# Clinical outcomes of high-risk patients treated with percutaneous cholecystostomy tube drainage: application of comorbidity scores in a retrospective cohort study

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**Background:** The definitive treatment for acute calculous cholecystitis (AC) is early cholecystectomy but not all patients are suitable candidates for early cholecystectomy. Although the Tokyo Guidelines (TG) help to stratify disease severity of AC, it does not incorporate patient comorbidities to determine surgical risk. Our study compared three comorbidity scoring systems, American Society of Anesthesiologists (ASA), Charlson Comorbidity Index (CCI), and Acute Physiology and Chronic Health Evaluation (APACHE II) to evaluate which was most helpful in selecting high surgical risk patients for initial non-operative management with percutaneous cholecystostomy tube (PCT) placement.

**Methods:** We retrospectively reviewed a cohort of 118 patients who underwent PCT with AC over a seven-year period from a single tertiary care hospital.

**Results:** Sixty percent of patients had PCT only while 40% also had delayed definitive cholecystectomy. ASA class and the Charleston Comorbidity Index were not significantly different between the two groups. PCT only patients had higher APACHE II scores compared to PCT with cholecystectomy (P=0.0001). The APACHE II scores were 10.1±1.0; 9.3±0.8; and 13.7±0.9 for Tokyo 1, 2 and 3 respectively, P=0.001. Mortality rates were 0%, 6.8%, and 40.4%, respectively. Among the patients who underwent a cholecystectomy, 60% were performed laparoscopically. No patient died from gallbladder-related symptoms such as untreated gangrenous cholecystitis. There were no differences in total hospital charges nor duration of hospital stay between patients undergoing PCT *vs.* PCT and cholecystectomy.

**Conclusions:** PCT drainage is appropriate for AC in patients with severe disease or patients who are not medically fit for early cholecystectomy. APACHE II scores correlated with survival among patients with AC requiring PCT. ASA and CCI scores do not correlate with Tokyo disease severity. The combined use of Tokyo grade and APACHE II scoring can help ascertain patients at high surgical risk, who should be considered primary PCT candidates.

**Keywords:** Acute cholecystitis; Tokyo Guidelines (TG); cholecystectomy; percutaneous cholecystostomy tube (PCT); complications; Acute Physiology and Chronic Health Evaluation II scores (APACHE II scores)

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## Introduction

Current recommendations for the definitive treatment of acute cholecystitis (AC) include the performance of expeditious cholecystectomy (1-7). Early cholecystectomy, defined as cholecystectomy during the index admission rather than delayed surgical intervention, has been shown to lower readmission rates, improve the patient's quality of life, and thereby decrease the overall cost to the health care system. Since patients with gallbladder-related disease comprise a heterogenous population with varying disease severities and comorbidities, early or same-admission cholecystectomy may not be the safest management option for all patients with AC, particularly for those with advanced disease severities and/or multiple comorbidities.

The Tokyo Guidelines (TG) have been formulated to help stratify disease severity of AC, predict rates of conversion to open surgery, morbidity, 30-day mortality, length of hospital stay, and medical costs (8). The guidelines were initially published in 2007, revised in 2013 (TG13) (8) and again in 2018 (TG18) (9). Both TG13 and TG18 revisions offer the same diagnostic criteria with high sensitivity and specificity for a clinical diagnosis of AC (9). Grade 1 (mild) AC is defined as a mild inflammatory process in an otherwise healthy patient with fever and/or elevated white blood cell count (WBC) and no organ dysfunction. Grade 2 (moderate) AC is characterized by clinical complaints >72-hour duration, an elevated WBC count of >18,000/mm$^3$, and a palpable tender mass in the right upper quadrant of the abdomen with signs of marked local inflammation (e.g., gangrenous or emphysematous cholecystitis, pericholecystic or hepatic abscess and biliary peritonitis). Grade 3 (severe) is associated with concurrent organ dysfunction (8).

The World Society of Emergency Surgery (WSES) (1) acknowledges that cholecystectomy for AC in elderly patients or those with comorbidities can be considered a high-risk procedure with mortalities up to 19% (10). Use of percutaneous cholecystostomy tube (PCT) offers an alternative management strategy for AC in these high-risk populations. The TG panel recommends the use of PCT for Tokyo 2 and 3 AC if the patient is too high risk to undergo early cholecystectomy (11). However, TG13/18 does not incorporate other patient comorbidities such as coronary artery disease or diabetes mellitus as risk factors for peri-operative complications. We retrospectively reviewed all patients over a seven-year period who underwent a PCT upon initial presentation of AC at our institution. Using the TG severity grading of AC along with the American Society of Anesthesiologists (ASA) physical status scores, Charlson Comorbidity Index (CCI) and the Acute Physiology and Chronic Health Evaluation (APACHE II) scores to assess for overall comorbidity risk, we compared the outcomes of patients with Tokyo 3 classification versus those with lower Tokyo classifications but high-risk comorbidities. To help guide clinical practice and select which AC patients may benefit from PCT, we evaluated three morbidity classification systems [ASA, Charleston Comorbidity Index (CCI) and/or APACHE II scores (12-14)]. We sought to determine which scoring system correlated with disease severity, and thereby may be a useful clinical adjunct to quantify high risk comorbidities. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/dmr-21-58).

## Methods

Under an Institutional Review Board-approved protocol, we retrospectively reviewed all consecutive patients who underwent a transhepatic PCT placement for acute calculus cholecystitis over a 7-year period (January 2012–March 2019) at the University of Texas Medical Branch (UTMB Health), a tertiary referral center in Galveston, Texas. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). It was approved by The University of Texas Medical Brach Institutional Review Board (No. 18-0042) and individual consent for this retrospective analysis was waived. Patient information was retrieved using the acute care surgery registry, operative logs, electronic medical records (EMR) (Epic Hyperspace 2017, Epic Systems Corporation), and billing from UTMB Health databases and Revenue Cycles Operations.

Inclusion criteria for this study were all inpatients who underwent placement of a PCT during their index admission with a diagnosis of AC at a tertiary care hospital system. Some patients also had a concurrent diagnosis of choledocholithiasis, cholangitis or gallstone pancreatitis. Patients were subsequently eligible for a cholecystectomy if their clinical parameters stabilized, or alternatively, if deemed unfit to undergo general anesthesia for an operation, patients were managed medically and discharged with a PCT. Patients diagnosed with acute acalculous cholecystitis were excluded. The percutaneous cholecystostomies were performed by four board-certified interventional radiologists and the cholecystectomies were performed by 17 board-certified general surgeons and residents-in-training. Selection criteria for PCT: the surgeons selected AC patients for PCT on a case-by-case basis relying on their clinical judgement.

Data collection included patient demographics, dates of hospitalization, diagnoses, comorbidities, vital signs and laboratory values at presentation, complications, re-admission data, and all charges associated with their medical care. Clinical data were used to calculate the ASA, CCI and APACHE II scores for each patient. Missing data values were rare; we assumed that the data missing were random and that the probability of any missing data was independent of the patient(s) belonging in any category. That is, if the liver function labs were missing, we assumed that this was a random event and that all patients with missing lab values were distributed randomly in terms of severity of disease categories. Clinical follow up after the first hospitalization was available on all patients where outcomes of interest were collected. The ASA score is a physical status classification that categorizes patients based on their fitness prior to surgery: (I) absence of systemic disease; (II) mild systemic disease; (III) severe systemic disease; (IV) a constant threat to life due to severe systemic disease (12). There were no patients classified as ASA V nor VI: (V) a person who is not expected to survive without the surgery (12); (VI) a person who has been declared brain-dead and whose organs are undergoing donation) (12). The CCI predicts the ten-year mortality for a patient with a range of comorbidities; ranging from 0–37; a higher score correlates with a lower estimated 10-year survival. The scoring is based on the age of the patient, a history of myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular accident or transient ischemic attack, dementia, chronic obstructive pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease, diabetes mellitus, hemiplegia, moderate to severe chronic kidney disease, solid tumor, leukemia, lymphoma and AIDS (13). The APACHE II score, developed by Knaus *et al*. (14), is a severity-of-disease classification system with scores ranging from 0–71. The APACHE II score is determined within 24 hours of admission to an intensive care unit. The score is calculated using the patient's age along with 12 physiological measurements: partial pressure of oxygen ($PaO_2$), temperature, mean arterial pressure, heart rate, respiratory rate, arterial pH, serum sodium and potassium levels, creatinine, hematocrit and WBC count and Glasgow coma scale. Additional criteria include history of severe organ failure or immunocompromise, such as patients with heart failure Class IV, cirrhosis, chronic lung disease, dialysis-dependent patients and acute kidney injury defined as a creatinine >1.5 mg/dL. Patients diagnosed with AC were stratified as per the TG18 into Grades 1, 2, and 3; the grading severity was determined via chart review: duration of complaints, local signs of gallbladder inflammation (e.g., right upper quadrant pain, tenderness or mass or Murphy's sign), systemic inflammatory signs (e.g., elevated WBC count or fever) and signs of organ dysfunction (e.g., hypotension requiring pressor support, decreased level of consciousness, PT-INR >1.5 or platelet counts <100,000/$mm^3$) along with characteristic findings on imaging.

### *Statistical analysis*

Descriptive statistics were evaluated by using univariate analyses of continuous and categorical variables, where appropriate. Fisher's exact tests, Student's *t*-tests, and one-way analysis of variance (ANOVA) were utilized for comparisons. To compare APACHE II scores, the data was normalized to fit the range of the score assessment where 0=0 and 71=100; the data were checked for normality visually with a QQ plot and the Kolmogorov-Smirnov test. The probability that each data point was considered normal was >99% and each set had a P value above 0.05. Based on these results, we used a parametric one-way ANOVA with Tukey's *post-hoc* test for multiple comparisons. Means, standard errors of mean (SEM), and medians were calculated for continuous data. Statistical significance was set at a P value <0.05. All analyses were executed in the GraphPad Prism Version 8.3.0(328), 2018 (available at https://www.graphpad.com/scientific-software/prism/).

## Results

One hundred-eighteen patients met the inclusion criteria for this study. Seventy-one patients (60%) underwent a PCT only, while 47 patients (39%) received a PCT followed by delayed cholecystectomy upon clinical stabilization. Since the release of TG13, the trend for PCT placement has increased, and is consistent with our institutional practice, demonstrating a rise in PCT use from 2012 to 2018 (*Figure 1*). *Table 1* shows the demographics of the two groups. The age, gender, body mass index, race, ethnicity, presenting diagnoses, ASA class and the Charleston Comorbidity Index were not significantly different between the patients who underwent PCT only versus the patients who received PCT with subsequent cholecystectomy.

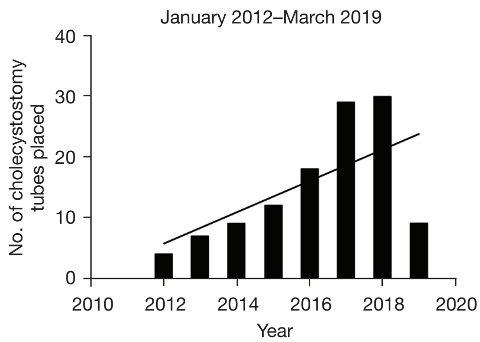


**Figure 1** Trend in the number of cholecystostomy tubes placed in this retrospective review (January 2012–March 2019).

However, APACHE II Scores were significantly higher in the PCT only group (13.4±0.7 *vs.* 8.1±0.6, P<0.0001). Among the laboratory values on admission, only the aspartate transaminase (AST) liver enzyme was significantly elevated in the PCT only group; all other lab values were statistically insignificant between the two groups.

Patients who had PCT plus surgery had earlier PCT placement compared to patients who received PCT only (2.3±1.9 *vs.* 4.0±5.0, P=0.03; *Table 2*). The mortality was also significantly lower for patients who were able to have subsequent surgery (6% *vs.* 28%, P=0.0039). Among the patients who underwent a cholecystectomy, 60% were

**Table 1** Patient demographics

| Variable | Cholecystostomy tube only (n=71) | Cholecystostomy tube + cholecystectomy (n=47) | P value | Total of all patients (n=118) |
|---|---|---|---|---|
| Age (years) | 68.0±1.9 | 64.1±2.0 | | 66.3±15.6 |
| <50 | 9 [13] | 7 [15] | | 16 [14] |
| 50–64 | 22 [31] | 10 [21] | 0.184 | 32 [27] |
| 55–79 | 22 [31] | 25 [53] | | 47 [40] |
| >80 | 18 [25] | 5 [11] | | 23 [20] |
| Gender | | | | |
| Male | 44 [62] | 30 [64] | 0.838 | 74 [63] |
| Female | 27 [38] | 17 [36] | | 44 [37] |
| Body mass index (kg/m$^2$) | 28.9±0.9 | 31.2±1.4 | | 29.9±8.5 |
| <18.5 | 3 [4] | 0 [0] | | 3 [3] |
| 18.5–25.0 | 17 [24] | 15 [32] | 0.139 | 32 [27] |
| 25.0–30.0 | 25 [35] | 14 [30] | | 39 [33] |
| >30.0 | 26 [37] | 18 [38] | | 44 [37] |
| Race/ethnicity | | | | |
| Caucasian | 46 [65] | 29 [62] | | 75 [64] |
| African American | 6 [9] | 6 [13] | 0.881 | 12 [10] |
| Hispanic/Latino | 15 [21] | 10 [21] | | 25 [21] |
| Others | 4 [6] | 2 [4] | | 6 [5] |
| Presenting diagnosis (# of patients) | | | | |
| All patients had acute cholecystitis | | | 0.162 | |
| Acute cholecystitis | 60 [85] | 45 [96] | | 105 [88.9] |
| Choledocholithiasis | 3 [4] | 0 [0] | | 3 [2.5] |
| Cholangitis | 4 [6] | 0 [0] | | 4 [3.4] |

**Table 1** (*continued*)

 

**Table 1** (*continued*)

| Variable | Cholecystostomy tube only (n=71) | Cholecystostomy tube + cholecystectomy (n=47) | P value | Total of all patients (n=118) |
|---|---|---|---|---|
| Gallstone pancreatitis | 4 [6] | 2 [4] | | 6 [5.1] |
| ASA [range] | 2.4±1.5 (n=63) [1–4] | 2.7±0.7 [1–4] | 0.837 | 2.5±1.2 [1–4] |
| Charleston Comorbidity Score [range] | 5.0±2.4 [0–15] | 3.2±2.0 [0–5] | 0.590 | 4.3±2.5 [0–15] |
| APACHE II Score | 13.4±0.7 | 8.1±0.6 | <0.0001* | 11.0±0.6 |
| Median [range] | 12 [1–29] | 8 [1–18] | | [1–29] |
| Laboratory values on admission | | | | |
| WBC | 13.8±6.9 | 14.7±6.8 | 0.430 | 13.5±6.6 |
| Total bilirubin | 3.0±3.5 | 2.4±2.5 | 0.350 | 2.4±3.1 |
| Median [range] | 1.7 [0.5–18.8] | 1.2 [0.4–8.2] | | |
| AST | 183.4±255.0 | 76.4±108.7 | 0.008* | 139.3±206.3 |
| Median [range] | 59 [16–1,102] | 37 [13–629] | | |
| ALT | 116.4±150.5 | 70.2±78.8 | 0.050 | 101.2±128.5 |
| Median [range] | 53 [9–741] | 39 [13–420] | | |
| ALK phosphatase | 209.0±200.0 | 153.2±111.5 | 0.080 | 196.4±186.4 |
| Median [range] | 138 [37–1,031] | 102 [46–436] | | |

Data are presented as n [%], mean ± SEM, median [range]. *, P<0.05. ASA, American Society of Anesthesiologist Class; APACHE, Acute Physiology and Chronic Health Evaluation; WBC, white blood cell; AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALK, alkaline; SEM, standard error of the mean; kg, kilogram; m, meters.

**Table 2** Days to PCT placement, surgery, and mortality

| Variable | PCT only (n=71) | PCT + cholecystectomy (n=47) | P value |
|---|---|---|---|
| Days to PCT placement from admission | 4.0±5.0 (2, 0–28) | 2.3±1.9 (1.5, 0–27) | 0.03* |
| Days with tube prior to surgery | NA | 77.3±60.9 | |
| Mortality[#] | 20/71 (28%) | 3/47 (6%) | 0.0039* |
| Readmission rate | 29 (41%) | 35 (75%) | 0.0004* |
| Follow-up (days) | | | |
| Median | 233 | 588 | |
| Range | 2–2,302 | 30–2,359 | |
| Mean ± SEM | 540±72 | 681±85 | 0.2091 |

Data are presented as n (%), mean ± SEM, median and range. [#], mortality is defined as a 1-month mortality, which includes both inpatient and outpatient settings; *, P<0.05. PCT, percutaneous cholecystostomy tube; SEM, standard error of the mean; NA, not applicable.

performed laparoscopically while the remaining 40% were open cholecystectomies. The mortality rate between the two types of cholecystectomies did not differ significantly [7% mortality in the laparoscopic group (n=2) versus 5.2% in the open cholecystectomy group (n=1)]; there were no perioperative mortalities. As expected, the readmission rates for patients managed with PCT followed by elective cholecystectomy were significantly higher (75% *vs.* 41%, P=0.0004). The median follow-up for patients managed with PCT only *vs.* patients with PCT and elective

**Table 3** Characteristics of acute cholecystitis using Tokyo Guidelines 2013/2018 and associated comorbidities

| Variable | Tokyo 1 (n=12) | Tokyo 2 (n=59) | Tokyo 3 (n=47) | P value |
|---|---|---|---|---|
| Days to PCT placement | 2.9±0.6 | 4.1±0.9 | 3.6±0.6 | 0.72 |
| Age of all patients | 65.6±19.0 | 67.1±14.8 | 65.4±16.0 | 0.97 |
| Patients age ≥80 | 3 | 7 | 10 | 0.32 |
| (I) Non-deceased | 65.6±19.0 | 66.0±14.8 | 62.2±15.9 | 0.98 |
| (II) Deceased | NA | 75.6±14.9 | 70.2±16.0 | 0.81 |
| Cholecystectomy | 3 [25] | 38 [64] | 6 [13] | <0.0001* |
| Readmission rate | 5 [42] | 26 [44] | 23 [49] | 0.34 |
| Mortality# | 0 [0] | 4 [7] | 19 [40] | <0.0001* |
| (I) Age | NA | 75.6±14.9 | 70.2±16.0 | 0.81 |
| (II) Cholecystectomy | NA | 2 [50] | 1 [5] | 0.07 |
| ASA Class [range] | 3.3±0.1 [1–4] | 3.0±0.1 [1–4] | 3.0±0.1 [1–4] | 0.66 |
| Charleston Comorbidity Score [range] | 4.6±0.7 [0–8] | 4.3±0.3 [0–15] | 4.5±0.3 [0–9] | 0.99 |
| APACHE II Score [range] | 10.0±1.0 [2–13] | 9.3±0.8 [2–22] | 13.7±0.9 [1–29] | 0.0012* |
| Laboratory values: WBC | 10.7±3.9 | 15.6±7.5 | 11.8±5.1 | 0.89 |
| Total bilirubin (median, range) | 1.1±1.0 (1.1, 0.4–4.0) | 2.4±2.6 (1.5, 0.4–9.1) | 2.7±4.0 (2.4, 0.5–18.0) | 0.98 |
| AST | 165.2±95.7 | 98.1±21.5 | 146.7±32.0 | 0.38 |
| ALT | 115.0±68.4 | 76.9±11.5 | 88.9±16.2 | 0.59 |
| Alkaline phosphatase | 118.9±17.7 | 165.4±19.9 | 187.3±22.9 | 0.35 |
| PT/INR | 1.2±0.1 | 2.4±3.6 | 1.9±2.1 | 0.98 |

Data are presented as n [%] or mean ± SEM. #, mortality is defined as a 1-month mortality, which includes both inpatient and outpatient settings; *, P<0.05. ASA, American Society of Anesthesiologist Class; APACHE, Acute Physiology and Chronic Health Evaluation; WBC, white blood cell; AST, aspartate aminotransferase; ALT, alanine aminotransferase; PT/INR, prothrombin time/international normalized ratio.

cholecystectomy was 233 *vs*. 588 days, respectively. Mean follow-up days for patients with PCT *vs*. PCT and elective cholecystectomy were not statistically significant (540±72 *vs*. 681±85 days, P=0.21).

When we stratified the patients based on the severity of AC by the TG13/18 grading system (*Table 3*), 10.1% of patients were classified Tokyo 1, 50.0% were Tokyo 2 and 39.8% were Tokyo 3. No significant differences were found in the number of days to PCT placement nor ages of the patients between the TG groups. The number of cholecystectomies performed was statistically significant (25%, 64% and 13% cholecystectomies for Tokyo 1, 2 and 3, respectively, P=0.0001). Mortality rates across the Tokyo groups differed significantly (n=0, 4 and 19 expired patients for Tokyo 1, 2, and 3, respectively, P=0.0001). The ASA classifications and Charleston comorbidity indices were not distinguishable between the groups (*Table 3*); however, the APACHE II scores for the three Tokyo grades were statistically significant (10.1±1.0, 9.3±0.8 and 13.7±0.9 for Tokyo 1, 2 and 3 respectively, P=0.001 (*Table 3*); post-hoc Tukey's multiple comparisons test showed a difference between Tokyo 2 *vs*. 3's APACHE II severity score (P=0.0003).

Known comorbidities among the Tokyo 3 cohort were higher than Tokyo 2 patients (*Table 4*). Both Tokyo 2 and 3 groups had two patients with diabetes mellitus who died. No Tokyo 2 patients died during the index admission whereas 17% of Tokyo 3 patients did. Most patients died after-discharge [100% (4/4) and 58% (11/19) patients for Tokyo 2 and 3, respectively]. The causes of death among both Tokyo 2 and 3 patients are listed in *Table 4*; no patient succumbed to lingering gallbladder-related symptoms such as untreated gangrenous cholecystitis.

In comparing total hospital charges between the PCT *vs*.

**Table 4** Mortality: Tokyo Grade 2 and 3 patients[#]

| Variable | Tokyo 2 (n=59) | Tokyo 3 (n=47) | P value |
|---|---|---|---|
| Mortality[##] | 4 [7] | 19 [40] | <0.0001* |
| Cholecystectomy | 2 [50] | 1 [5] | 0.07 |
| Charleston Comorbidity Score | 5.6±0.8 | 5.8±1.7 | 0.99 |
| APACHE II Score | 8.5±3.3 | 16.5±1.4 | 0.03* |
| Age | 73.0±9.0 | 71.5±17.3 | 0.99 |
| Listed comorbidities | Coronary artery disease s/p percutaneous coronary intervention (n=3); hypertension (n=4); congestive heart failure (n=2); diabetes mellitus (n=2); cancer (n=3) | Hypercapnic respiratory failure (n=3); hypertension (n=11); cancer (n=5); chronic kidney disease (n=4); chronic obstructive pulmonary disease (n=3); coronary artery disease, cerebrovascular insufficiency, myocardial infarction (n=5); diabetes mellitus (n=2) | |
| Deceased during index admission | 0 | 8 [42.1] | 0.26 |
| (i) Days post tube placement [median, range] | NA | 19±409.8 [2, 1–18] | |
| (ii) Charleston Comorbidity Score | NA | 5.6±0.6 | |
| Deceased post discharge from index admission | 4 [100] | 11 [57.9] | 0.26 |

Data are presented as n [%] or mean ± SEM. #, no patients died of gallbladder related sepsis; ##, mortality is defined as a 1-month mortality, which includes both inpatient and outpatient settings; *, P<0.05. APACHE, Acute Physiology and Chronic Health Evaluation; SEM, (standard error of the mean; s/p, status post.

**Table 5** Total charges, number of inpatient and outpatient visits and duration of hospital stay in patients with PCT *vs*. PCT plus cholecystectomy

| Variable | PCT (n=71) | PCT + cholecystectomy (n=47) | P value |
|---|---|---|---|
| Total charges ($) | 149,485.45±18,626.55 | 128,227.97±18,703.97 | 0.44 |
| Number of inpatient visits | 1.5±0.2 | 1.7±0.2 | 0.52 |
| Duration of hospital stay[#] | 17.1±2.0 | 15.7±2.3 | 0.67 |
| Number of outpatient visits | 2.7±0.3 | 3.1±0.5 | 0.49 |
| Follow-up (days): median, mean ± SEM | 233, 540±72 | 588, 681±85 | 0.21 |

Data are presented mean ± SEM. #, length of hospital stay is the total number of days in hospital as an inpatient; the total number of days for one, two or more hospitalizations have also been combined into one number. PCT, percutaneous cholecystostomy tube; SEM, standard error of the mean.

PCT and cholecystectomy groups, *Table 5* demonstrates no significant differences. This is consistent with the finding that the hospital length of stays was also not different. The number of inpatient and outpatient visits also did not vary considerably between the two groups.

## Discussion

The definitive treatment for acute calculous cholecystitis (AC) is early cholecystectomy (9); however, not all patients are suitable candidates for early operative management. In a large study with nearly 48,000 patients, the 30-day operative mortality for emergent cholecystectomy was 10-fold higher (95% CI: 2.41–41.95) compared to planned cholecystectomy (15). Additionally, patients between ages 50–70 and >70 had a 2.12 (95% CI: 0.67–6.74) and a 7.04-fold (95% CI: 2.23–22.26) increase risk of death compared to patients age <50, respectively (15). TG 2018 for AC recommend PCT for Tokyo grades 2 or 3 patients who cannot tolerate the risk of acute surgical intervention due to multiple comorbidities and/or severe systemic disease (16). Clinical management to determine which patients should undergo PCT are not clearly guided using TG18 grading criteria alone. While the Tokyo severity grading does incorporate the acute systemic effects of organ damage due to AC, we sought to determine if other clinical scoring systems (ASA, CCI, APACHE II), which can account for the patients' comorbidities, can be useful adjuncts to help determine which patients should be selected for PCT.

The literature on the use of PCT for AC in high-risk surgical patients or elderly patients with AC is conflicting. Some studies conclude that PCT is useful with acceptable clinical outcomes compared to emergent cholecystectomy for high-risk surgical patients (17). A Cochrane review in 2013 found no significant differences in morbidity or mortality between (I) PCT followed by early laparoscopic cholecystectomy versus delayed cholecystectomy and (II) PCT versus delayed cholecystectomy (18). Although some authors advocate its use as part of a staged procedure, with PCT as a bridge to cholecystectomy (19), others advocate that PCT alone for high-risk surgical patients with AC is safe with a high success rate; follow-up cholecystectomy is not required (20-23).

Other authors present poor outcomes with PCT use; however, these studies are retrospective in nature and thus, selection bias confounds their results (10,24-26). Winbladh *et al*. (10) conducted a systematic review of 53 studies consisting of 1,918 patients and concluded there was clinical improvement with PCT (85.6%) and low procedural mortality (0.36%). However, the 30-day mortality was high (15.4%) compared to those who were treated with cholecystectomy (4.5% mortality), a result which could be attributed to the fact that patients who undergo PCT are overall in poor clinical condition and unfit for surgical intervention. Similarly, in our study, 9 of 19 (47%) patients with Tokyo 3 who had only received PCT treatment, died <30 days from tube placement.

Only 68% of the patients in Winbladh's systematic review had gallstones (10); therefore, it is possible that some of the patients who underwent PCT did not have acute cholecystitis. They report that among the "uncertain cholecystitis" group, mortality was 33% whereas, mortality was 11.7% among those with a definitive diagnosis of acute cholecystitis (10). Loozen *et al*. (27) reported on a randomized clinical trial (CHOCOLATE) comparing PCT versus early laparoscopic cholecystectomy in patients with an APACHE II score of between 7–14 found that patients undergoing definitive surgery had less complications, lower recurrence of biliary disease, and shorter hospital length of stay. Mortality was not statistically different between the cholecystectomy group (3%) and the PCT group (9%, P=0.3) (27). As expected, the PCT group had a higher rate of recurrent biliary disease, increased re-admissions, increased re-interventions, longer hospital stays and higher overall medical costs (27). Tokyo classifications of the patients in this study were not reported. The study concluded that laparoscopic cholecystectomy was the preferred treatment strategy in high-risk patients for better clinical outcomes and overall lower cost of care (27). In our study population, 24% of patients had an APACHE II score greater than 14, unlike the CHOCOLATE trial, which excluded patients with a score of >15. In addition, over half of the patients in their study were ASA I and II; these patients would clearly have better clinical and economic outcomes with early definitive cholecystectomy. Among our patients, only 18.5% our patients were ASA I or II.

Gallbladder drainage via PCT for AC has been shown to be a safe procedure that effectively temporizes and improves the clinical conditions of high risk patients (10,28,29); however, PCT has been associated with higher total charges and longer length of stay compared to cholecystectomy (24). Our study did not show significant differences in total hospital charges between patients undergoing PCT *vs.* PCT and cholecystectomy, nor differences in the duration of hospital stay. At our institution, total hospital charges and length of stay for an emergent cholecystectomy for this time frame was approximately $44,500±59,000 for an approximate length of stay of 3.4±5.3 days (30). As expected, a patient with AC requiring PCT will have greater charges compared to one who is safely able to undergo emergent cholecystectomy.

The limitations of this study are the retrospective nature of our data and the small sample size at one academic teaching institution. The institutional setting of this study may not be generalizable to other clinical practices. In a minority of cases, Tokyo 1 patients had higher than average operative risk (ASA ≥3, median APACHE II score of 10, *Table 3*). Tokyo 2 patients had significantly lower APACHE II scores, higher chance of delayed cholecystectomy, and lower mortality rates compared with Tokyo 3 patients. Our analysis indicates that the combined use of Tokyo grade and APACHE II scoring can help ascertain high surgical risk patients, who should be considered primary PCT candidates. Although it may be intuitive and obvious that Tokyo 3 patients with many comorbidities should proceed to PCT, we also show that patients with lower Tokyo grades and an elevated APACHE II undergoing PCT and subsequent elective cholecystectomy have a good clinical outcomes with low mortality. Our findings highlight (I) the limitation of solely relying on Tokyo grading severity as an indication for operative versus non-operative management; and (II) the importance of using APACHE II data to assess for initial treatment with PCT prior to undergoing cholecystectomy.

## Conclusions

In conclusion, the frequency of PCT placements has increased over the recent past years. Patients with AC who have Tokyo 3 grade severity or those at high operative risk for mortality regardless of disease severity patient should be considered for PCT as the initial treatment. APACHE II scores should be utilized to help quantify the risk of comorbid conditions. Future directions to prospectively validate the use of APACHE II clinical scoring may help to identify a patient's risk for emergent cholecystectomy.

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## Footnote

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