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Percutaneous cholecystostomy-tube for high-risk patients with acute cholecystitis: current practice and implications for future research

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Abstract

Background While cholecystectomy (CCY) is the standard of care for gallstone-related acute cholecystitis, percutaneous cholecystostomy-tube (CCYT-tube) is an alternative option in patients with significant comorbid conditions. We sought to identify immediate and longitudinal hospital outcomes of patients who underwent CCYT-tube placement and determine predictors of CCYT-tube placement and eventual CCY on a national level in the US.

Methods We identified all adults (age ≥ 18 years) with a primary diagnosis of acute calculous cholecystitis from January to November 2013 in the Nationwide Readmissions Database (NRD). The NRD allows longitudinal follow-up of a patient for one calendar year. Outcomes of patients undergoing CCY and CCYT-tube were compared. Separate univariable and multivariable regression analyses were performed to identify predictors of CCYT-tube placement and failure to undergo subsequent CCY.

Results A total of 181,262 patients had an index hospitalization with acute cholecystitis where 178,095 (98.3%) patients underwent only CCY and 3167 (1.7%) patients were managed with CCYT-tubes. Among patients with CCYT-tube, 1196 (37.8%) underwent eventual CCY in 2013, while 1971 (62.2%) did not. One in five patients with CCYT-tube were readmitted within 30 days of hospital discharge. Multivariable analysis demonstrated that increasing age, male gender, coronary artery disease, cirrhosis, atrial fibrillation, diastolic congestive heart failure, and sepsis were associated with CCYT-tube placement. Longitudinal follow-up revealed that older age (OR 1.16, 95% CI 1.09–1.23), Elixhauser comorbidity score 3–4 (OR 1.94, 95% CI 1.03–3.63), cirrhosis (OR 3.28, 95% CI 1.59–6.79), and diastolic congestive heart failure (OR 2.47, 95% CI 1.33–4.60) were associated with failure to undergo subsequent CCY.

Conclusion In this national survey, nearly two in three patients who receive CCYT-tube for acute cholecystitis do not get CCY during longitudinal data capture within the same calendar year. Future research needs to target novel options for drainage of the gallbladder in high-risk patient populations.

Keywords Percutaneous cholecystostomy-tube · Acute calculous cholecystitis · Cholecystectomy

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In surgically fit patients, laparoscopic cholecystectomy (CCY) is the standard of care for acute calculous cholecystitis and should be performed early [1]. However, elderly patients with comorbidities and critically ill patients with acute calculous cholecystitis may not tolerate surgical intervention, as peri-operative mortality can reach up to 19% in these patients [2]. Most of these patients fail to respond to intravenous antibiotics alone and consequently may require immediate decompression of the gall bladder. Percutaneous cholecystostomy-tube (CCYT-tube) placement accomplishes this, has been shown to improve mortality in high-risk patients, and can even be a definitive treatment in certain patients [3].

A CCYT-tube is typically placed under fluoroscopic guidance by an interventional radiologist and is taken out after 7–8 weeks when acute inflammation has resolved. The theory is that biliary decompression with a CCYT-tube prevents further worsening of inflammation and resultant sepsis [4]. Published guidelines recommend immediate drainage of bile with a CCYT-tube as a bridging procedure in high-risk patients with acute cholecystitis where immediate CCY is not feasible [5–9]. CCYT-tube placement combined with eventual CCY then reduces recurrent biliary events and improves mortality [5, 9]. However, prolonged CCYT-tubes are associated with recurrent acute calculous cholecystitis, multiple readmissions, and increased costs [5, 6, 10–12], and at a national level, there are no studies evaluating the rates and factors influencing eventual cholecystectomy in patients with CCYT-tubes.

To address this gap in knowledge, this study aims to (i) evaluate outcomes of healthcare utilization including mortality, 30-day readmission, hospital costs, and length of stay (LOS) in patients with CCYT-tube placement, (ii) evaluate the predictors which determine percutaneous CCYT-tube placement, and (iii) evaluate the rates of and factors influencing eventual cholecystectomy after CCYT-tube placement at index admission.

Materials and methods

Data source

To realize the study aims, we utilized the Nationwide Readmission Database (NRD). The NRD is sponsored by the Agency for Healthcare Research and Quality (AHRQ) as part of the Healthcare Cost and Utilization Project (HCUP), an administrative claims databank that is the largest all-payer inpatient care database in the United States. The NRD is designed to analyze national readmission rates for hospitals across all age groups. The 2013 NRD was constructed from 22 state inpatient databases. This accounts for 51.2% of total US population and 49.3% of all hospitalizations [13]. All hospital admissions within the state are tracked with special patient linkage numbers and hospital identifiers, but not across state lines. Up to 24 diagnoses codes, 20 procedure codes and 29 comorbidity variables were included in each hospitalization with a total of more than 100 patient and hospital-related variables. All the data are de-identified and cannot be tracked to specific individual patients. The NRD excludes non-community, rehabilitation, and long-term care hospitals, which serve subacute to chronic patient population.

The Nationwide readmission database was queried from January 2013 to November 2013 using the International Classification of Diseases, Ninth Revision, and Clinical Modification (ICD-9-CM) diagnosis and procedure codes. December month hospitalizations were excluded due to an inability to track 30-day readmissions. Hospitalizations for acute calculous cholecystitis were selected using ICD-9-CM diagnostic codes (574, 574.00, 574.01, 574.10, 574.11, 574.30, 574.31, 574.40, 574.41, 574.60, 574.61, 574.70, 574.71, 574.80, and 574.81). Procedure codes for percutaneous cholecystostomy-tube (ICD-9 procedure code 51.01) and cholecystectomy (ICD-9 procedure codes 51.21, 51.22, 51.23, and 51.24) were used. Patient-related comorbidities were identified using ICD-9-CM codes as per Supplementary Table 1.

The Ohio State University Data and Specimen Policy and Human Subjects Research Policy does not require Institutional Review Board approval for population-based public data set. Per 45 Code of Federal Regulations (CFR 46.101), research using certain publicly available data sets does not involve "human subjects."

Patients and outcomes

All patients having a principal diagnosis of acute calculous cholecystitis including a procedure code for either CCY or CCYT-tube (Supplementary Table 1) were selected for potential inclusion (Fig. 1). Patients with the following criteria were excluded: (a) age < 18 years; (b) having gallstone pancreatitis, choledocholithiasis in the absence of a gallbladder, hepatobiliary or intestinal malignancy, or autoimmune biliary diseases; (c) CCYT-tube placement in those without gallstones; and (d) discharged in the month of December (2013). For patients having multiple admissions that would qualify, the earliest admission was included as the index admission. Also, patients who underwent neither CCYT-tube placement nor CCY were not included in the study as they were deemed stable enough to be discharged home.

The 'cases' were defined as patients having acute calculous cholecystitis and a primary procedure code for CCYT-tube, with or without subsequent CCY in the index admission. The 'controls' were defined as patients with acute calculous cholecystitis who underwent primary CCY without a preceding CCYT-tube placement. Primary outcomes were mortality, length of stay, total hospital costs, and 30-day readmissions. Secondary outcomes were predictors for CCYT-tube placement and predictors of not undergoing subsequent/elective CCY after primary CCYT-tube placement in the same calendar year. Length of hospital stay and total hospital costs were collectively referred to as "healthcare resource utilization."

Patient-level variables included age, sex, median household income quartile for patient's zip code, and type of insurance. Comorbidities for risk adjustment were derived from AHRQ comorbidity measures based on the methods

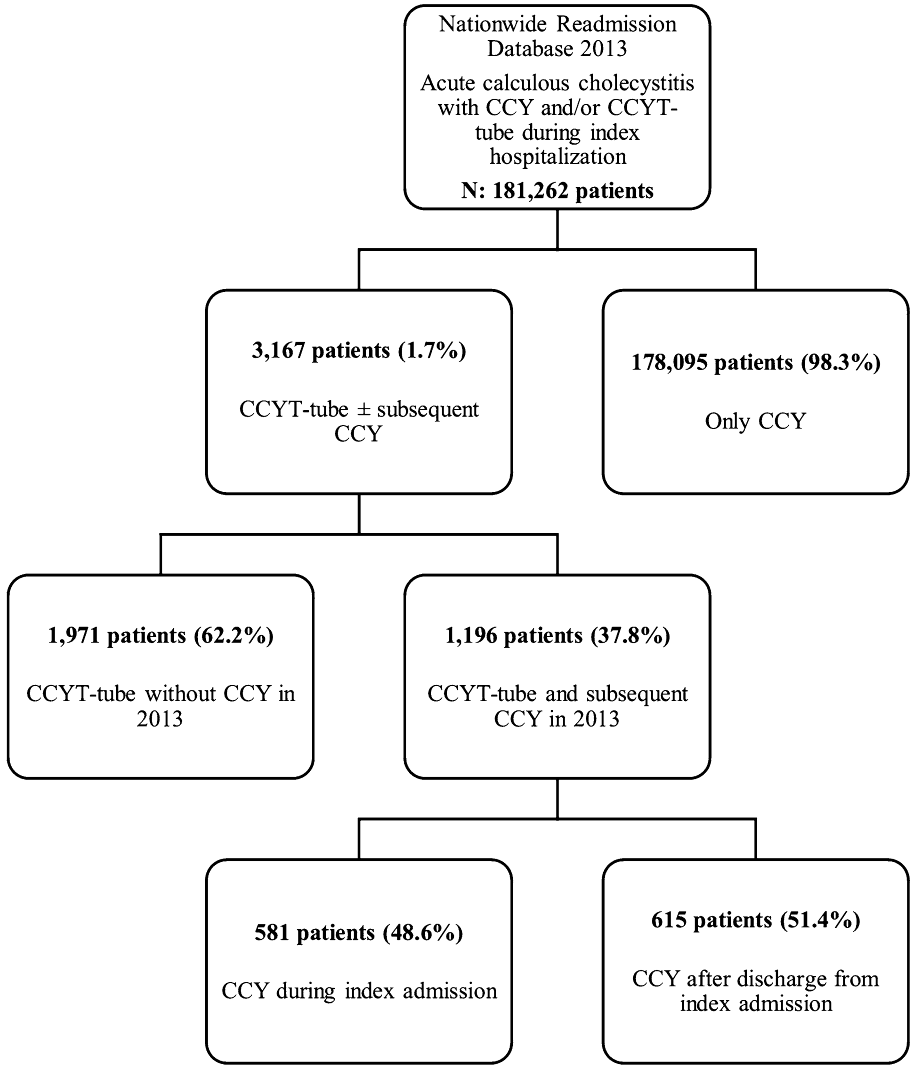

Fig. 1 Study schematic and patient flow. *CCY* cholecystectomy, *CCYT-tube* cholecystostomy-tube

by Elixhauser et al. [14] Patients were categorized based on the number of comorbidities present: 0, 1–2, 3–4, and ≥ 5. Hospital-related variables were hospital type (metropolitan non-teaching, metropolitan teaching, and non-metropolitan) and hospital bed size (large, medium, and small). Hospital bed size was classified as small, medium, or large based on the algorithm developed by HCUP.

To compare the NRD results to our institution, patients who received a CCYT-tube (ICD 9 code: 47490) for acute gallstone cholecystitis (ICD 9: 574.00, 574.01, 574.10, 574.11, 574.30, 574.31, 574.40, 574.41, 574.60, 574.61, 574.70, 574.71, 574.80, and 574.81) were also identified at The Ohio State University from January 1, 2010 until June 30, 2014. These patients were followed until Dec 31, 2014 for eventual CCY both inpatient CCY (ICD 9: Laparoscopic-51.23, Open-51.22) and outpatient CCY (CPT codes: Laparoscopic-47562, 47563, 47564 Open-47600, 47605, 47610) after removal of CCYT-tube. Rates of CCY after CCYT-tube removal were analyzed.

Statistical analysis

All analyses utilized the NRD sampling weights, stratification, and clustering. Associations with CCYT-tube placement at index hospitalization were assessed by univariable and multivariable logistic regression models. The multivariable model included all variables considered in univariable analysis, as the number of events was large enough to support all variables with no signs of overfitting. Secondary outcomes were compared between the CCYT-tube and cholecystectomy only groups by Chi-square tests for in-hospital mortality and readmissions within 30 days (excluding in-hospital mortality patients) and by linear regression of log-transformed values for length of stay and total cost of index admission. Length of stay and hospital costs had right-skewed distributions and were therefore summarized as median and interquartile range and log-transformed for regression analysis. Hospital costs were estimated by multiplying the hospital charges by the hospital-specific cost-to-charge ratios provided by HCUP. Among patients having a CCYT-tube procedure at index, univariable and multivariable logistic regression was used to identify factors associated with not having a cholecystectomy within the 2013 calendar year. The NRD does not provide data on the demographic of 'race.'

The only missing values for variables used in the study were for type of insurance (0.1%), income quartile (1.6%), and cost (2.3%). For insurance and income, a missing value category was created and included as a level for summarization and analysis. Patients with missing cost data were excluded from the cost analysis. All statistical comparisons were evaluated at $\alpha = 0.05$ significance level. All analyses were performed in SAS 9.4 (Cary, NC).

Results

A total of 181,262 patients were identified with a principal diagnosis of acute calculous cholecystitis from January to November 2013, of which 178,095 (98.3%) received only a CCY and 3167 (1.7%) received a CCYT-tube (Fig. 1). Among the patients who received a CCYT-tube, 1196 (37.8%) patients underwent eventual CCY in 2013, but a majority (62.2%) did not. Among the CCYT-tube patients with subsequent CCY, 581 (48.6%) were performed during index hospitalization, while the remaining (51.4% of CCYs) were completed at a later time in 2013.

Mortality and hospital outcomes of patients with CCYT-tube

Compared to patients who underwent only CCY, those with a CCYT-tube had longer lengths of stay (median 5.7 days vs. 2.2 days, $p < 0.001$), higher in-hospital mortality rates (2.8% vs. 0.3%, $p < 0.001$), greater total costs ($13,621 vs. $10,216, $p < 0.001$), and greater 30-day readmission rates (22% vs. 6.7%, $p < 0.001$) (Table 1).

Predictors of CCYT-tube placement during index admission

The univariable analysis comparing patients receiving a CCYT-tube vs. those without is shown in Supplementary Table 2. On univariable analysis, multiple demographic, patient, and hospital factors were associated with a primary CCYT-tube. Multivariable analysis (Table 2) revealed that increasing age [odds ratio (OR) 1.20 for 5 year increase, 95% confidence interval (CI) 1.16–1.25], male gender (OR 1.35, 95% CI 1.18–1.56), increasing Elixhauser comorbidity index, Medicaid insurance (OR 1.69, 95% CI 1.33–2.14), metropolitan teaching hospital status (OR 2.87, 95% CI 1.98–4.15), coronary artery disease (CAD) (OR 1.54, 95% CI 1.28–1.85), cirrhosis (OR 1.65, 95% CI 1.20–2.27), atrial fibrillation (OR 1.48, 95% CI 1.27–1.74), sepsis (OR 4.53, 95% CI 3.53–5.82), and diastolic congestive heart failure (CHF) (OR 1.55, 95% CI 1.13–2.14) were associated with greater odds of CCYT-tube placement.

Predictors for failure to undergo cholecystectomy following CCYT-tube placement

The univariable analysis of predictors of patients not receiving CCY following CCYT-tube placement is shown in Supplementary Table 3. The multivariable analysis (Table 3) demonstrated that older age (OR 1.16 for 5-year increase, 95% 1.09–1.23), Elixhauser comorbidity score 3–4 (OR 1.94, 95% CI 1.03–3.63), cirrhosis (OR 3.28, 95% CI 1.59–6.79), and diastolic CHF (OR 2.47, 95% CI 1.33–4.60) were associated with greater odds of not receiving a CCY after CCYT-tube placement.

Sensitivity analysis

To validate rates of CCY following CCYT-tube placement, we compared the frequency of post-CCYT-tube CCY rates at our tertiary academic center to that of the NRD. A total

Table 1 Univariable analysis of hospital outcomes for patients receiving a cholecystostomy-tube (CCYT-tube) versus those without in the management of calculous acute cholecystitis; Nationwide Readmission Database 2013

Outcome	CCYT-tube ($n = 3167$)	No CCYT-tube; only CCY ($n = 178{,}095$)	p value
Readmissions within 30 days[a]	678 (22.0%)	11,938 (6.7%)	< 0.001
In-hospital mortality (index admission)	89 (2.8%)	510 (0.3%)	< 0.001
Total cost of index admission, median (IQR)	13,621 (9328–20,837)[b]	10,216 (7548–14,318)[c]	< 0.001
Length of Stay, median (IQR)	5.7 (3.4–9.1)	2.2 (1.2–3.9)	< 0.001

CCYT-tube cholecystostomy-tube, *CCY* cholecystectomy, *IQR* interquartile range

[a]Excluding in-hospital mortality at index

[b]$n = 3069$ non-missing

[c]$n = 174{,}043$ non-missing

Table 2 Multivariable analysis of predictors for cholecystostomy-tube (CCYT-tube) placement in acute calculous cholecystitis; 2013 Nationwide Readmission Database

Variable	Multivariable odds ratio (95% CI)	*p* value
Age (OR for 5 year increase)	1.20 (1.16, 1.25)	< 0.001
Sex, male	1.35 (1.18, 1.56)	< 0.001
AHRQ-Elixhauser comorbidity index[a]		
0	Reference	
1–2	1.45 (1.12, 1.87)	0.01
3–4	2.27 (1.70, 3.05)	< 0.001
≥ 5	3.76 (2.70, 5.23)	< 0.001
Type of insurance		
Private	Reference	
Medicare	1.06 (0.87, 1.30)	0.55
Medicaid	1.69 (1.33, 2.14)	< 0.001
Self-pay	1.11 (0.76, 1.62)	0.58
No charge	0.33 (0.10, 1.04)	0.06
Other	0.85 (0.56, 1.30)	0.45
Missing data	2.90 (0.71, 11.75)	0.14
Income[c]		
$1–$37,999	Reference	
$38,000–$47,999	1.22 (0.99, 1.50)	0.06
$48,000–$63,999	1.30 (1.07, 1.59)	0.01
$64,000 or more	1.29 (1.03, 1.62)	0.02
Missing data	1.67 (1.07, 2.62)	0.02
Hospital type		
Metropolitan non-teaching	1.26 (0.88, 1.81)	0.21
Metropolitan teaching	2.87 (1.98, 4.15)	< 0.001
Non-metropolitan	Reference	
Hospital bed size[b]		
Small	Reference	
Medium	1.31 (0.91, 1.89)	0.15
Large	1.50 (1.07, 2.12)	0.02
Hypertension	0.80 (0.70, 0.92)	0.002
Type 2 DM	1.00 (0.87, 1.15)	0.99
Chronic renal failure	0.93 (0.74, 1.16)	0.51
CAD	1.54 (1.28, 1.85)	< 0.001
COPD	1.06 (0.90, 1.25)	0.51
Dialysis	1.33 (0.82, 2.17)	0.24
Cirrhosis	1.65 (1.20, 2.27)	0.002
Atrial fibrillation	1.48 (1.27, 1.74)	< 0.001
Sepsis	4.53 (3.53, 5.82)	< 0.001
Mechanical ventilation	0.67 (0.40, 1.13)	0.13
Hyperlipidemia	0.94 (0.82, 1.06)	0.31
Dementia	1.38 (0.50, 3.81)	0.54
CVA	0.20 (0.03, 1.51)	0.12
Hyperthyroidism	1.26 (0.46, 3.49)	0.65
CHF diastolic	1.55 (1.13, 2.14)	0.01
CHF systolic	1.37 (0.95, 2.00)	0.10

OR odds ratio, *CI* confidence interval, *CCYT-tube* cholecystostomy-tube, *DM* diabetes mellitus, *CAD* coronary artery disease, *COPD* chronic obstructive pulmonary disease, *CVA* cerebrovascular accident, *CHF* congestive heart failure, *AHRQ* agency for healthcare research and quality

[a]Comorbidities for risk adjustment were derived from AHRQ comorbidity measures based on the methods by Elixhauser [14]. A total of 29 comorbidity indicators are reviewed

[b]Bed size categorizes are based on hospital beds and are specific to the hospital's location and teaching status. Bed size assesses the number of short-term acute beds in a hospital [13]

[c]Estimates of national quartiles are subject to variations on an annual basis: 2013 ranges were low ($1–$38,999), moderate ($39,000–$47,999), high ($48,000–$63,999), and very high ($64,000 or more) [13]

of 111 patients underwent CCYT-tube placement for acute gallstone cholecystitis at The Ohio State University Medical Center. Of these patients, 35 patients (31.5%) underwent CCY, while 76 patients (68.5%) failed to undergo a subsequent CCY. There was no statistical difference ($p = 0.20$) when compared to the rates of subsequent CCY in the NRD (1196, 37.8%; Fig. 1).

Discussion

Percutaneous CCYT-tube placement is an infrequent event, so we used a national survey to evaluate predictors and outcomes of this procedure when performed for acute calculous cholecystitis. Approximately 2% of all patients with acute calculous cholecystitis undergo CCYT-tube in the US, though a majority (*n*: 1971; 60%) of patients who receive these purportedly temporary CCYT-tubes do not undergo subsequent CCY during one calendar year. While increasing age, cumulative comorbidities, cardiac diseases, cirrhosis, and sepsis determine CCYT-tube placement, elderly patients, diastolic CHF, cirrhotics, and multiple comorbidities are most associated with not undergoing an elective CCY at a later date. Although not causatively associated, CCYT-tube placement is correlated with adverse hospital outcomes of mortality, duration of hospitalization, costs, and 30-day readmission. To our knowledge, this is the first study to evaluate CCYT-tube placement in a large population database.

Similar to prior studies, [15] we found that patients undergoing CCYT-tube placement have higher mortality, 30-day readmission rates, length of stay, and higher hospital costs. This is attributable to all the variables independently associated with CCYT-tube placement. It is understandable that CCYT-tubes are placed in very ill patients who need longer recovery times, utilize greater healthcare resources, and have higher risks of in-hospital mortality.

Increasing age is associated with high post-operative complications. Age > 80 years was an independent risk factor for morbidity and mortality even among healthy patients

Table 3 Multivariable analysis of predictors of not undergoing cholecystectomy following cholecystostomy-tube (CCYT-tube) placement in acute calculous cholecystitis; 2013 Nationwide Readmission Database

Variable	Multivariable odds ratio (95% CI)	*p* value
Age (OR for 5 year increase)	1.16 (1.09, 1.23)	< 0.001
Sex, female	1.01 (0.78, 1.31)	0.93
AHRQ-Elixhauser comorbidity index[a]		
0	Reference	
1–2	1.55 (0.90, 2.70)	0.12
3–4	1.94 (1.03, 3.63)	0.04
≥ 5	1.69 (0.87, 3.27)	0.12
Type of insurance		
Medicare	1.50 (0.96, 2.36)	0.08
Medicaid	1.50 (0.89, 2.51)	0.13
Private	Reference	
Self-pay	1.60 (0.80, 3.22)	0.19
No charge	n/a	n/a
Other	1.71 (0.67, 4.38)	0.26
Missing data	0.72 (0.05, 9.38)	0.80
Income[c]		
$1–$37,999	Reference	
$38,000–$47,999	0.88 (0.58, 1.33)	0.54
$48,000–$63,999	0.96 (0.66, 1.39)	0.82
$64,000 or more	0.80 (0.52, 1.23)	0.30
Missing data	0.57 (0.25, 1.29)	0.18
Hospital type		
Metropolitan non-teaching	0.70 (0.40, 1.22)	0.21
Metropolitan teaching	1.06 (0.62, 1.82)	0.83
Non-metropolitan	Reference	
Hospital bed size[b]		
Small	Reference	
Medium	0.76 (0.41, 1.39)	0.36
Large	0.74 (0.42, 1.30)	0.30
Hypertension	0.95 (0.68, 1.32)	0.76
Type 2 DM	1.21 (0.90, 1.62)	0.21
Chronic renal failure	1.12 (0.68, 1.84)	0.65
CAD	0.93 (0.66, 1.31)	0.69
COPD	1.05 (0.77, 1.43)	0.76
Dialysis	2.08 (0.76, 5.70)	0.15
Cirrhosis	3.28 (1.59, 6.79)	0.001
Atrial fibrillation	0.95 (0.67, 1.34)	0.77
Sepsis	0.87 (0.54, 1.38)	0.54
Mechanical ventilation	0.78 (0.38, 1.59)	0.49
Hyperlipidemia	0.67 (0.51, 0.88)	0.004
CHF diastolic	2.47 (1.33, 4.60)	0.004
CHF systolic	0.99 (0.55, 1.80)	0.98

OR odds ratio, *CI* confidence interval, *CCYT-tube* cholecystostomy-tube, *DM* diabetes mellitus, *CAD* coronary artery disease, *COPD* chronic obstructive pulmonary disease, *CHF* congestive heart failure, *AHRQ* Agency for Healthcare Research and Quality

[a]Comorbidities for risk adjustment were derived from AHRQ comorbidity measures based on the methods by Elixhauser [14]. A total of 29 comorbidity indicators are reviewed

[b]Bed size categorizes are based on hospital beds and are specific to the hospital's location and teaching status. Bed size assesses the number of short-term acute beds in a hospital [13]

[c]Estimates of national quartiles are subject to variations on an annual basis: 2013 ranges were low ($1–$38,999), moderate ($39,000–$47,999), high ($48,000–$63,999), and very high ($64,000 or more) [13]

undergoing non-cardiac surgery [16]. Frailty and malnutrition may contribute to this and are associated with adverse post-surgical outcomes [17]. In addition, high-risk coronary artery disease is an independent risk factor for peri-operative cardiac complications in non-cardiac surgeries [18]. Metropolitan teaching hospitals may be more equipped to place percutaneous CCYT-tubes and thus perform a greater proportion of these procedures. Sepsis had the highest odds (OR 4.53, 95% CI 3.53–5.82) for a CCYT-tube placement. Mortality rates from biliary infection alone and related sepsis is as high as 3.6% [2] and this compounds the risk of an emergent cholecystectomy.

We found that 62.2% of patients who had a cholecystostomy-tube did not eventually undergo cholecystectomy in the study period. Older age, an Elixhauser score of 3–4, cirrhosis, and diastolic CHF during index admission were associated with not receiving a CCY after CCYT-tube placement. Older patients with multiple comorbidities are prone for selection bias and thus are less likely to get CCY. The presence of these disease processes itself should not be a contraindication when the comorbidities are well controlled and clinical situation is appropriate. Also, with improved surgical techniques and peri-operative care, mortality related to CCY has decreased in recent years [2]. Despite these improvements, the surgical risk may persist in small subset of patients who may never be candidates for CCY.

Cirrhosis was associated with both placement of a CCYT-tube and failure to undergo elective subsequent CCY. Despite some older studies that reported higher mortality rates in patients with acute calculous cholecystitis in cirrhotic patients, [19] more recent studies have demonstrated that CCY in patients with cirrhosis is feasible with infrequent mortality and low morbidity, especially in patients with Child's class A cirrhosis [20].

Cholecystostomy-tube alone can be a final management strategy following resolution of acute cholecystitis and removal of the tube in select patients with a limited life expectancy [21]. However, this cannot be generalized to all patients with a CCYT-tube since recurrent cholecystitis rates up to 23.5% have been reported [10, 22]. This may necessitate a repeat CCYT-tube or emergency CCY. Also, early complications of a CCYT-tube include hemorrhage, liver hematoma, hemobilia, biliary peritonitis, intestinal perforation, sepsis, pneumothorax, and catheter dislocation, while late complications can result in abdominal wall abscess, bile leak, duodenal fistula, and tube dislodgement [23, 24]. Hence, when feasible, definitive CCY is recommended after resolution of acute cholecystitis, albeit laparoscopic CCY is technically more challenging in such patients due to adhesions [5–8]. This implies rigorous follow-up care of patients with CCYT-tube.

Recent novel management strategy for patients who are surgically deemed unfit for CCY includes endoscopic gallbladder drainage. Percutaneous CCYT-tube is associated with an approximate 14% risk of adverse events and is contraindicated in patients with cirrhosis who have ascites. Hence, alternative routes for drainage of the gallbladder have been explored [25]. Endoscopic gallbladder drainage continues to evolve and is performed by two different methods: (a) transpapillary or (b) transmural. Endoscopic retrograde cholangiography (ERC) is utilized for transpapillary drainage through the cystic duct with placement of small caliber plastic stents. Endoscopic ultrasound (EUS)-guided transgastric or transduodenal lumen apposing metal stents provide transmural drainage [26]. In a recent meta-analysis, the EUS-guided procedures demonstrated better technical (93% vs. 83%) and clinical success (97% vs. 93%) rates over ERC-based gallbladder drainage [26]. Potentially, endoscopy-guided procedures could offer comparable, if not safer options for gallbladder drainage than percutaneous CCYT-tube. We have identified several variables which determine failure of receiving an eventual CCY following a CCYT-tube. Specifically, patients with cirrhosis (and more so when there is ascites) may be appropriately managed with ERC-guided long-term stents [26].

Our study has several limitations that are inherent to an administrative database dependent on ICD-9-CM coding. We utilized the NRD rather than other large database (National Inpatient Sample) to account for individual patient admissions and examine readmission rates. This database does not track patients between state lines, and hence patients who get CCY in a different state than CCYT-tube are not captured. Patients who got CCYT-tube, being sick, may take longer time to recover and eventual CCY may not be captured due to limited follow-up that ends with one calendar year. However, the database is limited by a lack of information on medication administration, laboratory values, Childs classification of cirrhosis, and outpatient follow-up. Since the NRD is not all inclusive, the possibility of unobserved confounding is nevertheless present. However, a major advantage of utilizing the NRD is that we can study a large number of individual/unique patients and review subsequent hospitalizations longitudinally for one calendar year. Since the NRD is a nationally representative sample, the results are thus generalizable to the US population.

To address an important limitation of the NRD involving potential loss of data where subjects with prior CCYT-tube could have underwent outpatient CCYs, we performed a sensitivity analysis by analyzing rates of CCYs in patients with CCYT-tube at a tertiary academic institute. At our center, we found only 31.5% of CCYT-tube patients eventually underwent outpatient or inpatient CCY which compares to national rates observed in this study. Similar results were found at another tertiary academic hospital in the US, in which only about one-third of patients underwent subsequent CCY [27]. A systematic review also demonstrated that approximately 38% of patients underwent eventual cholecystectomy after CCYT-tube placement for acute calculous cholecystitis [2].

Cholecystectomy is the standard of care for acute calculous cholecystitis and is superior to any other treatment. Patients who are deemed high risk for CCY undergo CCYT-tube placement. Although subsequent elective CCY is warranted, a majority of patients do not undergo removal of the gallbladder. Although limited in procedural volume and experience, endoscopic (ERC- or EUS-guided) drainage procedures of gallbladder have demonstrated comparable efficacy and safety; hence there is a need for continued research comparing percutaneous and endoscopic management of the described patient population.

Author Contributions RBP: study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content; and study supervision. DL: study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; and critical revision of the manuscript for important intellectual content. KP: statistical analysis; acquisition of data; analysis and interpretation of data; and critical revision of the manuscript for important intellectual content. SAM: critical revision of the manuscript for important intellectual content. DLC: Critical revision of the manuscript for important intellectual content. SGK: study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content; and study supervision.

Compliance with ethical standards

Disclosures Ravi B. Pavurala, Daniel Li, Kyle Porter, Sara A. Mansfield, Darwin L. Conwell, and Somashekar G. Krishna have no conflicts of interest or financial ties to disclose.

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