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Patient and surgeon factors contributing to bailout cholecystectomies: a single-institutional retrospective analysis

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Abstract

Background Laparoscopic cholecystectomies continue to pose trouble for surgeons in the face of severe inflammation. In the advent of inability to perform an adequate dissection, a "bailout cholecystectomy" is advocated. Conversion to open or subtotal cholecystectomy is among the standard bailout procedures in such instances.

Methods We performed a retrospective single institution review from January 2016 to August 2019. All patients who underwent a cholecystectomy were included, while those with a concurrent operation, malignancy, planned as an open cholecystectomy, or performed by a low volume surgeon were excluded. Patient characteristics, operative reports, and outcomes were collected, as were surgeon characteristics such as years of experience, case volume, and bailout rate. Univariable and multivariable analysis were performed.

Results 2458 (92.6%) underwent laparoscopic total cholecystectomy (LTC) and 196 (7.4%) underwent a bailout cholecystectomy (BOC). BOC patients tended to be older ($p<0.001$), male ($p<0.001$), have a longer duration of symptoms ($p<0.001$), and higher ASA class ($p<0.001$). They also had more signs of biliary inflammation, as evidenced by increased leukocytosis ($p<0.001$), tachycardia ($p<0.001$), bilirubinemia ($p=0.003$), common bile duct dilation ($p<0.001$), and gallbladder wall thickening ($p<0.001$). The BOC cohort also had increased rates of complications, including bile leak (16%, $p<0.001$), retained stone (5.1%, $p=0.005$), operative time (114 min vs 79 min, $p<0.001$), and secondary interventions (22.7%, $p<0.001$). Male gender (aOR = 2.8, $p<0.001$), preoperative diagnosis of acute cholecystitis (aOR = 2.2, $p=0.032$), right upper quadrant tenderness (aOR = 3.0, $p=0.008$), Asian race (aOR = 2.7, $p=0.014$), and intraoperative adhesions (aOR = 13.0, $p<0.001$) were found to carry independent risk for BOC. Surgeon bailout rate ≥ 7% was also found to be an independent risk factor for conversion to BOC.

Conclusions Male gender, signs of biliary inflammation (tachycardia, leukocytosis, dilated CBD, and diagnosis of acute cholecystitis), as well as surgeon bailout rate of 7% were independent risk factors for BOC.

Keywords Bailout cholecystectomy · Conversion · Subtotal cholecystectomy · Hierarchical regression

Cholecystectomies continue to be one of the most common surgeries in the USA. Laparoscopic cholecystectomy is considered the standard of care for biliary disease and nearly 80–90% of cholecystectomies are now performed laparoscopically [1, 2]. However, severely diseased gallbladders are often associated with inflammation that obscures the anatomy and renders dissection difficult. These challenges are well-known risk factors for vasculobiliary injury.

"Bailout" cholecystectomies (BOCs) refer to intraoperative strategies that depart from the initial goal of completing a laparoscopic total cholecystectomy in order to avoid vasculobiliary injury. Subtotal cholecystectomies have been well described as one such technique [3], in which only a portion of the gallbladder is excised while avoiding dissection in areas of severe inflammation near the hepatic duct and artery. They are gradually supplanting another bailout option which is conversion to an open cholecystectomy [2, 4], in which dissection proceeds with greater exposure along with the added benefit of direct tissue handling. While laparoscopic subtotal cholecystectomy avoids a larger incision,

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it has been associated with higher rates of biliary fistula and secondary interventions in comparison to open conversion [5–7]. Bailout to an open surgery itself is associated with higher surgical site infections (SSIs) and, despite increased exposure, does not guarantee success in achieving a complete cholecystectomy [5, 8, 9].

Within the last decade, there has been increasing utilization of bailout procedures [5, 10] as widespread adoption of a culture of safety [11] has recognized that vasculobiliary injuries carry significant morbidity and cost [12, 13]. Although there are mounting data from several retrospective studies that certain risk factors increase the likelihood of employing a bailout strategy [2, 14], there is still no strict guideline describing the optimal use of BOCs. We aim to add to the current literature by examining our cohort of cholecystectomies to identify patient and surgeon factors associated with BOCs.

Methods

Study population

A retrospective chart review was conducted in our urban hospital from January 2016 to August 2019. All patients who underwent a cholecystectomy during this period were identified through the Picis Operating Room Manager software (Picis Clinical Solutions, Inc., Wakefield, MA). Exclusion criteria were simultaneous index operation for alternate diagnoses (e.g., laparoscopic sleeve gastrectomy), malignancy, aborted procedure, planned open cholecystectomy, or cholecystectomies performed by low volume (< 50 cases) surgeons during the study period. Reported operative outcomes for each patient were then stratified into 2 groups: laparoscopic total cholecystectomy (LTC) if the cystic duct and artery were ligated laparoscopically during the index operation, or bailout cholecystectomy (BOC) for all other operations requiring a different surgical strategy not resulting in LTC (Fig. 1). Specifically, a bailout operation was any subtotal cholecystectomy or conversion from a laparoscopic to open operation in order to avoid a vasculobiliary injury. Bile duct injuries recognized intraoperatively were excluded since a change in operative plan was rendered after recognition of the injury and thus the operation was not considered a bailout. In the current cohort, we excluded 7 bile duct injuries recognized intraoperatively with an overall incidence of 0.26%.

Data collection

The electronic medical record was accessed to collect preoperative data on demographics, patient history, laboratory values, imaging, and outcomes. Operative reports were reviewed to determine the reason for conversion. Perioperative data including operative duration and American Society of Anesthesiologists (ASA) classification were obtained through Picis. We also measured surgeon characteristics including number of years in practice, average operative duration, and bailout rate, which was defined as the ratio of bailout cases to total cholecystectomies. Of the attending surgeons at our institution, we identified 14 surgeons who performed at least 50 cholecystectomies during this study period, excluding 6 surgeons. Surgeon experience was calculated as years since medical school graduation. All surgeons were regular teaching faculty and consistently operated with surgical residents.

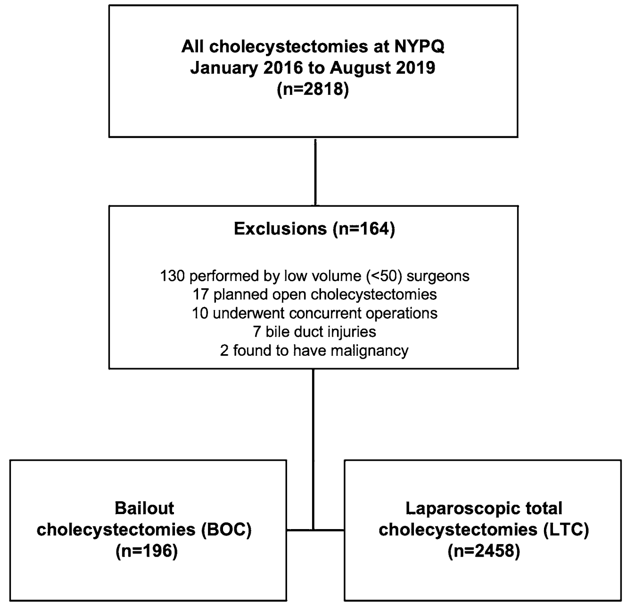

Fig. 1 Cholecystectomy cohort formation

Hospital outcomes collected include length of hospital stay (LOS), 30-day readmission, bile leak, SSI, retained stone, reoperation, secondary interventions, and 30-day mortality. Secondary interventions were defined as reoperation, postoperative endoscopic or percutaneous procedures. Bile leak was defined as symptomatic biloma or persistent bilious drainage.

Statistical analysis

The two-sample t-test or Wilcoxon rank-sum test was used, as appropriate, to compare continuous variables between BOC patients and LTC patients. The chi-square test or Fisher's exact test was used, as appropriate, for categorical variables. To account for potential clustering of data collected within each surgeon, hierarchical logistic regression models were conducted to evaluate the patient-level and surgeon-level characteristics associated with the use of BOC [15]. The first-level covariates in the model consisted

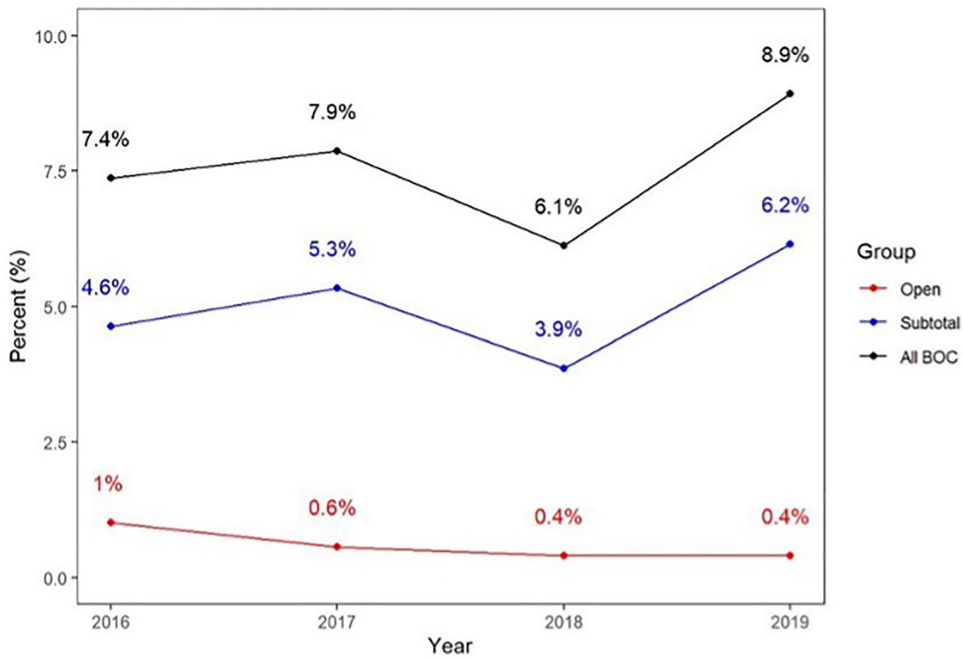

Fig. 2 Bailout trends over the study period

of patient demographic and clinical characteristics. The second-level covariates consisted of surgeon characteristics. We included a random intercept for surgeon characteristics to account for patient clustering within a given physician. All covariates in the hierarchical models were chosen based on univariate analysis of each variable with a *p* value cutoff point of 0.05. Collinearity between predictors in the models were evaluated prior to the formulation of the final multivariable models. To study the impact of a surgeons' tendency for bailout operations as a risk for BOCs, we dichotomized the bailout rate by choosing a cutoff point maximizing Youden's index [16, 17].

We assumed that missing data were conditional on observed covariates. A sensitivity analysis was performed using multiple imputation for missing continuous variables (Supplement S.1). The predictive mean matching imputation was implemented using the *mice* package for R [18]. We transformed continuous variables into categorical variables after imputation for model building. Twenty imputed datasets were generated, and pooled model results were estimated (Supplement S.2). We also performed a subgroup analysis for the urgent and inpatient cohort because of the higher rate of missing data in the outpatient group. Adjusted odds ratios and 95% confidence intervals for patient-level and surgeon-level variables were estimated from the multivariable hierarchical models. Two-sided *p* values were calculated with statistical significance evaluated at the 0.05 alpha level. All analyses were performed using R Version 4.0.3 in Rstudio Version 1.4.1103 [19].

Results

Patient characteristics

Of the 2654 patients who underwent a cholecystectomy during the study period, we identified 2458 (92.6%) who underwent LTCs and 196 (7.4%) who underwent BOCs (Table 1). Of BOCs, 129 (65.8%) underwent a laparoscopic subtotal cholecystectomy, while 67 (34.2%) were converted to open operations. Annual rates of BOCs are shown in Fig. 2. Patients of Asian (28%, $n=744$) and Hispanic ethnicity (37%, $n=980$) were prevalent in our cohort. Diabetes mellitus and hypertension accounted for 16% ($n=414$) and 33% ($n=880$) of patients, respectively. Other common findings include 40% ($n=1052$) who had undergone a prior abdominal surgery, 20% ($n=535$) who presented initially after 72 h of symptoms, 56% ($n=1492$) who were tender in the right upper quadrant (RUQ) and 25% ($n=673$) who had a documented Murphy's sign. The most common preoperative diagnosis was acute cholecystitis (41%, $n=1076$).

Of BOCs, male patients were a significantly larger proportion (62%, $n=121$) than in the LTC group (32%, $n=793$, $p<0.001$). The BOC cohort was associated with more comorbidities, including diabetes, hypertension, and coronary artery disease (CAD), and higher ASA classification as compared to the LTC cohort (Table 1). Also more frequently in BOC than in LTC, 32% ($n=62$) reported having symptoms for 72 or more hours and 69% ($n=136$) had tenderness in the RUQ on initial abdominal exam ($p<0.001$). Furthermore, 33% of patients who

Table 1 Baseline and perioperative characteristics of all patients undergoing cholecystectomy

	LTC $n=2458$	BOC $n=196$	*p* value
Age (median [IQR])	48 [35–62]	62 [49–73]	< 0.001
BMI (median [IQR])	28 [25–32]	27 [24–32]	NS
Gender (%)			< 0.001
Male	793 (32)	121 (62)	
Female	1665 (68)	75 (38)	
Race (%)			< 0.001
White	363 (15)	40 (20)	
Black	136 (5.5)	15 (8.1)	
Hispanic	926 (38)	54 (28)	
Asian	675 (27)	69 (35)	
Other	358 (15)	18 (9.2)	
Chronic obstructive pulmonary disease (%)	30 (1.2)	8 (4.1)	0.005
Diabetes mellitus (%)	360 (15)	54 (28)	< 0.001
Hypertension (%)	774 (31)	103 (53)	< 0.001
Coronary artery disease (%)	125 (5.1)	24 (12)	< 0.001
Congestive heart failure (%)	13 (0.5)	6 (3.1)	0.002
Chronic kidney disease (%)	37 (1.5)	8 (4.1)	0.015
Prior abdominal surgery (%)	978 (40)	74 (38)	NS
Symptoms ≥ 72 h (%)	473 (19)	62 (32)	< 0.001
RUQ tenderness (%)	1356 (55)	136 (69)	< 0.001
Murphy's sign (%)	608 (25)	65 (33)	0.009
Peritonitis (%)	6 (0.2)	3 (1.5)	0.024
Preoperative diagnosis (%)			< 0.001
Acute cholecystitis	967 (39)	109 (56)	
Chronic cholecystitis	134 (5.5)	19 (9.7)	
Bile duct obstruction	459 (19)	46 (23)	
Symptomatic cholelithiasis	761 (31)	19 (9.7)	
Other	137 (5.6)	3 (1.5)	
WBC count ≥ 12,000 (%)	478 (26)	80 (42)	< 0.001
Heart rate ≥ 90 (%)	363 (15)	55 (28)	< 0.001
Total bilirubin ≥ 4 (%)	72 (3.9)	16 (8.4)	0.003
CBD ≥ 6 mm (%)	502 (28)	75 (47)	< 0.001
Pericholecystic fluid (%)	283 (15)	53 (31)	< 0.001
Gallbladder wall ≥ 4 mm (%)	527 (33)	85 (54)	< 0.001
Timing of surgery (%)			< 0.001
Urgent inpatient[a]	13 (0.5)	28 (14)	
Inpatient	1462 (59)	114 (58)	
Outpatient	983 (40)	54 (28)	
ASA class ≥ 3 (%)	536 (22)	83 (43)	< 0.001
Intraoperative adhesions (%)	507 (21)	148 (76)	< 0.001

[a]Within 24 h of admission

underwent BOC had a reported Murphy's sign on exam, while 1.5% presented with signs of peritonitis, compared with 24.7% and 0.2%, respectively, among those who had a LTC ($p=0.01$ and $p=0.02$).

Of the BOC patients, 109 (56%) had a preoperative diagnosis of acute cholecystitis and 114 (58.1%) underwent surgery during the same hospitalization. A higher number of patients in the BOC cohort were found to have white blood cell counts (WBC) ≥ 12,000/uL and heart rate ≥ 90 bpm in comparison to the LTC cohort. A higher proportion of patients were also found to have sonographic evidence of cholecystitis and choledocholithiasis, such as a common bile duct (CBD) diameter ≥ 6 mm, evidence of pericholecystic fluid, and a thickened gallbladder wall. In addition, 43% of the BOC patients had an ASA classification of 3 or higher, compared to 22% of the LTC patients ($p<0.001$). 76% of BOC patients were noted to have adhesions intraoperatively compared with 21% in the LTC group ($p<0.001$).

Surgeon characteristics

We characterized surgeons based on their rates of performing BOCs and chose an optimal cutoff of 7% based on analysis of the receiver operating characteristic curve (Fig. 3). We measured operating times for cholecystectomies in inpatient versus outpatient settings that resulted in LTC or BOC (Table 2) and found that BOCs required longer operating times, but that they were even longer in outpatient (elective) settings when compared to inpatient settings.

Patient outcomes

Overall, 131 patients (4.9%) experienced a complication (Table 3). The BOC cohort had an overall higher complication rate at 28% compared to 3.1% in the LTC cohort ($p<0.001$). Mean operative time was 128 min for a BOC, which was longer than 78 min for LTC ($p<0.001$). The BOC group had higher complication rates, including bile leak, retained stone, hemorrhage, SSI, pneumonia,

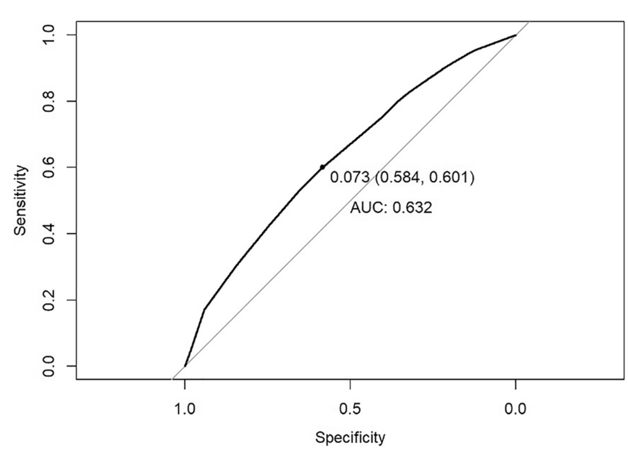

Fig. 3 Receiver operating curve for varying cutoffs of bailout rates

Table 2 Comparison of operating room (OR) times between inpatient and outpatient cases resulting in either LTC or BOC

Characteristic	N	Outpatient	Inpatient	p value
LTC OR time (mins)	2458	n = 983	n = 1475	< 0.001
Mean (SD)		71 (30)	83 (37)	
Median (IQR)		65 (51–83)	76 (60–99)	
BOC OR time (mins)	196	n = 54	n = 142	0.061
Mean (SD)		149 (83)	123 (47)	
Median (IQR)		120 (101–168)	114 (92–142)	

LOS, secondary intervention, readmission and 30-day mortality.

In a subgroup analysis of patients with BOCs, we compared outcomes between laparoscopic subtotal cholecystectomies and laparoscopic converted to open cholecystectomies. We found that operative times (157 ± 58 min vs. 113 ± 37 min, $p < 0.001$) and length of stay (6.2 ± 4.6 days vs. 4.6 ± 5.7 days) were longer in laparoscopic converted to open operations. However, bile leak rates (20% vs. 9.0%, $p = 0.04$) were higher in the laparoscopic subtotal cholecystectomy subgroup. Overall mortality was not different between the laparoscopic subtotal (1.6%) and conversion to open cholecystectomy (3.0%).

Multivariable analysis

Multivariable logistic regression showed that male gender (aOR 2.82, 95% CI 1.69–4.70, $p < 0.001$), Asian race (aOR 2.7, 95% CI 1.23–5.97, $p = 0.014$), and adhesions during surgery (aOR 12.99, 95% CI 7.57–22.28, $p < 0.001$) were significant factors for patients undergoing BOC (Table 4). Tenderness in the RUQ (aOR 2.96, 95% CI 1.33–6.57, $p = 0.008$), heart rate ≥ 90 bpm (aOR 2.08, 95% CI

Table 4 Mixed Effect Logistic Regression of Patient and Surgeon Factors Associated with BOC

	Adjusted odds ratio (95% CI)	p value
Patient factors		
Male gender	2.8 (1.7 – 4.7)	< 0.001
CBD ≥ 6 mm	1.8 (1.1 – 3.1)	0.022
Total bilirubin ≥ 4	2.8 (1.1 – 6.9)	0.025
Right upper quadrant tenderness	3.0 (1.3 – 6.6)	0.008
Adhesions	13.0 (7.6 – 22)	< 0.001
HR ≥ 90	2.1 (1.2 – 3.7)	0.011
Acute cholecystitis	2.2 (1.0 – 4.4)	0.032
Race Asian (vs. Caucasian)	2.7 (1.2 – 6.0)	0.014
Inpatient (vs. outpatient)	0.15 (0.04 – 0.5)	0.002
Surgeon factors		
BOC rate ≥ 7.0%	4.7 (2.0 – 10.8)	< 0.001

CI confidence interval

Table 3 Post-operative outcomes after LTC and BOC

	LTC n = 2458	BOC n = 196	p value
Any complication (%)	75 (3.1)	56 (29)	< 0.001
Bile leak (%)	9 (0.4)	32 (16)	< 0.001
Retained stone (%)	44 (1.8)	10 (5.1)	0.005
Hemorrhage[a] (%)	13 (0.5)	7 (3.6)	< 0.001
Surgical site infection (%)			< 0.001
Superficial	14 (0.6)	8 (4.1)	
Deep	0 (0)	2 (1.0)	
Organ space	7 (0.3)	13 (6.6)	
Hospital length of stay (median [IQR])	1 [0–3]	4 [3–6]	< 0.001
Reoperation (%)	10 (0.4)	3 (1.5)	NS
Secondary intervention (%)			< 0.001
ERCP only	72 (2.9)	31 (16)	
PD only	8 (0.3)	6 (3.1)	
Both	3 (0.1)	7 (3.6)	
Mean operative time, min (mean [SD])	79 [56–92]	114 [93–156]	< 0.001
30-day Readmission (%)	108 (4.4)	28 (14)	< 0.001
30-day mortality (%)	0 (0)	2 (1.0)	< 0.001

[a]Requiring transfusion or reoperation

1.18–3.67, $p = 0.011$), and a preoperative diagnosis of acute cholecystitis (aOR 2.17, 95% CI 1.07–4.42, $p = 0.032$) also carried higher risk for conversion to any BOC. CBD ≥ 6 mm (aOR 1.84, 95% CI 1.09–3.08, $p = 0.022$) and total bilirubin ≥ 4 (aOR 2.81, 95% CI 1.14–6.90, $p = 0.025$) were also independently associated with increased risk for BOC. Among the surgeon factors, bailout rates of 7% or higher (aOR 4.68, 95% CI 2.02–10.80, $p < 0.001$) was found to be associated with BOC.

We performed two sensitivity analyses to account for missing data. The aforementioned associations were consistent between analyses (Supplement S.2). We found that the rate of missing data was less in a specific subgroup of patients who were admitted inpatient during the cholecystectomy (Supplement S.3). The results of the subgroup analysis are captured in Table 5. Nearly the same significant variables identified in Table 4 were found in Table 5.

Discussion

Consistent with prior reports, this study shows that patients requiring BOCs were more often older and male [14, 20, 21], and had longer duration of symptoms [22, 23] as well as more comorbidities [24–26]. These factors are likely surrogate markers for increased inflammation and fibrotic response, which then makes dissection in the hepatocystic triangle challenging, preventing a critical view of safety [27]. Previous findings also associated tachycardia and leukocytosis, markers of sepsis, with higher risks of bailout [23, 27, 28]. The Tokyo guidelines (TG18) also incorporate leukocytosis as a marker of severity, predicting a difficult cholecystectomy [29]. Studies characterizing moderate (Grade II) and severe (Grade III) acute cholecystitis based on TG18 have been shown to predict conversion to open surgery [30–32]. Not surprisingly, many diagnostic criteria for Grade II and III acute cholecystitis were identified in our analysis as risk factors for BOCs. We find, however, that operations within 24 h of admission were at a decreased risk for conversion to BOCs. This result is consistent with prior studies showing early compared to delayed cholecystectomy had less morbidity and shorter hospital stays [33–35].

Table 5 Mixed effect logistic regression of patient and surgeon factors associated with BOC, inpatient cholecystectomies only

	Adjusted odds ratio (95% CI)	*p* value
Patient factors		
Male gender	2.9 (1.7 – 4.9)	< 0.001
CBD ≥ 6 mm	2.3 (1.3 – 4.0)	0.003
Total bilirubin ≥ 4	2.8 (1.1 – 6.8)	0.026
Right upper quadrant tenderness	2.8 (1.2 – 6.4)	0.014
Adhesions	12. (6.9 – 21)	< 0.001
HR ≥ 90	2.1 (1.2 – 3.7)	0.013
Acute cholecystitis	2.3 (1.1 – 4.8)	0.022
Symptoms ≥ 72 h	1.7 (1.0 – 2.9)	0.042
Surgeon factors		
BOC rate ≥ 7.0%	4.79 (2.10 – 10.95)	< 0.001

Our study also finds that CBD dilation and elevation of total bilirubin, two factors that commonly suggest choledocholithiasis, were associated with BOCs. CBD dilation has previously been noted to be a significant predictor of a difficult laparoscopic cholecystectomy [36–38]. Similarly, total bilirubin has been previously shown to be a notable factor associated with open conversion [39–42]. Our patients who present with choledocholithiasis and cholangitis are typically able to undergo ERCP in a timely manner and can subsequently undergo same-admission cholecystectomy. However, preoperative ERCP may produce inflammation of the CBD, resulting in a difficult cholecystectomy [43–45].

The variable with the highest odds ratio for converting to a bailout operation was the report of adhesions encountered during dissection. Prior literature has used the presence and density of adhesions as a predictor for a difficult cholecystectomy [46, 47], or shown that prior abdominal surgery with subsequent extensive and dense adhesions, had higher conversion rates and longer operating time [48]. In this study, the significance of adhesions might be confounded by a lack of standardization on reporting the type of adhesion encountered. The presence of adhesions as a risk factor for conversion to BOC might also reflect surgeon preference.

Patients with BOCs had longer operations, higher complication rates, greater LOS, and more frequent need for secondary interventions. Bile leak (16%) was the most common complication in the BOC group. The rate was 20% in the subtotal cholecystectomy subgroup, which is comparable with 8 to 18% reported in the literature after subtotal cholecystectomies [5, 6, 49, 50]. We also noted an increased incidence of choledocholithiasis in the BOC cohort, which is also described in the literature [6, 50, 51]. BOCs tended to have increased incidences of postoperative interventions (22.7%, $n = 44$) requiring percutaneous drains or endoscopic retrograde cholangiopancreatography. The need for these interventions in turn directly increased the 30-day readmission rate and LOS among BOCs. Interestingly, the only mortalities within 30 days in our entire cohort underwent BOCs, again likely reflecting the generally sicker condition of this cohort.

Surgeon factors such as experience have been reported to influence the rate of conversion to open operation [37, 52, 53]. In this study, the experience of the operating surgeon did not have a significant effect on the rate of BOCs, of which open operations were a minority. Similarly, a recent article showing laparoscopic or open subtotal cholecystectomy rates were not correlated with experience [21]. In the hierarchical model, patients who underwent cholecystectomy with a surgeon that performed BOCs at a rate of greater than 7% annually were shown to have an increased risk for BOCs independent of other variables (Tables 4 and 5). The estimated cutoff point may not be applicable to a different or larger group of surgeons. The hierarchical model theoretically removed possible group biases in patient cohorts that vary from one surgeon to another. To our knowledge, this is the first report correlating surgeon performance with tendency toward BOCs. While BOCs have gained popularity over the last decade and some factors related to BOC have been reported, the decision to perform BOC remains at the discretion of the operating surgeon. Without well-defined criteria for conversion, there is a necessarily subjective component to the decision to convert. Anecdotally, some of our more veteran surgeons convert to BOCs at earlier time points when faced with difficult cholecystectomies in acute cholecystitis. This reported finding is corroborated in other studies which show that more experienced surgeons had a higher rate of conversion to open cholecystectomy [54, 55]. This effect is suggested in Table 2 which showed that in outpatient cases where the acuity of gallbladder inflammation was expected to be less severe, the time to perform a BOC tended to be longer compared to an inpatient cholecystectomy, although the result did not reach significance. Our results suggest that after accounting for patient differences between surgeon cohorts, there might be differences in surgeon preferences that explain differences in rates of BOCs.

The limitations of this study are due to its retrospective nature in a single institution. The analysis is affected by missing data, since many of the outpatient cholecystectomies included in this study did not have routine laboratory studies performed. Data derived from operative reports are subject to reporting and recall bias.

Conclusion

This study characterized the patient and surgeon factors contributing to risk of bailout cholecystectomy in a single institution. Our findings recapitulate many of the findings previously noted in the literature, particularly patient clinical demographics, preoperative imaging and laboratory findings, and intraoperative findings. In a novel use of hierarchical logistic regression, we report the influence of surgeon preference, measured by frequency of bailout operations, as an independent risk factor as well.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00464-021-08942-9.

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Declarations

Disclosures Miya C. Yoshida, Takuya Ogami, Kaylee Ho, Eileen X. Bui, Shahenda Khedr, and Chun-Cheng Chen have no conflict of interest.

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