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ORIGINAL ARTICLE

Outcome After Percutaneous Cholecystostomy for Acute Cholecystitis: a Single-Center Experience

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Abstract
Background Percutaneous cholecystostomy is an alternative treatment for acute cholecystitis patients with high surgical risk.
Methods One hundred and sixty-six patients consecutively treated by percutaneous cholecystostomy for acute cholecystitis in a single medical center were retrospectively reviewed.
Results The cohort included 121 males and 45 females with mean age of 75.9 years. The overall inhospital mortality rate was 15.1 % (n=25). Elevated serum creatinine level at diagnosis [odds ratio (OR) 1.497; p=0.020], septic shock (OR 11.755; p=0.001), and development of cholecystitis during admission (OR 7.256; p=0.007) were predictive of inhospital mortality. Of 126 patients who recovered from calculous cholecystitis, 11 experienced recurrent cholecystitis within 2 months. Serum C-reactive protein (CRP) level >15 mg dl^{-1} at diagnosis [hazard ratio (HR) 10.141; p=0.027] and drainage duration of cholecystostomy longer than 2 weeks (HR 3.638; p=0.039) were independent risk factors of early recurrence. The 53 patients who underwent cholecystectomy had an 18.9 % perioperative complication rate and no operation-related mortality.
Conclusions In-patients or those with septic shock or renal insufficiency have worse outcome. Prolonged drainage duration and high CRP level predict early recurrence. Removal of the drainage tube is recommended after resolution of the acute illness.

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Keywords Acute cholecystitis · Cholecystectomy · Percutaneous cholecystostomy

Introduction

Acute cholecystitis is usually related to gallstone disease, a condition present in about 10–15 % of the adult western population.[1] Acute calculous cholecystitis is associated with increased overall, cardiovascular disease, and cancer mortality.[2] Although acalculous cholecystitis accounts for only ~10 % of acute cholecystitis, it usually occurs in critically ill patients and is associated with high morbidity and mortality.[3] Patients diagnosed with acute cholecystitis should be initially treated with intravenous fluids, analgesia, and antibiotics, with nothing orally.[4] Early cholecystectomy is the standard treatment with laparoscopy as the preferred method.[5] The perioperative mortality rate of early laparoscopic cholecystectomy is around 1 % in low-risk patients.[6,7] However, in the elderly and in patients with significant comorbidities, cholecystectomy can result in morbidity up to 41 % and perioperative mortality up to 18 %.[7–11]

Percutaneous cholecystostomy is a minimally invasive radiologic procedure first described by Radder for patients with acute cholecystitis in the 1980s.[12] In previous studies, it has been shown as a safe option and alternative treatment for severe septic patients or for those with serious comorbidities not responding to conservative treatment or those unfit to undergo surgery.[13–16] Clinical improvement within 72 h after percutaneous cholecystostomy is reliably common, with a range of 82–93 %.[13–16] In a recent systemic review, rates for mortality caused by biliary tract infection and associated with the procedure were 3.6 and 0.36 %, respectively.[13] Delayed cholecystectomy (2 months after the initial attack has subsided) was suggested in patients with gallstones to prevent recurrence.[17–20]

However, the clinical predictors of mortality for patients with acute cholecystitis treated with percutaneous cholecystostomy remain unclear, as well as how long the drainage tube should remain. The present study aimed to analyze these outcomes after cholecystostomy.

Material and Methods

Patients

Between January 2009 and August 2010, 166 patients consecutively diagnosed as acute cholecystitis who underwent percutaneous cholecystostomy at Taipei Veterans General Hospital were enrolled in this retrospective study. Diagnosis was based on clinical presentation, physical examination, laboratory data, and imaging studies like abdominal sonography or computer tomography (CT).[20] When acute cholecystitis was diagnosed, all patients received immediate medical treatment and evaluation of their surgical risk based on the American Society of Anesthesiologists (ASA) classification.[21] One hundred and six-one patients (97 %) were classified in ASA class III or IV and refused early cholecystectomy because of high surgical risk. The remaining five patients with ASA class II refused surgery due to personal reasons. The indications of percutaneous cholecystostomy were severe sepsis, septic shock, local gallbladder rupture, or poor response to 48-h medical treatment.

Percutaneous Cholecystostomy

Percutaneous cholecystostomy was performed by radiologists and was technically successful in all patients. After local anesthesia with lidocaine, an 8-Fr pigtail catheter (Bioteque Corporation, Taipei, Taiwan) was inserted into the gallbladder through transhepatic route under ultrasound guidance. Bile sample was obtained for culture.

Data Collection

Medical records were reviewed for data collection. The following data were collected: (1) patients characteristics, such as age, sex, underlying diseases, and ASA scores; (2) clinical findings like vital signs on admission, symptoms, and indications of drainage; (3) serum biochemistry, including alanine aminotransferase (ALT), aspartate aminotransferase, total bilirubin (TB), alkaline phosphatase (Alk-P), γ-glutamyl-transferase (γ-GT), blood urea nitrogen, creatinine, complete blood cell counts, and C-reactive protein (CRP) by Rochi/Hitachi Modular Analytics Systems (Roche Diagnostics GmbH, Mannheim, Germany); (4) abdominal CT scan or sonography; (5) procedure-related complications and mortality; and (6) duration of drainage, hospital stay, inhospital mortality, and causes of mortality.

The patients were followed up until December 2011 (median follow-up, 25.4 months). During this period, the recurrence of biliary events and subsequent cholecystectomy was recorded. In patients who underwent cholecystectomy, the type of surgery, conversion rate from laparoscopic to open cholecystectomy, perioperative complications, and operation time were also recorded.

Statistical Analysis

All statistical analyses were performed using the SPSS 17.0 for Windows (SPSS. Inc., Chicago, IL, USA). Continuous variables were presented as mean±standard deviation. Logistic regression was used to determine the effects of variables on inhospital mortality, conversion surgery, and perioperative complications. Only variables with p value proximal to 0.1 in univariate analysis were selected for multivariate analysis.

Effects of categorical variables on outcomes were tested by chi-square test.

Univariate analysis of early recurrence of acute cholecystitis (within 2 months after the initial attack has subsided) was performed by log rank test, and multivariate analysis was performed by multivariate Cox regression models using variables selected by univariate analysis. Subjects were censored on the last day of follow-up (2 months) or cholecystectomy. The event considered was recurrent acute cholecystitis. A two-tailed $p<0.05$ was considered as significant.

Results

Basic Patient Characteristics and Clinical Efficacy of Cholecystostomy

The basic characteristics of the enrolled patients showed that most (72.9 %) were male (Table 1). One hundred and fifty-one patients (90.9 %) had abdominal pain and 120 patients (72.3 %) had fever at the time of presentation. Changes of symptoms and laboratory data 3 days after percutaneous cholecystostomy were shown in Table 2. Clinical improvement of abdominal pain and fever within 3 days was noted in 129 (85.4 %) and 106 (88.3 %) patients, respectively. There was significant reduction of white blood cell count and improvement of laboratory data, including TB, ALT, γ-GT, and CRP.

Safety of Percutaneous Cholecystostomy

Drainage duration of cholecystostomy was 16.6±14.0 days and 27 patients (16.3 %) experienced drainage tube-related complications, such as tube dislodgement ($n=17$), bleeding that required transfusion ($n=6$), bile leakage ($n=3$), and tube obstruction ($n=1$). Six patients with dislodged tubes underwent cholecystostomy re-insertion or revision because the acute illness did not resolve completely. Two of three patients with bile leakage suffered from peritonitis due to bile leak. One patient received emergency laparotomy and recovered well, while another refused surgery and died. One patient had biloma formation that improved after drainage and three had bloody drainage that improved after correction of coagulopathy or blood transfusion. Two patients had hematoma formation that resolved spontaneously under conservative treatment. One patient suffered from uncontrolled bleeding but refused surgery or angiographic intervention and died. Overall, the procedure-related mortality rate was 1.2 % ($n=2$).

Clinical Outcomes and Predictors of Inhospital Mortality

The clinical outcomes of all 166 patients were shown in Fig. 1. In total, 25 patients (15.1 %) died during hospitalization, most ($n=15$, 60 %) due to acute cholecystitis-induced sepsis. On univariate analysis, levels of hemoglobin, serum albumin, and creatinine, Alk-P, diabetes mellitus, acalculous cholecystitis, septic shock, and in-patients admission for other reasons compared to out-patients primarily presenting at the emergency department (ED) had prognostic value on inhospital mortality (Table 3). By multivariate analysis, higher serum creatinine levels, presence of septic shock, and in-patients admission for other reasons were independent risk factors of inhospital mortality, which was 43.2 % (19 of 44) among patients with septic shock compared to 4.9 % for patients without septic shock (6 of 122) ($p<0.001$). Receiver operating characteristic curve

Table 1 Basic characteristics of acute cholecystitis patients treated with percutaneous cholecystostomy ($n=166$)

Variables	Number (percent)
Gender	
Male	121 (72.9)
Female	45 (27.1)
Age (years old)	
<60	25 (15.1)
60–69	10 (6.0)
70–79	48 (28.9)
≥80	83 (50)
ASA classifications	
II	5 (3.0)
III	123 (74.1)
IV	38 (22.9)
Calculous	144 (86.7)
Acalculous	22 (13.3)
Common bile duct stone	31 (18.7)
Patients present at emergency department	135 (81.3)
In-patients admitted for other reasons	31 (18.7)
Comorbidities	
Cardiovascular	106 (63.9)
Diabetes	51 (30.7)
Pulmonary	20 (12.1)
Renal	22 (13.3)
Neurologic	27 (16.3)
Malignancy	35 (21.1)
Indications of cholecystostomy	
Septic shock/severe sepsis	66 (39.8)
Gallbladder rupture	13 (7.8)
Poor response after 48-h conservative treatment	87 (52.4)

Patients present at emergency department represented patients diagnosed as acute cholecystitis at the emergency department; in-patients admitted for other reasons were those diagnosed as acute cholecystitis during hospitalization but were admitted for reasons other than biliary disease. Cardiovascular comorbidities included hypertension, coronary artery disease, heart failure, valvular heart disease, or arrhythmia. Pulmonary comorbidities included chronic obstructive pulmonary disease or asthma. Renal comorbidities included chronic kidney disease or end-stage renal disease. Neurologic comorbidities included cerebral vascular accidents, Parkinsonism, and seizure

Table 2 Changes in laboratory data and symptoms after cholecystostomy in all patients (n=166)

	Before	After (3 days)	p value
Laboratory data			
WBC (cumm^{-1})	14346±6491	9947±5584	<0.001
Creatinine(mg dl^{-1})	1.77±1.70	1.64±1.75	0.032
T-B (mg dl^{-1})	2.53±2.98	1.65±2.54	<0.001
Alk-P (U l^{-1})	148.02±116.00	144.40±117.45	0.558
ALT (U l^{-1})	63.16±93.45	44.55±58.57	0.005
γ-GT (mg dl^{-1})	134.84±160.24	112.23±112.84	0.010
CRP (mg dl^{-1})	16.29±9.36	10.04±7.93	<0.001
Symptoms			
Abdominal pain, n (%)	151 (90.96)	22 (13.25)	
Fever, n (%)	120 (72.29)	14 (8.43)	

Data were expressed as mean ± standard deviation

WBC white blood cell count, *T-B* total bilirubin, *Alk-P* alkaline-phosphatase, *ALT* alanine aminotransferase, *γ-GT* gamma-glutamyl trans-peptidase, *CRP* C-reactive protein

analysis demonstrated that a cutoff value of serum creatinine of 1.5 mg dl^{-1} had the best prognostic value for inhospital mortality, with 68 % sensitivity and 75.2 % specificity (Fig. 2). The average length of hospital stay was 24.8±21.4 days. The calculous cholecystitis patients with choledocolithiasis or cystic duct stones did not have higher cholecystostomy-related complications and inhospital mortality compared with those with gallstones only (Supplementary Table 1).

In this cohort, 15 patients recovered from acalculous cholecystitis and none had recurrent cholecystitis within 2 months. Among the 126 patients who recovered from calculous cholecystitis, 11 (8.7 %) had early recurrence of acute cholecystitis within 2 months while waiting for delayed cholecystectomy. On univariate and multivariate analyses, serum CRP level >15 mg dl^{-1} at diagnosis of acute cholecystitis and drainage duration of cholecystostomy tube longer than 2 weeks were predictive of early recurrence of acute cholecystitis (Table 4; Fig. 3). The cumulative recurrence rate at 2 months of patients with serum CRP level higher or lower than 15 mg dl^{-1} was 15.6 and 1.6 %, respectively. Patients with drainage duration more or less than 2 weeks had a cumulative recurrence rate of 16.7 and 4.8 %, respectively. The interval of recurrence was 37.8±12.3 days post-drainage in the higher CRP group.

In 53 patients who received cholecystectomy, laparoscopic cholecystectomy (LC) was performed in 35 (66.1 %) and was converted to open cholecystectomy (CONV) in 12 (34.3 %) due to severe adhesions. The rate of previous abdominal surgery between the LC and CONV patients was not different (13.1 vs. 8.3 %; p=1.000). The overall operation-related complication rate was 18.9 % (Table 5) with no perioperative mortality. The mean operation time of LC, CONV, and OC was 117.1±54.1, 230.8±78.1, and 182.3±74.2 min, respectively.

The outcomes of patients stratified with different indications for cholecystostomy are shown in Table 6. The patients with severe sepsis or septic shock had a higher inhospital mortality rate and a lower rate of remission of fever. There is no significant difference in laboratory data changes, improvement of abdominal pain, complications of cholecystostomy,

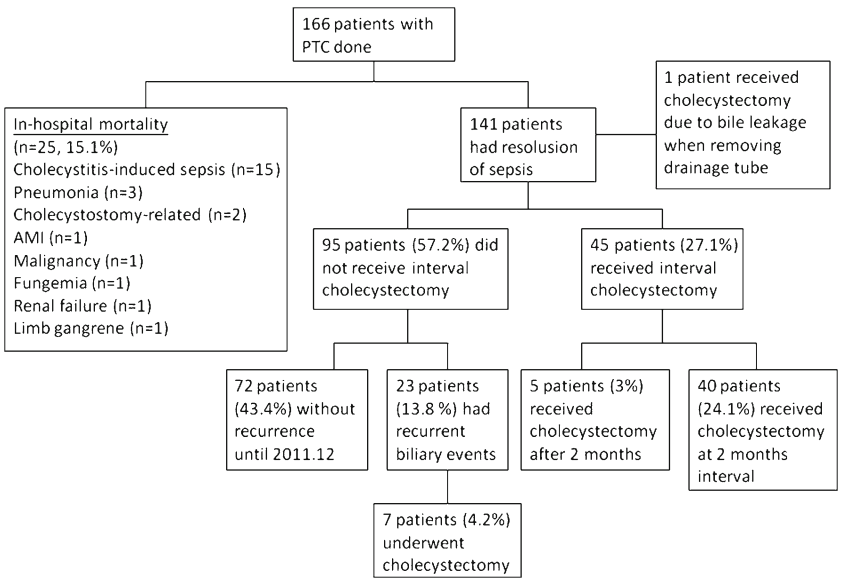

Fig. 1 Outcomes of patients with acute cholecystitis treated with percutaneous cholecystostomy (n=166)

Table 3 Univariate and multivariate analysis for risk factors related to inhospital mortality

Variables	Univariate analysis			Multivariate analysis		
	OR	95 % CI	*p* value	OR	95 % CI	*p* value
Age (years)	1.010	0.977−1.043	0.558			
Gender (male vs. female)	0.610	0.248−1.499	0.281			
WBC (cumm^{-1})	1.000	1.000−1.000	0.584			
Hemoglobin (g dl^{-1})	0.778	0.631−0.959	0.019			
Albumin (g dl^{-1})	0.275	0.110−0.686	0.006			
Creatinine (mg dl^{-1})	1.359	1.118−1.652	0.002	1.447	1.059−1.977	0.020
Alk-P (U l^{-1})	1.004	1.000−1.007	0.035			
T-B (mg dl^{-1})	1.112	0.984−1.258	0.090			
CRP (mg dl^{-1})	1.020	0.974−1.607	0.403			
Positive blood culture	1.605	0.538−4.787	0.396			
Positive bile culture	1.007	0.415−2.443	0.987			
Acalculous cholecystitis	3.267	1.173−9.096	0.023			
In-patients	4.754	1.893−11.935	0.001	7.256	1.723−30.564	0.007
Septic shock	14.693	5.328−40.524	<0.001	11.75	2.928−47.191	0.001
Comorbidities						
Cardiovascular	1.242	0.501−3.076	0.640			
Pulmonary	2.100	0.687−6.415	0.193			
Neurologic	0.403	0.089−1.823	0.238			
Malignancy	1.220	0.447−3.330	0.699			
Diabetes	2.502	1.050−5.962	0.038			

OR odds ratio, *CI* confidence interval, *Alk-P* alkaline-phosphatase, *WBC* white blood cell count, *T-B* total bilirubin, *CRP* C-reactive protein

early recurrence of acute calculous cholecystitis, perioperative complications, conversion rate, and operation time among the three groups.

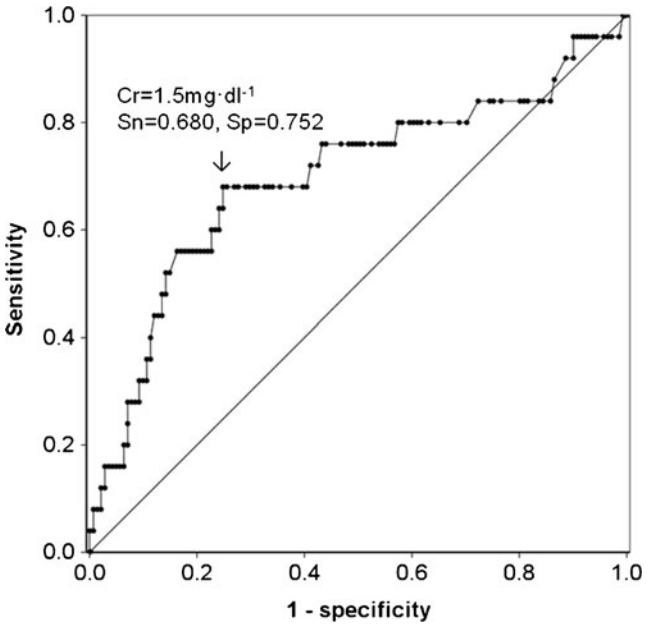

Fig. 2 The receiver operating characteristic curve of serum creatinine levels for predicting inhospital mortality. A cutoff value of 1.5 mg dl^{-1} has the best prognostic value, with 68 % sensitivity and 75.2 % specificity. The area under curve is 0.696 (p=0.002). *Sn* sensitivity, *Sp* specificity, *Cr* creatinine

The CONV patients had significantly more complications than LC patients (33.3 vs. 4.5 %; p=0.042). No variables like age, white blood cell counts, serum CRP, or albumin levels, body mass index, and drainage duration of cholecystostomy were associated with conversion surgery or perioperative complications (Table 7). However, patients who underwent conversion surgery were all males (p=0.032, Fisher's exact test). Besides, neurologic comorbidities (i.e., cerebral vascular accidents, Parkinsonism, and seizure) were associated with conversion surgery. On multivariate analysis, neurologic comorbidities were not predicative of conversion surgery (p=0.546).

Discussion

This study shows that percutaneous cholecystostomy is an effective and safe treatment for acute cholecystitis in patients at high risk for surgery. Serum creatinine level, septic shock, and inpatient admission for other reasons have predictive value on inhospital mortality. Moreover, higher serum CRP level and prolonged drainage duration of cholecystostomy are independent risk factors of early recurrence of acute calculous cholecystitis.

In this series, percutaneous cholecystostomy was technically successful in all patients, with a clinical improvement rate of 88 % that is comparable to another study.[13] Laboratory data also

Table 4 Univariate and multivariate analysis for risk factors of early recurrence of acute cholecystitis within 2 months

Variable	Univariate analysis			Multivariate analysis		
	N	HR	*P* value	HR	95 % CI	*P* value
Age (>75/≤75 years old)	85/41	1.196	0.791			
Male/female	96/30	0.750	0.712			
WBC (>12,000/≤12,000 cumm^{-1})	75/51	1.144	0.830			
Albumin (<3/≥3 gdl^{-1})	47/38	0.438	0.297			
Cr (>1.5/≤1.5 mg dl^{-1})	29/97	0.313	0.241			
T-B (>2/≤2 mg dl^{-1})	38/88	0.217	0.108			
Alk-P (>100/≤100 Ul^{-1})	62/64	1.689	0.397			
CRP (>15/≤15 mg dl^{-1})	64/62	10.119	0.006	10.14	1.30−79.25	0.027
Bile culture (positive/negative)	49/47	2.737	0.178			
Blood culture (positive/negative)	17/109	1.391	0.671			
CBD stones (yes/no)	29/97	0.692	0.636			
Cystic duct stones (yes/no)	10/116	0.043	0.309			
Diabetes (yes/no)	30/96	0.310	0.236			
Septic shock (yes/no)	21/105	1.037	0.963			
In-patients (yes/no)	19/107	1.822	0.368			
Drainage duration (>2/≤2 weeks)	42/84	3.628	0.022	3.64	1.06−12.44	0.039

HR hazard ratio, *CI* confidence interval, *WBC* white blood cell count, *Cr* creatinine, *T-B* total bilirubin, *Alk-P* alkaline-phosphatase, *CRP* C-reactive protein, *CBD* common bile duct

significantly improved within the first 3 days. Most complications of cholecystostomy were minor while fatal complications were rare. Compared to the high morbidity and mortality rates of cholecystectomy in patients with high surgical risk and acutely inflamed gallbladder,[7,10,11] this study confirmed that percutaneous cholecystostomy is a technically easier, relative safer, and effective treatment that may be a good bridge for delayed cholecystectomy until the patient's condition improves.

In previous studies, Joseph et al.[22] found that in-patients who developed acute cholecystitis on admission had significantly higher 30-day mortality than patients who presented to the ED primarily with acute cholecystitis. Ha et al.[19] found that shock on admission was an independent risk factor for inhospital death. In the present study, patients with septic shock and in-patients with acute cholecystitis were associated with higher inhospital mortality. In-patients admitted for other reasons often have more comorbidities or concomitant acute illnesses than out-patients presenting with cholecystitis at the ED. Septic shock is associated with poor prognosis in patients with infection, with mortality rate approximately 40 % even with optimal treatment.[23] This suggests that inhospital mortality is mainly associated with the patient's general condition and severity of sepsis.

Interestingly, the present study reveals that higher serum creatinine level is an independent risk factor of mortality. Elevated serum creatinine level reflects underlining chronic kidney disease and/or acute renal failure due to sepsis. It has been known that chronic kidney disease and acute renal failure are associated with increased risk of infection-related mortality.[24,25] Based on the findings here, more attention should be given to patients who develop acute cholecystitis during admission, who manifest with septic shock, or who have serum creatinine levels >1.5 mg dl^{-1} on diagnosis.

How long the drainage tube should remain is still unclear. Morse et al.[17] found that the cholecystostomy tube should remain in place in critically ill patients until cholecystectomy

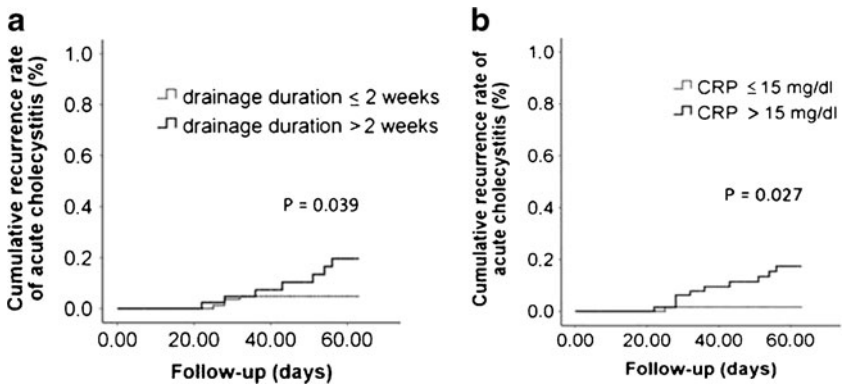

Fig. 3 Cumulative recurrence rate of acute cholecystitis within 2 months in **a** patients with drainage duration of cholecystostomy of more or less than 2 weeks or **b** patients with serum C-reactive protein level higher or lower than 15 mg dl^{-1} at diagnosis of acute cholecystitis. The *p* value corresponds to log-rank test

Table 5 Types and numbers of post-cholecystectomy complications

	LC	OC	CONV
Patient number (*n*)	23	18	12
Complications (*n*)			
Bile duct injury	0	1	0
Wound infection	1	3	2
Duodenum injury	0	1	2
Total	1	5	4

LC laparoscopic cholecystectomy, *OC* open cholecystectomy, *CONV* converted cholecystectomy

because removal of the drainage tube before subsequent cholecystectomy is associated with high recurrence of cholecystitis. In the present study, 11 patients suffered from recurrent acute cholecystitis within 2 months while waiting for delayed cholecystectomy. However, drainage duration of cholecystostomy tube longer than 2 weeks is an independent risk factor of early recurrence. It is demonstrated in animal studies that irritation of the gallbladder mucosa (mechanically or by infusion of irritant) results in acute cholecystitis.[26,27] Patients with prolonged drainage duration in the present study may have more irritation of gallbladder mucosa that resulted in recurrent cholecystitis. Furthermore, bacterial colonization of the drainage catheter may also increase the risk of infection.[28] In this study, most patients had resolution of acute cholecystitis within 8–10 days from cholecystostomy insertion to full recovery. Therefore, the cholecystostomy tube is better removed after resolution of the acute illness.

Moreover, higher serum CRP levels at diagnosis also predict early recurrence. Higher CRP level reflects more severe local inflammation that may lead to easy recurrence of cholecystitis. Sub-acute cholecystectomy (within 6 weeks after resolution of acute illness) may be suggested in these patients to prevent early recurrence. However, prospective studies are needed to elucidate the advantages and disadvantages of sub-acute surgery on these patients.

Notably, 35 patients in the present study began as laparoscopic cholecystectomy and 12 converted to the open procedures due to severe adhesion in the abdomen during surgery. The conversion rate of laparoscopic cholecystectomy in patients with acute cholecystitis ranges between 5 and 30 % in different cohorts.[20] There are many established factors associated with conversion, including age over 60 years, WBC >18,000 cumm^{-1} at the time of presentation, male, obesity, emergency status, serum albumin, multiple comorbidities, previous abdominal surgery, and inexperienced operator.[20,29,30] In the current study, the conversion rate is only significantly related to males and neurologic comorbidities, not to age, WBC, levels of albumin and CRP at diagnosis, previous

Table 6 Outcomes after cholecystostomy in patients with different indications

	Severe sepsis/septic shock (*n*=66)	Gallbladder rupture (*n*=13)	Poor response after 48-hr conservative treatment (*n*=87)	*P* value
Changes in lab data after 3 days				
Δ WBC (cumm^{-1})	−4593.5±6317.4	−2923.1±7994.6	−4475.2±5351.1	0.177
Δ Creatinine (mg dl^{-1})	−0.21±0.82	−0.15±0.25	−0.05±0.69	0.243
Δ T-B (mg dl^{-1})	−0.94±2.07	−0.38±0.54	−0.87±1.17	0.435
Δ Alk-P (U l^{-1})	−9.43±84.22	−15.00±31.56	1.59±46.25	0.681
Δ ALT (U l^{-1})	−13.93±83.68	−0.5±15.69	−25.40±78.39	0.243
Δ γ-GT (mg dl^{-1})	−38.42±104.52	4.67±6.09	−14.04±68.43	0.250
Δ CRP (mg dl^{-1})	−5.60±10.20	−10.05±6.89	−6.26±9.47	0.393
Changes in symptoms after 3 days				
Improvement of abdominal pain (%)	46/58 (79.3)	6/8 (75.0)	77/85 (90.6)	0.119
Remission of fever (%)	38/48 (79.2)	8/9 (88.9)	60/63 (95.2)	0.033
Complications of cholecystostomy (%)	10/66 (15.2)	3/13 (23.1)	14/87 (16.1)	0.777
Inhospital mortality (%)	17/66 (25.8)	1/13 (7.7)	7/87 (8.0)	0.007
Early recurrence of biliary events (%)	8/49 (16.3)	1/12 (8.3)	9/80 (11.3)	0.627
Patients receiving cholecystectomy (%)	14/49 (28.6)	3/12 (12.5)	36/80 (45.0)	0.112
Conversion rate (%)	4/8 (50)	1/2 (50)	7/25 (28)	0.365
Perioperative complications (%)	4/14 (28.6)	0/3 (0)	6/36 (16.7)	0.433
Operation time (min)	164.29±77.82	143.33±18.93	166.97±84.89	0.946

Data were expressed as mean ± standard deviation. Statistics: Continuous variables were tested by ANOVA test and categorical variables were tested by chi-square test

Δ the lab data after 3 days subtract the lab data before cholecystostomy, *WBC* white blood cell count, *T-B* total bilirubin, *Alk-P* alkaline-phosphatase, *ALT* alanine aminotransferase, *γ-GT* gamma-glutamyl trans-peptidase, *CRP* C-reactive protein

Table 7 Univariate analysis of predictors for conversion surgery and perioperative complications

Conversion surgery	Univariate analysis		
	Odds ratio	95 % CI	*p* value
Variables			
Age (>60/≤60 years old)	5.867	0.637−53.999	0.118
Albumin (g dl^{-1})	0.048	0.002−1.043	0.053
WBC (>18,000/≤18,000 $cumm^{-1}$)	0.944	0.190−4.698	0.944
Creatinine (mg dl^{-1})	1.754	0.770−3.995	0.181
T-B (mg dl^{-1})	0.916	0.595−1.410	0.690
CRP(mg dl^{-1})	1.083	0.995−1.179	0.066
BMI (kg m^{-2})	<0.001	<0.001−	1.000
Drainage duration (days)	1.026	0.980−1.074	0.277
Severe sepsis	2.375	0.473−11.922	0.293
Comorbidities			
Cardiovascular	0.800	0.190−3.374	0.761
Pulmonary	<0.001	<0.001−	0.999
Neurologic	11.000	1.064−113.031	0.044
Malignancy	0.909	0.074−11.194	0.941
Diabetes	1.500	0.275−8.189	0.640
Previous abdominal surgery	0.432	0.043−4.366	0.477
Complications			
Variables			
Age (years old)	1.060	0.992−1.134	0.087
Albumin (g dl^{-1})	0.302	0.052−1.752	0.182
WBC ($cumm^{-1}$)	1.000	1.000−1.000	0.483
Creatinine (mg dl^{-1})	1.275	0.886−1.834	0.191
T-B (mg dl^{-1})	0.833	0.526−1.320	0.436
CRP (mg dl^{-1})	1.044	0.968−1.126	0.264
BMI	0.988	0.840−1.162	0.887
Drainage duration (days)	0.973	0.922−1.027	0.327
In-patients	4.667	0.266−81.795	0.292
Severe sepsis	1.487	0.358−6.179	0.585
Comorbidities			
Cardiovascular	0.453	0.111−1.852	0.271
Pulmonary	4.179	0.764−22.861	0.099
Neurologic	0.822	0.085−7.937	0.866
Malignancy	0.667	0.071−6.259	0.723
Diabetes	0.472	0.052−4.283	0.505
Previous abdominal surgery	0.917	0.165−5.098	0.921

CI confidence interval, *WBC* white blood cell count, *T-B* total bilirubin, *CRP* C-reactive protein, *BMI* body mass index

abdominal surgery, drainage duration, or obesity. The surgeons in this study were all experienced in laparoscopic surgery. Nevertheless, most patients enrolled were male, which may explain the relatively higher conversion rate in this study.

Moreover, there is limited data about perioperative morbidities and mortality of subsequent cholecystectomy in patients previously treated with cholecystostomy. The perioperative morbidity rate varies from 12 to 30 % in several retrospective studies with small patient numbers.[31,32] In a recent systemic review, more than 40 % of patients eventually came to surgery, with 2.1 % mortality rate in elective cholecystectomy (mainly laparoscopic, either sub-acute or delayed).[13] In this study, which has larger patient numbers, the overall perioperative complication rate is 19.2 % with no perioperative mortality. In addition, the CONV patients in this study have a higher perioperative complication rate than LC patients. The results here are comparable to a large cohort in the USA.[33] Taken together, patients treated with cholecystostomy have a high conversion rate of interval laparoscopic cholecystectomy, which is associated with high morbidity rate after cholecystectomy.

The limitations of this study pertain primarily to its retrospective nature, which results in incomplete data acquisition for some patients. Furthermore, the patients treated at the study institution, which is a veterans hospital and tertiary center with a large population of elderly males with advanced comorbidities, may not correlate well with the general population.

In conclusion, percutaneous cholecystostomy is an effective treatment for acute cholecystitis in patients with high surgical risk. The outcomes are worse in patients with renal insufficiency and septic shock, and in-patients who developed cholecystitis during admission. High serum CRP level and prolonged drainage duration of cholecystostomy significantly predict early recurrence within 2 months. Removal of the drainage tube is suggested after resolution of the acute illness.

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Conflict of Interest None

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