Safe laparoscopic subtotal cholecystectomy in the face of severe inflammation in the cystohepatic triangle: a retrospective review and proposed management strategy for the difficult gallbladder

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Background: Laparoscopic subtotal cholecystectomy (LSC) can be employed when extensive fibrosis or inflammation of the cystohepatic triangle prohibits safe dissection of the cystic duct and artery. The purpose of this study was to compare postoperative outcomes in patients with severe cholecystitis who underwent laparoscopic cholecystectomy (LC) or LSC.

Methods: In this retrospective study, we compared the postoperative outcomes of patients with severe cholecystitis who underwent LC or LSC between July 2010 and July 2016 at St. Joseph's Health Centre, Toronto. We further stratified LSC cases on the basis of the extent of gallbladder (GB) dissection and GB remnant closure.

Results: A total of 105 patients who underwent LC and 46 who underwent LSC were included in the study. There were 4 bile duct injuries in the LC group and 0 in the LSC group. Bile leaks (relative risk [RR] 3.4, 95% confidence interval [CI] 1.01–11.5) and subphrenic collections (RR 3.1, 95% CI 1.3–8.0) were more common in the LSC group. Overall postoperative morbidity did not differ significantly between the 2 groups. Postoperative endoscopic retrograde cholangiopancreatography (ERCP) (RR 3.2, 95% CI 1.1–9.5) and biliary stent insertion (RR 4.6, 95% CI 1.2–17.5) were more common in the LSC group. Bile leaks appeared to be more prominent with open GB remnants but all cases of leak were successfully managed with ERCP and biliary stenting.

Conclusion: LSC may mitigate the risk of bile duct injury when dissection into the cystohepatic triangle is unsafe. There were more bile leaks in patients who underwent LSC; however, they were readily managed with endoscopic stents. Long-term biliary fistulae were not observed. LSC should be considered early as a means of completing difficult cholecystectomies safely without the need for cholecystostomy tube or conversion to laparotomy.

Contexte : La cholécystectomie laparoscopique subtotale (CLS) peut être utilisée si une fibrose ou une inflammation étendue du triangle cystohépatique empêche l'ablation sécuritaire du canal et de l'artère cystiques. Cette étude avait pour but de comparer les résultats postopératoires chez des patients atteints de cholécystite grave ayant subi une cholécystectomie laparoscopique (CL) ou une CLS.

Méthodes : Dans cette étude rétrospective, nous avons comparé les résultats postopératoires des patients atteints de cholécystite grave ayant subi une CL ou une CSL entre juillet 2010 et juillet 2016 au St. Joseph's Health Centre de Toronto. Nous avons ensuite stratifié les cas de CSL selon la proportion de la vésicule biliaire excisée et la suture du reliquat.

Résultats : En tout, 105 patients ayant subi une CL et 46 une CLS ont été inclus dans l'étude. On a dénombré 4 lésions du canal cholédoque dans le groupe CL et 0 dans le groupe CLS. Les fuites biliaires (risque relatif [RR] 3,4, intervalle de confiance [IC] de 95 % 1,01–11,5) et les collections sous-diaphragmatiques (RR 3,1, IC de 95 % 1,3–8,0) ont été plus fréquentes dans le groupe CSL. Globalement, la morbidité postopératoire n'a pas été significativement différente entre les 2 groupes. La cholangiopancréatographie rétrograde endoscopique (CPRE) postopératoire (RR 3,2, IC de 95 % 1,1–9,5) et la pose d'une endoprothèse biliaire (RR 4,6, IC de 95 % 1,2–17,5) ont été plus fréquentes dans le groupe CLS. Les fuites biliaires ont semblé plus marquées en l'absence de suture des reliquats, mais tous les cas de fuite ont été traités avec succès par CPRE et endoprothèse biliaire.

Conclusion : La CLS pourrait atténuer le risque de lésion du canal cholédoque lorsqu'il est contre-indiqué d'intervenir au niveau du triangle cystohépatique. On a observé plus de fuites biliaires chez les patients soumis à la CLS; par contre, ces fuites ont rapidement été corrigées à l'aide d'endoprothèses. Aucune fistule biliaire n'a été observée à long terme. La CLS devrait être envisagé sans tarder pour finaliser sécuritairement les cholécystectomies compliquées sans recourir au drain de cholécystostomie ou à conversion en laparotomie.

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After the introduction and rapid adoption of the laparoscopic cholecystectomy (LC), concerns arose about increased rates of bile duct injuries.[1–3] Over the last 25 years, however, improvements in surgical training with emphasis on achieving the "critical view of safety"[4] have resulted in rates of bile duct injury similar to those seen in the prelaparoscopic era.[5,6] Recent studies have shown that rates of conversion to open cholecystectomy are decreasing as well. Conversion rates were as high as 38% in the 1990s for acute cholecystitis but have since dropped to as low as 2.6%.[7,8] This trend toward fewer open cholecystectomies is evident both in practice and in resident training. A recent study showed that the mean number of open cholecystectomies done at a single academic centre by residents in their chief year has dropped from 70.4 to 3.6 in the last 3 decades.[9]

More recent trends have pointed toward reduced morbidity with early cholecystectomy for management of acute gallbladder pathology. Specifically, de Mestral and colleagues demonstrated that patients who were discharged without cholecystectomy had a 29% probability of returning to hospital within 1 year with another gallbladder (GB) related event.[10] It was also determined that early cholecystectomy was associated with fewer bile duct injuries.[11] Although early LC represents the best approach for most patients with biliary disease, there is a subset of patients with marked local GB inflammation in whom bile duct injuries are more prevalent. The Tokyo guidelines for severity of acute cholecystitis published in 2012 proposed a classification system based on intraoperative assessment of GB inflammation as well as associated organ dysfunction.[12] Törnqvist and colleagues retrospectively applied this classification system to a cohort of patients who had undergone LC and found that extensive inflammation (Tokyo grade II) more than doubled the risk of bile duct injury.[13] Within this subset of patients where the cystohepatic triangle cannot be safely skeletonized, laparoscopic subtotal cholecystectomy (LSC), also referred to as fenestrated cholecystectomy,[14] is a viable surgical option.

We proposed 3 tenets as the foundation of the management of severe cholecystitis: (a) early identification of a severely inflamed and possibly fused cystohepatic triangle resulting in a decision to avoid further dissection and prepare for LSC; (b) mobilization of the GB off of the liver bed in a counterclockwise direction well above the vasculobiliary pedicle using what we call the top-around technique; this is followed by opening of the GB at the level of Hartmann's pouch and leaving a remnant without approaching the cystohepatic triangle at all; and (c) removal of all stones from the GB remnant and identification of the cystic duct orifice to determine if there is bile leakage. The GB remnant can subsequently either be left open or be closed with laparoscopic sutures or loop ligature. A drain is often left in place over the GB remnant. In some cases, dissection off of the liver bed is also considered unsafe and thus the GB is opened only anteriorly.

The purpose of this study is to compare postoperative outcomes between LCs and LSCs done in the setting of severe inflammation. Recognizing that the operation may vary depending on the degree of inflammation and involvement of associated structures, we will also stratify these postoperative outcomes into our institutional classification system for subtotal cholecystectomies.

Methods

Patients and study method

This is a retrospective analysis of postoperative outcomes in patients with severe cholecystitis who underwent either LC or LSC at St. Joseph's Health Centre, Toronto, from July 2010 to July 2016. St. Joseph's Health Centre is a 400-bed teaching hospital affiliated with the University of Toronto. It is a hepatopancreatobiliary (HPB) referral centre that receives patients with severe cholecystitis from the surrounding area. All inpatient cholecystectomies, both elective and emergent, performed by the 9 staff general surgeons at this hospital during the study period were initially examined. All elective outpatient cholecystectomies, planned open cholecystectomies, and cholecystectomies that were performed as adjuncts to larger operations (e.g., Whipples, hepatectomies) were excluded from the final analysis. Patients with early cholecystitis or with other uncomplicated biliary pathology (choledocholithiasis, gallstone pancreatitis, crescendo biliary colic, GB polyps) were also excluded. Those with severe cholecystitis were included. These were all patients with gangrenous, perforated, chronic or acute on chronic cholecystitis. All operative reports were analyzed to identify the severe cholecystitis cohort. Attention was placed on the surgeon's description of the GB and its surrounding environment, specifically the extent of inflammation or fibrosis, as well as the involvement of any omental adhesions, colon or duodenum. Difficulty of dissection into the pericholecystic tissue was also an important feature, specifically whether there was a thick fibrous rind or a manageable inflammatory plane.

Those patients who underwent a LSC were stratified to our institutional LSC classification system on the basis of the extent of GB resection and whether the GB remnant was left open or closed. Details pertaining to severity of cholecystitis, the operation performed and the intraoperative techniques employed were all extracted from the individual operative reports. Postoperative outcomes were compared between the different types of LSC. It should be noted that the LSC techniques employed at our institution for the management of severe cholecystitis were favoured primarily by 1 of our HPB surgeons. This approach was adopted and used by many of our general surgeons; however, a majority of the cases reported on in this study are from a single surgeon. The proposed study was approved by the St. Joseph's Health Centre Research Ethics Board (no. 2015-023E).

For all patients, preoperative demographic information including existing comorbidities, laboratory values and imaging findings was collected. The indication for LSC or LC was gathered from preoperative imaging and bloodwork as well as the individual operative reports. Details pertaining to postoperative course were also analyzed. These included length of stay and postoperative morbidity including bile duct injuries, bile leaks, development of subphrenic or abdominal abscesses, use of percutaneous drains, endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic biliary stent placement as well as reoperation and mortality. These data were extracted from the electronic medical record and paper charts. The postoperative period for capturing complications and mortality varied. Patients who had their operation closer to the time of data collection had less time to manifest a complication. Our study relied on patients returning to our emergency department acutely if a complication arose.

The primary outcome was incidence of bile duct injuries, described as an injury to the common bile duct (CBD), common hepatic duct or first-order branches. Secondary outcomes included postoperative bile leak and the need for ERCP and biliary stenting, retained CBD stones, abscess formation and the need for percutaneous drain insertion, wound infection, reoperation and mortality.

Statistical analysis

All data were summarized using descriptive statistics. We used χ^2 tests to compare all ordinal data between the LC for severe cholecystitis group and the LSC group. The Shapiro–Wilk test for normality determined that continuous variables (age, length of stay) were nonparametric. Nonparametric, continuous data were compared using a Mann–Whitney test. Relative risk (RR) was calculated for all postoperative complications (bile duct injury, bile leak, subphrenic collection, wound infection, mortality) and all postoperative interventions (postoperative ERCP, endoscopic biliary stent placement, percutaneous drain placement, reoperation). All analyses were conducted in SPSS at a significance level of 0.05.

Operative method and proposed classification system

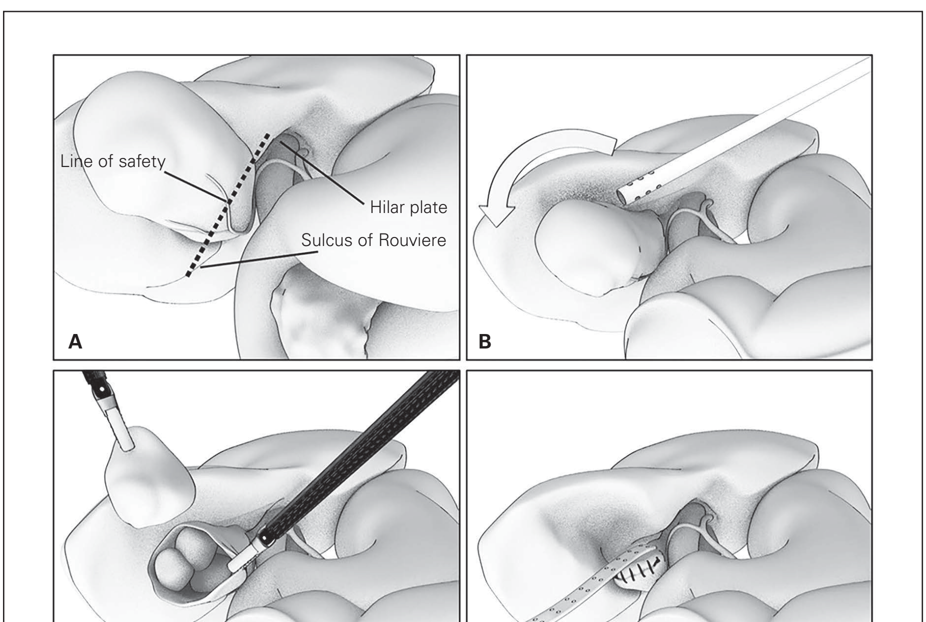

Fig. 1. Stepwise approach to laparoscopic subtotal cholecystectomy. (A) We identified the "line of safety" between the sulcus of Rouviere and the hilar plate in an attempt to start dissection away from the common bile duct in the setting of severe inflammation. (B) We performed gallbladder (GB) decompression followed by top-around mobilization off of the liver bed, mostly with blunt dissection. (C) We deroofed the GB and evaculated all stones, then we made an attempt to identify the cystic duct orifice to delineate hepatocystic triangle anatomy. (D) If we were still unable to safely identify structures in the hepatocystic triangle, we proceeded to close the GB remnant with sutures or endoloop. If the GB remnant could not be closed, we left it open and left a drain in place. These illustrations were created by the Toronto Video Atlas of Surgery (www.tvasurg.ca).

All operations were started as a standard LC with 2 10-mm laparoscopic ports and 2 5-mm laparoscopic ports. With the pneumoperitoneum established, the right upper quadrant was brought into view. If a critical view of safety was achieved, we proceeded with LC. Alternatively, if the cystohepatic triangle was fused and the cystic artery and cystic duct could not be safely skeletonized, we employed a stepwise approach for the management of the difficult GB (Fig. 1). The decision to abort unsafe dissection into the cystohepatic triangle was made very early in the course of the operation, avoiding potential bile duct injury. Instead, the GB was first decompressed. Then, using a line, which we call the line of safety, between the sulcus of Rouviere and the hilar plate as the proximal boarder of dissection (Fig. 1A), the GB was mobilized off of the liver bed in a top-around approach using mostly blunt dissection with the laparoscopic suction irrigator (Fig. 1B). If mobilization of the GB off of the liver allowed for better access to the cystohepatic triangle in a safe manner, we would proceed with LC. Alternatively, the GB was opened circumferentially, and we evacuated all of the stones and placed them into a laparoscopic retrieval bag (Fig. 1C). At this point, an attempt was made to follow the GB down to the cystic duct takeoff and perform a completion LC. We examined the cystic duct orifice for any evidence of bile leakage. If the cystic duct could not be controlled safely, we proceeded with attempted closure of the GB remnant with either laparoscopic sutures or loop ligature. A drain was typically left in situ following LSC (Fig. 1D). This decision tree is summarized in Figure 2.

Our institutional LSC classification scheme, summarized in Figure 3, categorizes the operation on the basis of the extent of dissection off of the liver bed as well as whether or not the GB remnant is left open or closed. We used this classification scheme to stratify our LSC cohort and associated postoperative outcomes. LSC are classified as follows: type 1A consists of cases where the entire back wall of the GB was dissected free of the liver bed and the Hartmann's pouch was closed; type 1B consists of a LSC where the Hartmann's pouch was closed but the posterior GB wall was left in situ; type 2A LSC involves fully mobilizing the back wall of the GB off of the liver bed but then leaving the GB remnant open; type 2B consists of leaving the back wall of the GB in situ while also leaving the GB remnant open; and type 3 LSC consists of cases where there are extensive adhesions and inflammation between the anterior surface of the GB and the adjacent duodenum and transverse colon preventing safe mobilization away from these structures. In this instance, the GB would be fenestrated high up on the fundus to prevent injury to both the transverse colon and duodenum, and the stones would be evacuated. We also refer to the type 3 approach as a damage-control cholecystectomy, employed only when hostile adhesions would prevent exposure of the anterior surface of the gallbladder altogether. Video examples of these approaches are available at http://tvasurg.ca/lapchole.

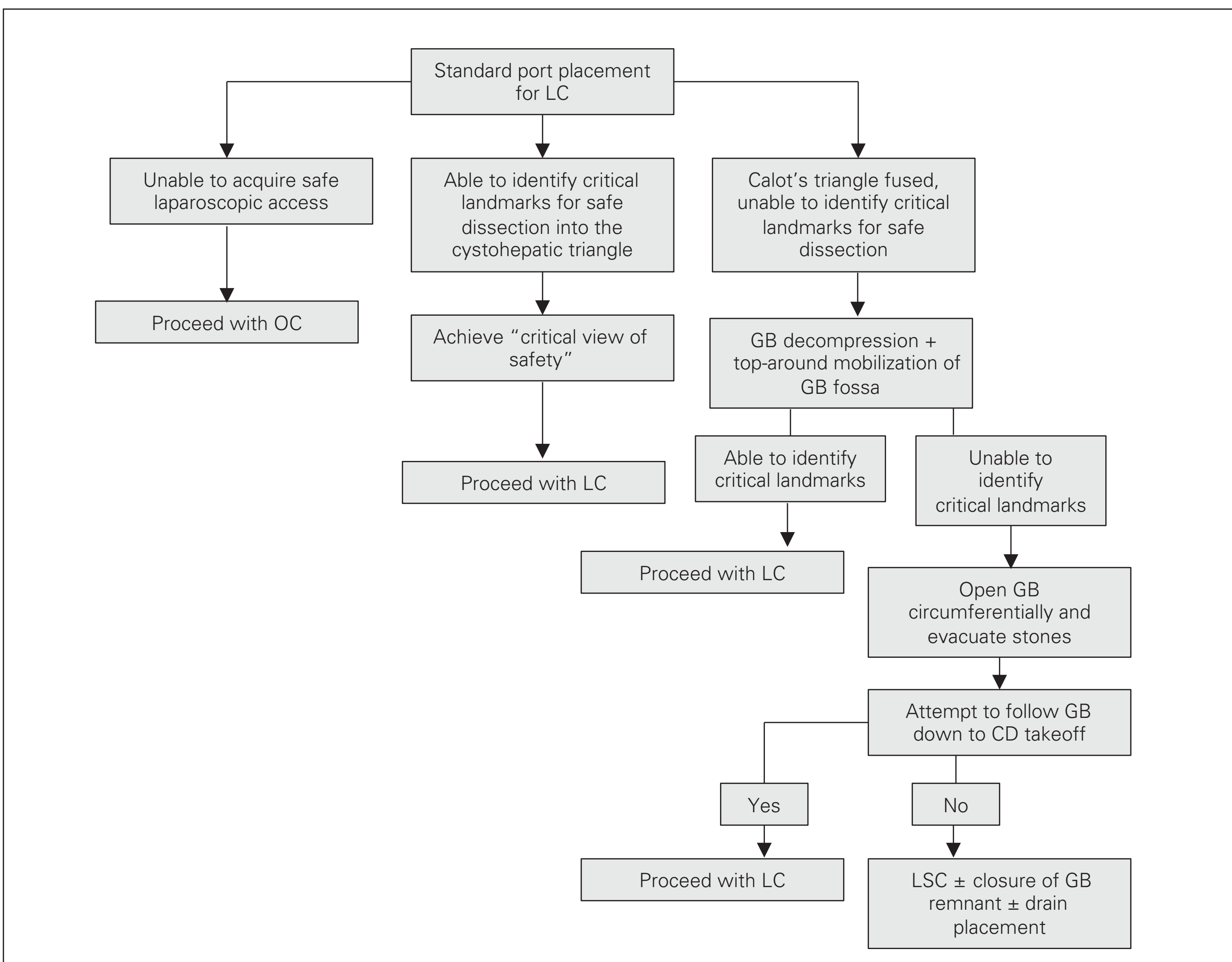

Fig. 2. Decision tree for the laparoscopic management of severe cholecystitis. GB = gallbladder; LC = laparoscopic cholecystectomy; LSC = laparoscopic subtotal cholecysectomy; OC = open cholecystectomy.

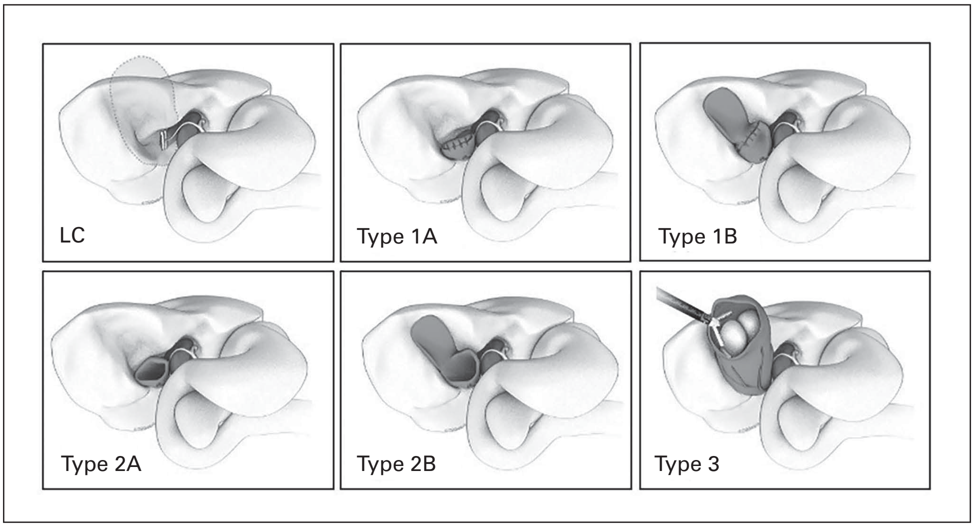

Fig. 3. Laparoscopic subtotal cholecystectomy (LSC) classification scheme. LC: a normal laparoscopic cholecystectomy. Type 1A LSC: the back wall of the gallbladder (GB) is fully dissected off the liver bed and Hartmann's pouch is closed following evacuation of gallstones. Type 1B LSC: the back wall of the GB is left in situ and Hartmann's pouch is closed. Type 2A LSC: the back wall of the GB is excised but Hartmann's pouch is left open. Type 2B LSC: the back wall of the GB is left in situ and Hartmann's pouch is left open. Type 3 LSC: the fundus of the GB is deroofed, the stones are evacuated and the GB remnant is left open. These illustrations were created by the Toronto Video Atlas of Surgery (www.tvasurg.ca).

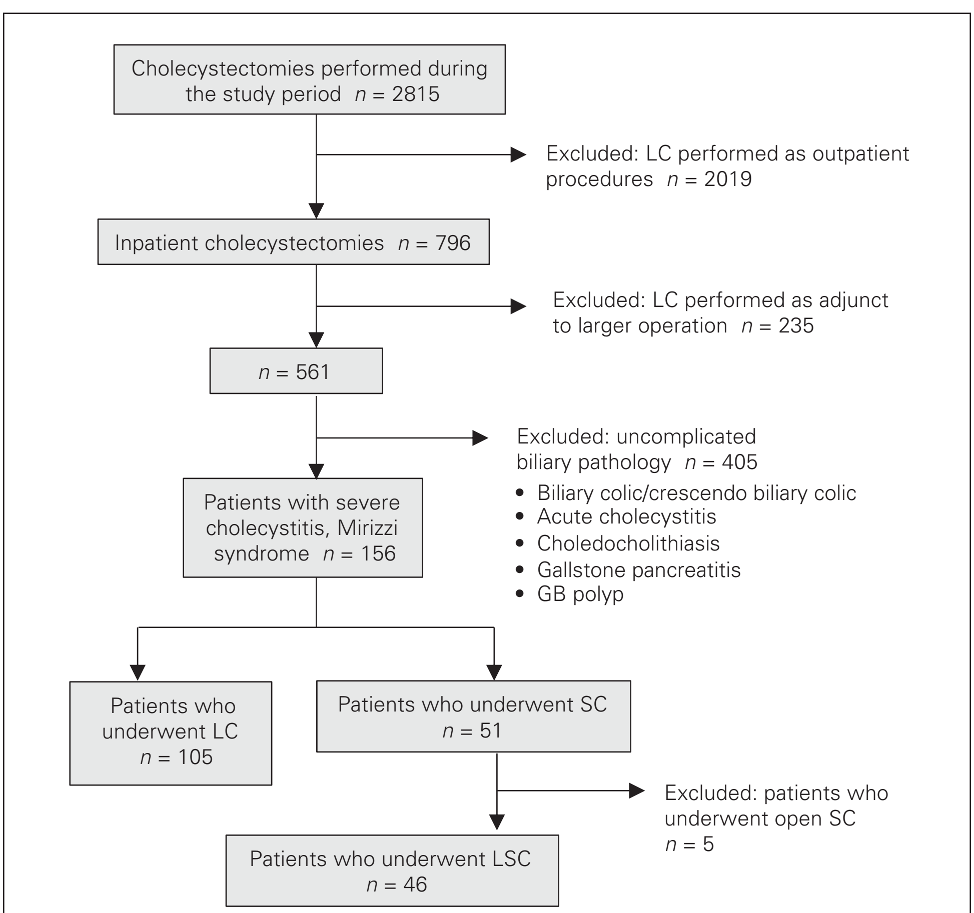

Fig. 4. Patient selection flow chart. GB = gallbladder; LC = laparoscopic cholecystectomy; LSC = laparoscopic subtotal cholecysectomy; SC = subtotal cholecystectomy.

Results

There were a total of 2815 cholecystectomies between July 2010 and July 2016 at St. Joseph's Health Centre. Of these, 2019 were done on an outpatient basis. The remaining 796 were done on an inpatient basis. Of these, 235 were done as adjuncts to larger hepatobiliary or upper gastrointestinal tract operations. Of the remaining 561 patients, 405 had findings of nonsevere cholecystitis, biliary colic or crescendo biliary colic, choledocholithiasis, gallstone pancreatitis, GB polyps or GB adenomyomatosis. There were 105 patients who underwent LC with severe cholecystitis and 51 patients who underwent subtotal cholecystectomies, of which 5 were performed open. The surgeries for these 5 patients were started as open procedures and were therefore excluded from the analysis. LSC was performed in 46 patients, all for severe cholecystitis. All comparisons were then performed between the 105 patients who underwent LC for severe cholecystitis and the 46 who underwent LSC. The flow of patients is summarized in Figure 4. Demographic information for both the LC and LSC cohorts are summarized in Table 1. There was no significant difference in age, male to female ratio, cases done on an emergency basis or length of stay. More patients had a cholecystostomy tube as a bridge to definitive surgery in the LSC cohort but this difference was also not significant (19.6% v. 10.5%, $p = 0.1$)

Patients in both cohorts had similar preoperative comorbidities, and indications for surgery were not significantly different between the two cohorts, either. All patients underwent either LC or LSC for severe cholecystitis: perforated, gangrenous, chronic or acute on chronic cholecystitis. There were 8 patients with Mirizzi syndrome in the LC cohort and none in the LSC cohort. Drains were used in 65.2% of LSC patients and 34.3% of patients in the severe cholecystitis LC group ($p < 0.001$). Conversion to open cholecystectomy was necessary in 11 (10.5%) patients who underwent LC for severe cholecystitis and none in the LSC group ($p = 0.02$). Of the patients who were converted to laparotomy, extensive fibrosis of the cystohepatic triangle necessitated open subtotal cholecystectomy in 5 patients.

Regarding postoperative complications, there were 4 bile duct injuries in patients who underwent LC for severe cholecystitis and none in the LSC cohort ($p = 0.4$). There were significantly more postoperative bile leaks in the LSC cohort than in the LC cohort (13.0% v. 3.8%, RR 3.4, 95% confidence interval [CI] 1.01–11.5). Subphrenic collections were also significantly more common in the LSC cohort (21.7% v. 6.7%, RR 3.1, 95% CI 1.3–8.0). The rates of wound infections and retained common bile duct stones were not significantly different between the 2 cohorts. There were 2 mortalities in the patients who underwent LC for severe cholecystitis and none in the LSC cohort. Total complications were not significantly different between the severe cholecystitis LC and LSC cohorts (23.8% v. 39.1%, RR 1.6, 95% CI 0.99–2.7).

Regarding postoperative interventions, there were significantly more postoperative ERCPs performed on patients who underwent LSC than on those who underwent LC for severe cholecystitis (15.2% v. 4.8%, RR 3.2, 95% CI 1.1–9.5). Indications for postoperative ERCP in cases of severe cholecystitis in the LC and LSC cohorts were bile leak in 4 and 6 cases, respectively, and there was 1 case of retained CBD stone in each group. Significantly more biliary stents were used in the LSC cohort (13.0% v. 2.9%, RR 4.6, 95% CI 1.2–17.5). Postoperative percutaneous drains for intraabdominal collections were used in 15.2% of patients who underwent LSC versus 6.7% in the LC cohort ($p = 0.1$). Reoperation was necessary in 4 patients who underwent LC and in 2 who underwent LSC ($p = 0.9$). Total interventions were significantly different between the severe cholecystitis LC and LSC cohorts (18.1% v. 47.8%, RR 2.6, 95% CI 1.6–44). Data pertaining to postoperative complications and interventions are summarized in Table 2.

Within the LSC cohort, it was identified during the operation that modifications were required depending on the degree of GB inflammation and fibrosis. Therefore, this cohort was stratified on the basis of our institutional classification scheme, represented in Table 3. Patients with a closed GB remnant (type 1A and 1B LSC) had intraoperative drains placed 53.3% and 50.0% of the time, respectively. All patients with an open GB remnant received drains (types 2A, 2B, 3). Two patients (6.7%) with type 1A LSCs underwent ERCP and biliary stent insertion for bile leak. Two (28.6%) patients with a type 2A, 1 (25.0%) patient with a type 2B and 1 (33.3%) patient with a type 3 LSC also underwent endoscopic biliary stent insertion. The condition of all patients with biliary stents improved and they were discharged without requiring further intervention. The stents were similarly subsequently removed without complication. None of the LSC patients experienced persistent leaks or cholecystocutaneous fistulae following ERCP and biliary stent insertion. The course for each patient managed with ERCP is summarized in Table 4. For the 7 patients who underwent ERCP, median time to intervention from LSC was 3 days. Median length of stay was 4 days.

Table 1. Demographic information, preoperative morbidity, operative indications and management for patients with severe cholecystitis who underwent either LC or LSC

Characteristic	No. (%) of patients*; study group LC n = 105	LSC n = 46	p value
Demographic information			
Age; median (range)	62.5 (18–90)	65 (32–90)	0.5
Male	47 (44.8)	27 (58.7)	0.1
Emergency case	72 (68.6)	26 (56.5)	0.2
Bridging cholecystostomy tube	11 (10.5)	9 (19.6)	0.1
Length of stay; median (range)	3 (1–42)	3 (1–26)	0.2
Preoperative morbidity			
Diabetes mellitus	18 (17.1)	10 (21.7)	0.5
Chronic kidney disease	8 (7.6)	3 (6.5)	0.8
Hypertension	40 (38.1)	25 (54.3)	0.06
Congestive heart failure	3 (2.9)	2 (4.3)	0.6
Obstructive sleep apnea	5 (4.8)	7 (15.2)	0.06
Cerobrovascular accident	5 (4.8)	0	0.2
Peripheral vascular disease	4 (3.8)	3 (6.5)	0.5
MI/PCI	11 (10.5)	4 (8.7)	0.9
Pulmonary disease	5 (4.8)	6 (13)	0.07
Liver dysfunction	4 (3.8)	0	0.2
Paraplegia	2 (1.9)	1 (2.2)	0.9
Dementia	3 (2.9)	1 (2.2)	0.6
Diagnosis			
Perforated cholecystitis	33 (31.4)	18 (39.1)	0.4
Gangrenous cholecystitis	28 (26.7)	8 (17.4)	0.2
Chronic cholecystitis	23 (21.9)	11 (23.9)	0.8
Acute on chronic cholecystitis	12 (11.4)	9 (19.6)	0.2
Mirizzi syndrome	8 (7.6)	0	0.05
Cholecystoduodenal fistula	1 (1)	0	
Operative management			
Laparoscopic drain placement	36 (34.3)	30 (65.2)	< 0.001
Conversion to open cholecystectomy	11 (10.5)	0	0.02

LC = laparoscopic cholecystectomy; LSC = laparoscopic subtotal cholecystectomy; MI/PCI = myocardial infarction/percutaneous coronary intervention.
*Unless indicated otherwise.

Table 2. Comparison of postoperative complications, mortality and postoperative interventions among patients with severe cholecystitis who underwent LC and LSC

Complication or intervention	No. (%) of patients; study group LC (n = 105)	LSC (n = 46)	RR (95% CI)
Postoperative complications			
Bile duct injury	4 (3.8)	0	0.3 (0.01–4.6)
Bile leak	4 (3.8)	6 (13.0)	3.4 (1.01–11.5)
Subphrenic collection	7 (6.7)	10 (21.7)	3.1 (1.3–8.0)
Retained CBD stones	5 (4.8)	2 (4.3)	0.9 (0.2–4.5)
Wound infections	3 (2.9)	0	0.3 (0.02–6.1)
Mortality	2 (1.9)	0	0.5 (0.02–9.2)
Total	25 (23.8)	18 (39.1)	1.6 (0.99–2.7)
Postoperative interventions			
Postoperative ERCP	5 (4.8)	7 (15.2)	3.2 (1.1–9.5)
Biliary stent insertion	3 (2.9)	6 (13.0)	4.6 (1.2–17.5)
Percutaneous drain insertion	7 (6.7)	7 (15.2)	2.3 (0.8–6.1)
Reoperation	4 (3.8)	2 (4.3)	1.^{1} (0.2–6.0)
Total	19 (18.1)	22 (47.8)	2.6 (1.6–4.4)

CBD = common bile duct; CI = confidence interval; ERCP = endoscopic retrograde cholangiopancreatography; LC = laparoscopic cholecystectomy; LSC = laparoscopic subtotal cholecystectomy; RR = relative risk.

Table 3. Stratification of LSC postoperative outcomes on the basis of LSC classification scheme

LSC type	No. (%) of patients; outcome n = 46 Total	Intraoperative drain placement	Bile duct injury	Bile leak	Retained CBD stones	Postoperative ERCP	Stent insertion	Subphrenic collection	Percutaneous drain insertion	Reoperation
1A	30 (65.2)	16 (53.3)	0	2 (6.7)	1 (3.3)	3 (10)	2 (6.7)	6 (20.0)	4 (13.3)	2 (6.7)*
1B	2 (4.3)	1 (50.0)	0	0	0	0	0	1 (50.0)	1 (50.0)	0
2A	7 (15.2)	7 (100)	0	2 (28.6)	0	2 (28.6)	2 (28.6)	3 (42.9)	2 (28.6)	0
2B	4 (8.7)	4 (100)	0	1 (25.0)	0	1 (25.0)	1 (25.0)	0	0	0
3	3 (6.5)	3 (100)	0	1 (33.3)	1 (33.3)	1 (33.3)	1 (33.3)	0	0	0

ERCP and stent placement the following day. CBD = common bile duct; ERCP = endoscopic retrograde cholangiopancreatography; JP = Jackson-Pratt; LSC = laparoscopic subtotal cholecystectomy.
*Both reoperations were in patients with type 1A LSC: intraabdominal hematoma from liver laceration. Takeback, laparotomy and washout on postoperative day 0; biloma indentified on postoperative day 2. Laparoscopic washout and placement of JP drain.

Table 4. Course of all LSC patients who received ERCP in the postoperative period

LSC type	ERCP, POD	Findings	Stent (Y/N)	JP drain status	Discharge, POD	Repeat ERCP, POD	Findings from second ERCP
1A	3	Taken back to OR on POD 2 for JP drain insertion; bile leak from GB remnant	Y	Home with drain	4	69	No leak; stent removed
1A	3	Intraoperative cholangiogram suggested choledocholithiasis; postoperative ERCP showed no choledocholithiasis; no bile leak	N	Removed before discharge	4	No repeat ERCP; no stent	
1A	2	Bile leak from GB remnant	Y	Home with drain	3	103	No leak; stent removed
2A	8	Failed ERCP on POD 8, repeat ERCP and biliary stenting on POD 13	Y	Home with drain	10	No information on second ERCP	
2A	11	Discharged home on POD 2, drain removed before discharge; readmitted on POD 9 with bile leak; percutaneous drain for biloma and ERCP stent insertion on POD 11	Y	Removed before discharge	16	130	No leak; CBD stones; stent removed; stones evacuated
2B	4	Bile leak from GB remnant	Y	Home with drain	5	110	No leak; stent removed
3	1	Bile leak from GB remnant	Y	Removed before discharge	2	77	No leak; stent removed

CBD = common bile duct; ERCP = Endoscopic retrograde cholangiopancreatography; GB = gallbladder; JP = Jackson-Pratt; LSC = laparoscopic subtotal cholecystectomy; N = no; OR = operating room; POD = postoperative day; Y = yes.

Among the 405 inpatients who underwent LC for indications other than severe cholecystitis during the study period, there were no additional bile duct injuries. Total complications and interventions in this group were 6.2% and 4%, respectively. Four patients (1%) required conversion to laparotomy and open cholecystectomy. One patient required reoperation and died in the postoperative period. In patients who underwent LC for severe cholecystitis, there were 4 reoperations and 2 mortalities. Reoperation was necessary in 2 patients following LSC, 1 for intra-abdominal hematoma secondary to liver laceration and the other for a biloma identified on postoperative day 2. Both patients were discharged from hospital subsequently without further morbidity.

Discussion

LC has been established as the gold standard for the management of benign GB disease. Although strategies have evolved to mitigate the risk of bile duct injury during LC, there is still a subset of patients with severe cholecystitis in whom dissection into the cystohepatic triangle is extremely hazardous. A strength of this study was the identification and distinction of patients with severe cholecystitis as a separate group who are more prone to complications than patients with typical GB disease. Total complications in the severe cholecystitis LC group were not significantly different from those in the LSC cohort, despite an increase in bile leaks and subphrenic collections in the latter. This is in contrast to the finding for patients who underwent LC for typical GB pathology, where complications where present in 6.2% of patients, of which the majority were retained CBD stones. We observed no bile duct injuries in the LSC cohort or in patients who underwent LC for indications other than severe cholecystitis. All 4 bile duct injuries occurred in patients with severe cholecystitis. Similar trends have been reported elsewhere. Tornqvist and colleagues identified a 2-fold increase in risk of bile duct injury when comparing patients with severe cholecystitis with patients with noninflamed GB.[13] Our experience suggests that patients with severe GB inflammation are at a much greater risk of bile duct injury. These patients are also at increased risk of other postoperative complications, regardless of the choice of LC or LSC. In this setting, early identification of a fused and hazardous cystohepatic triangle and transition to a subtotal cholecystectomy is advocated.

A literature review of 15 retrospective cohort studies and case series with 625 patients yielded a single bile duct injury in patients having LSC.[15] This bile duct injury occurred in a study that included patients who underwent full dissection of the cystohepatic triangle and isolation of the cystic duct.[16] It is plausible that this injury may not have occurred if the strategies we advocate had been used. Within the literature review, postoperative bile leaks occurred in 10.5% of patients, with 7.5% requiring ERCP. This is lower than the rate of bile leak and postoperative ERCP reported in our series. Of note, all patients in our LSC cohort did proceed with ERCP very early in their postoperative course if a bile leak was detected. It is possible that had we waited, some of these would have resolved spontaneously without further intervention. Although ERCP does confer a risk of pancreatitis, gastrointestinal bleed or duodenal injury[17,18] that should not be discounted, bile duct injury should be the primary concern when performing a LC in the setting of severe inflammation. A higher bile leak rate in this setting was viewed as acceptable in comparison with a possible bile duct injury given that all of these patients ultimately had favourable outcomes.

In the past, other options have been employed for management of the difficult GB. These have included placement of a cholecystostomy tube with the possibility of more definitive surgical management in the future. Our experience has shown that tube-cholecystostomy was used as a bridge to LSC in 19.6% of patients. These were all patients with severe cholecystitis who may have ultimately benefited from definitive LSC at the outset. Alternatively, conversion to a laparotomy and open cholecystectomy has historically been advocated for the difficult GB. This option, however, does confer a significantly longer inpatient stay as well as increased morbidity and wound-related complications and does not necessarily mitigate the risk of bile duct injury altogether.[19] Moreover, several studies have identified a trend toward fewer open cholecystectomies during residency.[20,21] Our conversion rate was 10.5% in LC patients with severe cholecystitis and 1% in all other patients, which is lower than what has been reported in recent literature.[7,22] Open cholecystectomy should be considered if laparoscopic access cannot be attained; however, the trend toward fewer open cases in residency and beyond is undeniable. LSC fits with the current model of technical training for most surgical residents, where comfort with laparoscopy has progressed and open cholecystectomy is no longer the more practised operation. Although this study was completed at an HPB referral centre, these operations were performed by specialists and general surgeons alike. The ability to successfully perform a LSC is within the skill set of the modern general surgeon.

One of the goals of this study was to stratify our LSC outcomes on the basis of the extent of GB dissection and closure of the GB remnant. Multiple previous studies have attempted to classify LSC on the basis of operative method but this is the first to our knowledge that has analyzed postoperative morbidity on the basis of the extent of GB resection and closure of the GB remnant.[15,16,23–25] The most common LSC performed at our institution was a type 1A, wherein the GB was taken down off the liver and the remnant closed. The bile leak rate of this subgroup was 6.7%. In comparison, when the GB lumen was left open as in types 2A, 2B and 3, there was a 25%–33.3% chance of bile leak requiring ERCP and biliary stent insertion.

We endeavour to provide a framework for the laparoscopic management of severe acute or chronic cholecystitis. We also aim to provide evidence in support of the use of LSC when opening the cystohepatic triangle to achieve a critical view of safety would put the patient at increased risk of bile duct injury. Variations in our technique can be employed if the GB fossa is also fused, or if the duodenum and transverse colon are densely adhered to the anterior surface of the GB. In these situations, more GB is left behind. As mentioned, in many cases, given the degree of inflammation, it may be too challenging to close the GB remnant. Our data suggest that if the remnant is left open, there is a higher risk of persistent bile leak postoperatively. Therefore, intraoperative drain placement is recommended.

Limitations

There are limitations to our study. First, it is a retrospective design and the inherent issues with respect to patient selection must be noted even though the LC and LSC groups appeared to represent similar groups of patients. Second, there were only 46 patients in the LSC group. Given that bile duct injuries occur at a rate of between 0.08% and 0.2%[5,6] in patients undergoing LC, it is possible that this study was not adequately powered to identify these within the LSC cohort. Additionally, regarding postoperative bile leaks, there is detection bias present. Since there were significantly more patients in the LSC cohort who received drains intraoperatively, we were more likely to identify bile leaks in these patients and treat them with ERCP and biliary stent. Although some patients in the LC cohort may have developed bile leaks, these may have been subclinical and were not detected if there was no drain present. The same detection bias is present across our classification of LSCs. All patients in whom the GB remnant was left open (types 2A, 2B and 3) received drains, making them more likely to have a bile leak detected. Additionally, the follow-up time varied for patients depending on how close to the time of data collection their operation was. Therefore, some patients had less time to manifest complications. Nevertheless, there were no persistent cholecystocutaneous fistulae or remnant cholecystitis reported in our cohort.

Conclusion

Ultimately, this study supports the use of LSC for the management of severe cholecystitis. We acknowledge that widespread adoption of the critical view of safety has decreased the rates of bile duct injury over the past 20 years. However, LSC is a safe alternative that mitigates the risk of bile duct injury by avoiding the portal structures altogether while also preventing the morbidity associated with an open operation in the setting of severe inflammation or fibrosis in the cystohepatic triangle. The goal of performing a LC is to address the underlying cause of inflammation and remove the GB safely without injury to the common bile duct or other structures. LSC is a safe and effective method of achieving these objectives in a minimally invasive fashion when dissection at the cystohepatic triangle is not feasible.

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