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Original Article

Risk Factors for Gangrenous Cholecystitis and the Outcomes of Early Cholecystectomy: A Retrospective Study of a Single-Center City General Hospital

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Gangrenous cholecystitis (GC) is classified as moderate acute cholecystitis according to the Tokyo Guidelines from 2018 (TG18). We evaluated the risk factors for GC and the outcomes of early cholecystectomy. A total of 136 patients who underwent emergency cholecystectomy for acute cholecystitis were retrospectively analyzed; 58 of these patients (42.6%) were diagnosed with GC (GC group) based on our retrospective pathologic diagnosis. We comparatively evaluated the patient backgrounds and surgical outcomes between the GC group and non-GC group. The GC group was significantly older and included more hypertensive patients than the non-GC group. The GC group was prescribed more antibiotics as initial treatment than the non-GC group, and they had more days between onset and surgery. The preoperative white blood cell count and C-reactive protein values were significantly higher in the GC group than in the non-GC group, and these values were predictive factors for GC. Cholecystectomy required a longer operation time and caused greater blood loss in the GC group. The GC group also had longer hospitalization times than the non-GC group; however, no significant differences were observed in terms of postoperative complications. In conclusion, gangrenous changes should be assessed when diagnosing cholecystitis, and appropriate treatment, such as surgery or drainage, should be undertaken.

Key words: gangrenous, cholecystitis, acute cholecystitis, laparoscopic cholecystectomy

Acute cholecystitis is progressive inflammation of the gallbladder that is usually caused by obstruction of the gallbladder neck or cystic duct by gallstones. The diagnosis and treatment strategies for acute cholecystitis are generally consistent with the Tokyo Guidelines from 2018 (TG18). More progressed cholecystitis often associates gangrenous changes, and gangrenous cholecystitis (GC) is classified as Grade II (moderate) acute cholecystitis according to TG18 [1]. Gangrenous changes occur following the congestive and edema phases of cholecystitis and are defined as necrosis and perforation of the gallbladder owing to occlusion of the peripheral arterial branches, and ischemic changes in the gallbladder wall caused by increasing pressure in the gallbladder [2]. The inflammation associated with early phase acute cholecystitis can usually be relieved simply by reducing the pressure of the enlarged gallbladder, since this inflammation is caused by obstruction rather than bacterial infection. However, gangre-

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nous changes in the gallbladder wall lead to perforation of the gallbladder, biliary peritonitis, pericholecystic abscess, and biliary fistula, which increase the severity of the condition.

Our hospital staff include hepato-pancreato-biliary surgeons specializing in laparoscopic gallbladder surgery, and our hospital has an urgent care system for emergency surgery. Therefore, we have a system for performing emergency cholecystectomy according to TG18, except for patients judged to be inoperable due to septic shock or other conditions requiring intubation. To uncover ways to improve the effectiveness of treatments for acute cholecystitis especially GC, we retrospectively reviewed the clinical and pathological outcomes of emergency cholecystectomy for GC.

Materials and Methods

Patients. Of the 327 patients who underwent cholecystectomy at Sasebo City General Hospital between April 2020 and June 2022, 136 patients underwent emergency cholecystectomy for acute cholecystitis. We retrospectively reviewed the medical records of these 136 patients. Percutaneous transhepatic gallbladder drainage (PTGBD) was performed for 3 patients owing to instability of their general condition, and they were not included (Fig. 1). Diagnosis and treatment of acute cholecystitis were made according to TG18, and surgical indications for cholecystectomy were similar in all cases; daytime patients underwent operation on the same day, and nighttime patients underwent operation on the following day if their condition permitted. In all cases, at least one hepato-pancreato-biliary surgeon was involved in the surgery. The 136 patients were divided into two groups according to the postoperative pathological findings: a non-GC (n = 78) and a GC (n = 58) group. All relevant data were collected from our database and the patients' individual medical records. This study was approved by the Ethics Committee of Sasebo City General Hospital (2021-A032) and conducted in accordance with the Declaration of Helsinki.

Clinical data. The following patient characteristics were evaluated as preoperative factors: age; sex (male or female); body mass index (BMI); and comorbidities such as hypertension, diabetes mellitus, cerebral stroke, and cardiac disease. Oral medications, such as anticoagulants and steroids, were investigated, and the age-adjusted Charlson Comorbidity Index and American Society of Anesthesiologists Physical Status (ASA-PS) were also evaluated. Any preoperative blood tests and medications administered over the period from cholecystitis onset to surgery were also examined. The extracted intraoperative factors were blood loss, operation time, and whether laparoscopic surgery was performed. Postoperative factors included complications, mortality, and length of postoperative admission. GC was diagnosed based on gangrenous changes in the pathological findings, and calculous cholecystitis was defined as cholecystitis with gallstone involvement.

Statistical analysis. Data are presented as the median, minimum, and maximum values. Statistical analyses were performed using the chi-square test and Mann–Whitney *U*-test when comparing the two groups. Uni- and multivariate analyses were performed by exchanging continuous categories for binary categories divided by the median values of all 136 cases. Differences with $p < 0.05$ were considered significant. The uni- and multivariate logistic regression models were used to calculate the odds ratios (OR) with 95% confidence intervals (CI) for all potential confounding factors for GC. To evaluate the ability of inflammatory biomarkers to predict GC, the area under the curve (AUC) was

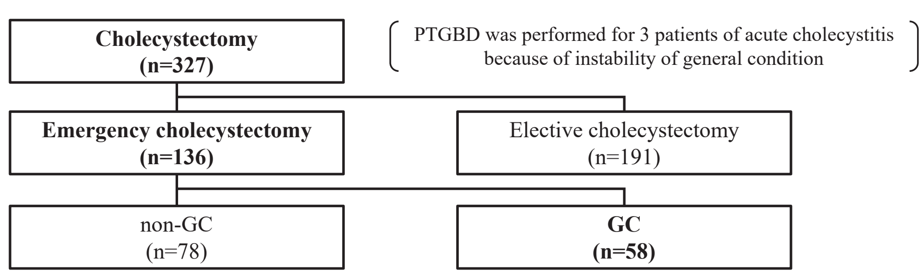

Fig. 1 Of the 327 cholecystectomies performed during the observation period, 136 were emergency surgeries for acute cholecystitis. Pathological gangrenous changes were observed in 58 patients. GC, gangrenous cholecystitis; PTGBD, percutaneous transhepatic gallbladder drainage.

determined using receiver operating characteristic (ROC) curves. AUC values were calculated to compare the ability of the inflammatory biomarkers to predict GC. The optimal cutoff points of the predictive factors for multivariate analysis were evaluated using ROC curves and the maximum Youden index, and statistical analysis was performed using StatMate V software (ATMS) (GraphPad Software, Boston, MA, USA).

Results

Patient characteristics. The patient characteristics are shown in Table 1. Pathological gangrenous changes were observed in 58 of the 136 patients (42.6%) included in the study. The median age was significantly higher in the GC group than in the non-GC group (72 vs. 80 years; $p=0.002$); however, no significant differences were observed for sex or BMI. The prevalence of comorbidities such as hypertension, diabetes mellitus, cerebral stroke, and cardiac disease tended to be higher in the GC group than in the non-GC group, and that of hypertension was significantly higher (56.4% vs. 75.9%; $p=0.019$). No significant differences were observed in the use of medications such as anticoagulants and steroids. The age-adjusted CCI was significantly higher in the GC group than in the non-GC group (5 vs. 5; $p=0.014$), although there was no significant between-group difference in the ASA-PS.

Preoperative treatment and blood biochemical examination. Table 2 shows the preoperative treatment and blood test results for patients with acute cholecystitis. Twenty-seven patients in the non-GC group and 31 patients in the GC group were treated with antibiotics before surgery for cholecystitis. The proportion was significantly higher in the GC group than in the non-GC group (34.6% vs. 53.4%; $p=0.028$). Patients treated with antibiotics were diagnosed with acute cholecystitis by a general practitioner. This patient group included those treated with antibiotics without a diagnosis of the cause of inflammation during hospitalization for other diseases at our hospital. No patients underwent PTGBD in the acute phase. The period from the onset of symptoms to cholecystectomy was significantly longer in the GC group than in the non-GC group (1 vs. 2 days; $p=0.020$). In terms of preoperative blood test results, the white blood cell (WBC) count and C-reactive protein (CRP) level were significantly higher in the GC group than in the non-GC group (WBC: 9,505 vs. 16,115/μL, $p<0.001$; CRP: 3.9 vs. 20.9 mg/dL, $p<0.001$). Similarly, the creatinine level was significant higher in the GC group than in the non-GC group (0.75 vs. 0.88 mg/dL; $p=0.049$). Significant

Table 1 Patient characteristics

	non-GC (n=78)	GC (n=58)	*P*-value
Age, median (range, year)	72 (30–96)	80 (31–98)	0.002
Sex (male/female)	42/36	29/29	0.520
BMI, median (range, kg/m^2)	22.9 (16.2–37.6)	24.3 (16.0–35.1)	0.655
Comorbidity (%)			
Hypertension	44 (56.4)	44 (75.9)	0.019
Diabetes mellitus	20 (25.6)	17 (29.3)	0.635
Cerebral stroke	11 (14.1)	14 (24.1)	0.203
Cardiac infraction	7 (9.0)	7 (12.1)	0.763
Atrial fibrillation	3 (3.8)	4 (6.9)	0.686
Medications (%)			
Anticoagulant	16 (20.5)	12 (20.7)	0.850
Steroid	3 (3.8)	3 (5.2)	0.960
Age-adjusted CCI, median (range)	5 (0–8)	5 (0–10)	0.014
ASA-PS, median (range)	2 (1–3)	2 (1–4)	0.191

GC, gangrenous cholecystitis; BMI, body mass index; CCI, Charlson comorbidity index; ASA-PS, American society of anesthesia-physical status.

decreases in the platelet count and exacerbation of hepatic function were not confirmed in the GC group during preoperative blood tests. There was no significant difference in Grade III (severe) acute cholecystitis, a condition which includes organ failure and is potentially life-threatening.

Intraoperative outcomes. The surgical procedures, intraoperative findings, and surgical findings are shown in Table 3. Usually, laparoscopic cholecystectomy (LC) is considered for acute cholecystitis; however, in some cases, adhesion owing to past surgery or inflammation of cholecystitis requires laparotomy. There was no significant difference in the number of patients requiring laparotomy for cholecystitis between the two groups. Total cholecystectomy was performed in all patients. Two patients in the GC group underwent other organ resections in addition to cholecystectomy; one underwent splenectomy due to hemorrhage of the spleen, and the other underwent partial resection of the 4th portion of the duodenum, which was diagnosed with a duodenal tumor. There was a significantly longer mean operation time and significantly greater mean blood loss in the GC group than in the non-GC group (operation time: 97 vs. 111.5 min, $p=0.001$; blood loss: 5.0 vs. 54.5 mL, $p<0.001$). The percentage of patients with cholecystitis that was not caused by gallstones was

Table 2 Preoperative characteristics

	non-GC (n=78)	GC (n=58)	*P*-value
Preoperative treatment (%)			
Use of antibiotics	27 (34.6)	31 (53.4)	0.028
PTGBD	0 (0)	0 (0)	
Onset to surgery, median (range, days)	1 (0–8)	2 (0–18)	0.020
Preoperative blood test (median, range)			
WBC (/μL)	9,505 (2,250–40,620)	16,115 (5,230–29,200)	<0.001
PLT ($\times 10^4/\mu$L)	20.7 (2.0–45.5)	20.4 (4.4–77.8)	0.822
CRP (mg/dL)	3.9 (0.0–40.5)	20.9 (0.2–39.4)	<0.001
T-bil (mg/dL)	0.9 (0.2–5.6)	1.2 (0.3–5.5)	0.319
AST (U/L)	28 (7–3,661)	26 (9–2,155)	0.317
ALT (U/L)	28 (3–1,950)	24 (3–913)	0.126
Cre (mg/dL)	0.75 (0.39–6.64)	0.88 (0.29–5.44)	0.049
Severe (Grade III) acute cholecystitis (%)	10 (12.8)	9 (15.5)	0.654

PTGBD, percutaneous transhepatic gallbladder drainage; WBC, white blood cell; PLT, platelet; CRP, C-reactive protein; T-bil, total bilirubin; AST, aspartate aminotransferase; ALT, alanine aminotransferase; Cre, creatinine.

Table 3 Surgical outcomes

	non-GC (n=78)	GC (n=58)	*P*-value
Procedure (%)			
Laparotomy, conversion to laparotomy	10 (12.8)	15 (25.9)	0.052
Subtotal cholecystectomy	0 (0)	0 (0)	–
Other organs resection	0 (0)	2 (3.4)	0.098
Intraoperative findings			
Operation time, median (range, min)	97 (47–268)	111.5 (37–293)	0.001
Blood loss, median (range, mL)	5 (2–1,530)	54.5 (2–2,476)	<0.001
Surgical findings (%)			
Acalculous cholecystitis	10 (12.8)	15 (25.9)	0.052
Gallbladder torsion	0 (0)	5 (8.6)	0.008
Bile duct injury	0 (0)	0 (0)	–
Gallbladder cancer	2 (2.6)	0 (0)	0.219

higher in the GC group than in the non-GC group, although not significant so (12.8% vs. 25.9%; $p=0.052$). Gallbladder torsion was confirmed in 5 patients in the GC group but was not confirmed in any patients in the non-GC group. No complications of bile duct injury were observed in either group. Two patients in the non-GC group were diagnosed with gallbladder cancer.

Risk factors and predictive factors for GC. Table 4 shows the predictive factors for GC. The univariate logistic analysis showed that the following patients were significantly more likely to have gangrenous changes: older patients (>78 years; odds ratio [OR] 2.951), patients with hypertension (OR 2.344), patients who underwent initial antibiotic therapy (OR 2.160), and patients who had a high WBC count (>12,265/μL; OR 7.723) or a high CRP value (>9.39 mg/dL; OR 8.710). Multivariate analysis showed that GC could be predicted by referring to the WBC count (OR 3.596) and CRP values (OR 3.912).

Inflammation biomarkers for GC. ROC curves were generated to predict GC with reference to simple and routine blood tests. The optimum cut-off point of the WBC count to predict GC was 10,463/μL. The sensitivity and specificity at the cut-off point were 81.0% and 70.1%, respectively, and the AUC at the cut-off point was 0.75 (Fig. 2A). In contrast, the CRP cut-off point was 6.34 mg/dL. The sensitivity, specificity, and AUC at the cut-off point were 87.9%, 70.1%, and 0.78, respectively (Fig. 2B).

Postoperative outcomes. The postoperative outcomes are shown in Table 5. There was no significant difference between the two groups in terms of the occurrence of complications above Clavien–Dindo classification II or IIIa (above classification II: 5.1% vs.

Table 4 Univariate and multivariate analyses of predictors for gangrenous cholecystitis

Variable	Univariate analysis			Multivariate analysis		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Age (>78 years old)	2.951	1.458–5.974	0.003	2.021	0.884–4.619	0.095
Sex (male)	0.800	0.405–1.580	0.521			
BMI (>23.08 kg/m^2)	1.824	0.917–3.628	0.087			
Comorbidity						
Hypertension	2.344	1.112–4.939	0.025	1.381	0.569–3.355	0.475
Diabetes mellitus	1.204	0.563–2.574	0.633			
Cerebral stroke	1.952	0.812–4.691	0.135			
Cardiac infraction	1.398	0.462–4.233	0.553			
Atrial fibrillation	1.868	0.401–8.697	0.426			
Medications						
Anticoagulant	1.011	0.436–2.342	0.980			
Steroid	1.370	0.266–7.044	0.707			
Preoperative treatment						
Use of antibiotics	2.160	1.078–4.328	0.030	1.456	0.631–3.361	0.378
Onset to surgery (>2 days)	1.977	0.982–3.977	0.056			
Preoperative blood test						
WBC (>12,265/μL)	7.723	3.568–16.717	<0.001	3.596	1.534–8.427	0.003
PLT (>20.6 × 10^4/μL)	0.843	0.427–1.663	0.621			
CRP (>9.39 mg/dL)	8.710	3.978–19.070	<0.001	3.912	1.638–9.341	0.002
T-bil (>1.0 mg/dL)	1.596	0.802–3.176	0.183			
AST (>27 U/L)	0.842	0.4267–1.663	0.621			
ALT (>25 U/L)	0.587	0.296–1.165	0.128			
Cre (>0.81 mg/dL)	1.824	0.917–3.628	0.087			
Calculous cholecystitis (or not)	0.419	0.173–1.018	0.055			

OR, odds ratio; CI, confidence interval.

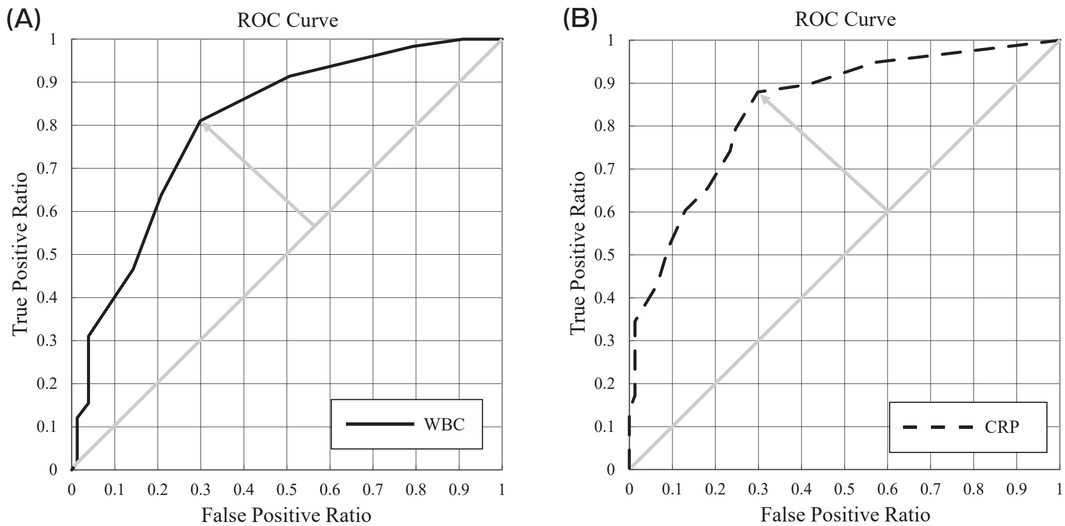

Fig. 2 The optimum cut-off points of WBC and CRP to predict gangrenous cholecystitis were calculated using the ROC analysis and indicated with arrows. (A) The cut-off point of the WBC count was 10,463/μL. Sensitivity, specificity and AUC at the cut-off point were 81.0%, 70.1% and 0.75, respectively. (B) The cut-off point of the CRP was 6.34 mg/dL. The sensitivity, specificity and AUC at the cut-off point were 87.9%, 70.1% and 0.78, respectively. WBC, white blood cell; CRP, C-reactive protein.

Table 5 Postoperative outcomes

	non-GC (n=78)	GC (n=58)	*P*-value
Complications > C-D II (%)	4 (5.1)	7 (12.1)	0.142
Complications > C-D IIIa (%)	2 (2.6)	5 (8.6)	0.114
C-D V, Mortality (%)	0 (0)	2 (3.4)	0.098
Details of complications (%)			
Surgical site infection	1 (1.3)	4 (6.9)	0.085
Aspiration pneumoniae	2 (2.6)	3 (5.2)	0.424
Bile leak from cystic duct	0 (0)	2 (3.4)	0.098
Delirium	0 (0)	1 (1.7)	0.244
Non-occlusive mesenteric ischemia	0 (0)	1 (1.7)†	0.244
Acute liver failure	0 (0)	1 (1.7)†	0.244
Intraabdominal abscess	2 (2.6)	0 (0)	0.219
Postoperative hospital stay, median (range, day)	6 (3–34)	8 (3–81)	<0.001

C-D, Clavien-Dindo classification.

12.1% for non-GC and GC, respectively, $p=0.142$; above classification IIIa: 2.6 vs. 8.6% for non-GC and GC, respectively, $p=0.114$). Details of minor complications were also recorded; no significant differences were observed in the incidence of any of these. Bile leaks from the cystic duct and intra-abdominal abscesses were relieved using endoscopic naso-biliary drainage and percutaneous drainage, respectively. Even though 2 patients in the GC group died during the study period, there was no significant difference in the number of deaths between the two groups (0% vs. 3.4%, respectively; $p=0.098$). One deceased patient, an 85-year-old man on hemodialysis, presented with right subdiaphragmatic ascites due to cholecystitis, and hemolytic ascites surrounding the spleen. Splenectomy was performed because of splenic hemorrhage, and he died on postoperative day 4 due to non-occlusive mesenteric ischemia. The operation time and blood loss were 184 min and 2,476 mL respectively. An 88-year-old man also presented with right subdiaphragmatic ascites due to cholecystitis, underwent partial resection of a 10 cm-sized duodenal tumor during cholecystectomy, and died on postoperative day 9 from acute liver failure. The operative time and blood loss were 257 min and 962 mL, respectively. The postoperative hospital stay was significantly longer in the GC group than in the non-GC group (6 vs. 8 days, $p < 0.001$).

Discussion

Acute cholecystitis is a common digestive disorder. When a diagnosis of acute cholecystitis is made, the patient is often referred to a hospital where surgery can be performed. However, if a proper diagnosis is not made, the patient may be administered antibiotics. Acute cholecystitis is often caused by obstruction of the gallbladder neck or cystic duct by gallstones; therefore, cholecystectomy or gallbladder drainage is essential. Our policy is to perform cholecystectomy as soon as possible after the diagnosis of acute cholecystitis. PTGBD is also an effective treatment; however, considering the prolonged hospital stay, recurrence of cholecystitis, and other complications associated with PTGBD [3], we decided to remove the edematous gallbladder. PTGBD is performed in cases where the patient cannot tolerate surgery, such as in those with other serious comorbidities.

Based on our retrospective pathological analysis, 42.6% of the patients analyzed in this study presented with GC during treatment for cholecystitis. It is known that gangrenous changes occur continuously, beginning with increasing pressure in the gallbladder [2] and continuing beyond proper diagnosis; physicians should thus be prepared for patients who do not respond to conservative treatment. Previous studies have reported that, among patients with acute cholecystitis, male sex, advanced age, delayed surgery, leukocytosis, cardiovascular disease, and diabetes mellitus were the risk factors for progression to GC [4-8]. Regarding image-based diagnosis of GC, contrast-enhanced computed tomography (CECT) has high specificity (96.0-100.0%) but lower sensitivity (29.3-70.6%) [9-11]. Our study also showed that patients who were older, had hypertension, and took a longer time to undergo cholecystectomy from onset often had gangrenous changes. Symptoms such as right quadrant pain and fever are less likely to appear in older patients; therefore, some cases may have been missed from the onset to the time of diagnosis. Aging and hypertension can easily lead to arteriosclerosis, and peripheral gallbladder arteries may be more susceptible to impaired blood flow. In our cases in which initial treatment of antibiotics was ineffective, gangrenous changes might have occurred in the gallbladder wall over time. The use of antibiotics may be administered as a bridge to cholecystectomy or gallbladder drainage, which are necessary treatments to relieve the obstruction of the cystic duct, but inflammation may be masked during treatment, and gangrenous changes may have occurred by the time surgery is performed. Some patients develop cholecystitis during hospitalization owing to other diseases. Approximately 1.2-2.7% of patients with acute cerebral infarction develop acute cholecystitis, and their characteristics include severe hemiparesis, a long duration of fasting, and bedridden status [12, 13]. Similarly, acute cholecystitis is associated with severe illness, infection, long intensive care unit stays, and multiple organ failure [14]. The condition of these patients leads to compromised circulation to the gallbladder and biliary obstruction due to gallbladder contraction dysfunction. Critically ill patients are not always able to complain of abdominal pain, so fever or increasing inflammatory markers necessitate an examination for suspected acute cholecystitis. It is important to be aware that antibiotic use without a diagnosis of cholecystitis can lead to gangrenous changes. GC has been reported to have a high mortality rate of between 15% and 50% [8, 15].

Regarding the prediction of GC at the time of therapeutic intervention, higher levels of WBC and CRP were important factors, in addition to age and duration from onset, in our study. Highly elevated leukocyte levels correlate with the severity of infection in the gallbladder wall [16]. Merriam *et al.* reported that a WBC count $> 17{,}000/\mu L$ predicted the development of GC [8], and levels $> 15{,}000/\mu L$ were significant in studies by Aydin *et al.* [6] and Fagan *et al.* [7]. However, a lower WBC count ($< 4{,}000/\mu L$) has been reported in mortality cases of GC [17]. Some studies have also reported a correlation between CRP levels and GC. In those studies, patients with GC showed higher CRP levels than non-GC patients, which is consistent with our report [18, 19]. Juvonen *et al.* found that an elevated CRP level of > 20.0 mg/dL had a 50% positive predictive value and a 100% negative predictive value for predicting GC, with 100% sensitivity and 87.9% specificity [20]. To diagnose cholecystitis, the following imaging examinations were performed depending on the patient: abdominal ultrasonography (US), CT, CECT, and MRCP. We could not consider using image analysis to judge whether gangrenous changes had occurred, because the imaging examinations differed among patients. Previous reports have shown that the detection of pericholecystic fluid using US predicts the development of GC [7]. Moreover, this fluid was found to be a significant predictor of mortality [17]. Contrast-enhanced US with Sonazoid has a sensitivity of 66-83% and specificity of 91-100% for diagnosis of GC [21, 22]. Bennett *et al.* reported that air in the gallbladder wall or lumen, an irregular or absent gallbladder wall, intraluminal membranes, pericholecystic abscess, and lack of gallbladder wall enhancement were specific findings of GC [9]. Accurate evaluation of images is affected by the resolution of CT and technical differences in US; however, it is important to comprehensively determine whether the gallbladder undergoes gangrenous changes.

LC has become a standard technique even in GC; however, one-fourth of the cholecystectomies for GC were performed through laparotomy at our facility. This surgical outcome was not significantly better than that in the non-GC group; however, surgery for GC was thought to be more invasive, considering the laparotomy rate, length of surgery, and blood loss. Subtotal cholecystectomy and bile duct injury were not confirmed because the edematous changes allowed us to operate safe cervical dissection during the acute inflammation phase. The mortality and morbidity rates did not differ significantly between groups, but two deaths occurred in the GC group. Although both patients were treated with resection of other organs during cholecystectomy, the results might have differed if PTGBD had been selected for cholecystitis; however, we can't state this with certainty.

At our institution, which has surgeons with high-level expertise in hepato-pancreato-biliary surgery, cholecystectomy, rather than PTGBD, is the first choice of treatment after assessment of the patient's condition. In a meta-analysis, Cai *et al.* described a better effect of delayed LC after PTGBD compared with early LC after PTGBD in terms of intraoperative bleeding, conversion rate to open surgery, postoperative complications, bile leakage, bile duct injury, and wound infection [23]. Conversely, in another meta-analysis, Cirocchi *et al.* showed that emergency cholecystectomy was superior in terms of postoperative mortality, hospital readmission for biliary complications, and length of hospital stay compared to delayed LC after PTGBD [24]. Furthermore, based on a multicenter randomized clinical trial, Loozen *et al.* reported that LC was superior to PTGBD in terms of postoperative mortality, major complications, incidence of reintervention, recurrence of biliary disease, and hospital stay in high-risk acute cholecystitis [25]. Cholecystectomy and PTGBD are effective treatments for acute cholecystitis, and PTGBD is considered a bridge to surgery in severe cases.

This study had some limitations, the first of which was that it was conducted at a single facility; the sample size was relatively small, and the study was retrospective. We would like to investigate the risk factors for gangrenous changes in cholecystitis and the safety of treatment in a prospective trial conducted at another facility; however, when PTGBD is selected, it is not possible to pathologically prove gangrenous changes. In addition, depending on the hospital system, more emergency surgeries may lead to exhaustion of medical staff, including surgeons.

In conclusion, through this study we were able to determine the risk factors and preoperative predictive factors for GC, in addition to demonstrating the safety of early cholecystectomy for GC. The presence of gangrenous changes should be determined when diagnosing cholecystitis, and appropriate treatment, such as surgery and drainage, should be performed.

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