in the present study were relatively acceptable. However, no studies have investigated the safety of SILC in patients with AC according to disease severity as done in the present study. Our results revealed that most surgical outcomes were worse in patients with grade II/III AC than in those with grade I AC in terms of conversion rate, operation time, postoperative hospital stay, and complication rate. Careful patient selection for safe surgery is more important than expanding the indications for SILC. Therefore, in patients with AC, the indications for SILC should be established according to disease severity.

SILC is an easy-to-perform and safe procedure for experienced laparoscopic and hepatobiliary surgeons. Previous studies have reported that the learning curve for the successful completion of SILC seems to be 8 to 25 cases [20–22]. However, in those studies, patients with AC were either excluded or only partly included. SILC should only be applied after overcoming the learning curve in patients with AC or other factors increasing surgical difficulties.

In the present study, age of ≥70 years (OR, 3.496) and DS (OR, 5.681) were statistically significant predictors of PPO. Old age is a predictor of PPO in most surgical procedures. Similar results were observed in the present study. SILC should be applied with caution in elderly patients to improve the postoperative outcomes. Importantly, DS was the most significant predictor of PPO, and the severity of AC was not statistically related to PPO. In SILC, reducing the difficulty of surgery is the most important way to achieve better surgical outcomes. Therefore, SILC should be carefully applied in patients with risk factors for DS, such as AC and high BMI, and should be avoided in patients with grade II/III AC, which is the most important cause of surgical difficulty.

This study had several limitations. First, this was a retrospective, single-center study, and some bias may exist in the results. As SILC is performed using various surgical methods across different institutions, the results may vary depending on the surgical method. In addition, although checking “critical view of safety” is considered the gold standard for securing the safety of cholecystectomy, this study was a retrospective study and could not confirm whether “critical view of safety” was checked during surgery. Second, this is the first study to recommend the optimal indications for SILC by defining DS and PPO for a comprehensive evaluation of surgical difficulty and postoperative outcomes. The disadvantages of this study are that the effectiveness of the integrated analysis has not been confirmed and a detailed analysis of each factor was not performed. Third, this study included only patients who underwent SILC. A comparison of perioperative outcomes according to AC severity is not sufficient to confirm the safety of SILC for AC. Therefore, we plan to compare the perioperative outcomes between SILC and CMLC in patients with AC using a propensity score-matched analysis.

In conclusion, owing to surgical difficulty and poor surgical outcomes, SILC is not recommended in patients with grade II/III AC and should be carefully performed by experienced and well-trained surgeons. Further studies comparing SILC with CMLC are needed to confirm the safety and effectiveness of SILC in patients with AC, high BMI, or advanced age.

NOTES

Ethics statements

This study was approved by the Institutional Review Board of Konyang University Hospital, and the requirement for informed consent was waived owing to the retrospective study design (No. 2021-02-004).

Authors’ contributions

Conceptualization, Formal analysis, Methodology, Visualization: SJL, ISC, JIM
Data curation, Investigation: All authors
Writing-original draft: SJL
Writing-review & editing: SJL, ISC, JIM
All authors read and approved the final manuscript.

Conflict of interest

All authors have no conflicts of interest to declare.

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