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# EUS-Guided Gallbladder Drainage versus Dual Stent Transpapillary Gallbladder Drainage for Management of Acute Cholecystitis

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**Conflict of Interest:** Dr. Nasser-Ghodsi is a consultant for Boston Scientific

Dr. Andrew Storm is a consultant for Apollo Endosurgery, ERBE, GI dynamics, and Olympus.

Dr. Marya is a consultant for Boston Scientific

None of the remaining authors have any conflicts of interest to disclose.

**Abstract:**
Background and Aim:
Cholecystectomy (CCY) is the standard treatment for acute cholecystitis. For non-surgical patients, percutaneous cholecystostomy tube (PT-GBD) is recommended but is associated with high readmission rates and poor quality-of-life. Endoscopic gallbladder decompression techniques, including endoscopic transpapillary gallbladder drainage (ET-GBD) and endoscopic ultrasound-guided gallbladder drainage (EUS-GBD), are alternatives. Studies comparing ET-GBD and EUS-GBD have shown EUS-GBD to have superior outcomes. However, these studies assessed ET-GBD mostly via single transcystic stent placement (SSET-GBD). This study aims to compare outcomes of dual transcystic stents (DSET-GBD) and EUS-GBD in non-surgical candidates with acute cholecystitis.

Methods:
A multicenter analysis was conducted on patients who underwent ET-GBD or EUS-GBD between January 2019 and January 2023. Data were extracted from electronic medical records and outcomes including technical success, success, adverse events, and recurrence rates of cholecystitis were measured.

Results:
Out of 129 procedures (56 EUS-GBD; 73 ET-GBD), technical success was achieved in 87.5% of EUS-GBD and 86.3% of ET-GBD attempts. Immediate clinical success was achieved in 98.1% for EUS-GBD and 100% for DSET-GBD. Adverse event rates were similar between the groups. Recurrent cholecystitis rates were 5.3% for EUS-GBD and 8.2% for DSET-GBD (p = 0.692).

Conclusions:
This study demonstrates that DSET-GBD has similarly low rates of recurrent acute cholecystitis compared to EUS-GBD. DSET-GBD should be considered as an alternative management strategy for the management of acute cholecystitis in patients who are unable to undergo CCY.

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**Introduction:**

Laparoscopic cholecystectomy (CCY) is the standard of care approach for patients with acute cholecystitis. The 2018 Tokyo guidelines recommend gallbladder decompression via percutaneous cholecystostomy tube (PT-GBD) as second-line therapy for non-surgical patients with AC.[1] The incidence of acute cholecystitis is increasing, as is the proportion of patients undergoing PT-GBD for management of acute cholecystitis, in part because of an aging population with a greater prevalence of comorbidities.[2] PT-GBD has previously been a favorable option because it can be performed at the bedside without sedation and is available in both academic and community hospitals; however, PT-GBD is associated with a diminished quality of life and an increased reintervention rate due to several associated issues, including tube occlusion or migration.[1, 2] Recent data shows that patients who undergo PT-GBD have a 50% readmission rate, which is comparable to conservative management of acute cholecystitis with antibiotics alone.[3]

Endoscopic gallbladder decompression is an emerging therapeutic intervention that offers definitive non-operative management of acute cholecystitis. Data suggests that endoscopic gallbladder decompression is associated with fewer surgical interventions, adverse events, and unplanned hospital admissions when compared to PT-GBD.[4] The two techniques used for endoscopic gallbladder decompression are endoscopic transpapillary gallbladder drainage (ET-GBD) and endoscopic ultrasound-guided gallbladder drainage (EUS-GBD). ET-GBD is performed via endoscopic retrograde cholangiopancreatography (ERCP) with transpapillary placement of a stent into the gallbladder via the cystic duct (i.e., transcystic stenting). Modern EUS-GBD technique most commonly involves placement of a cautery-enhanced lumen apposing metal stent (LAMS) into the gallbladder via a transgastric or transduodenal approach.[5]

Prior studies comparing ET-GBD and EUS-GBD have shown EUS-GBD to have higher rates of technical success and lower rates of recurrent AC compared to ET-GBD.[6] However, these studies assessed ET-GBD mostly via single transcystic stent placement (SSET-GBD). Patients who undergo ET-GBD with dual transcystic stents (DSET-GBD) are less likely to have recurrent acute cholecystitis compared to SSET-GBD. This is likely because of a “wicking” effect, whereby two stents facilitate the flow of bile between the stents as opposed to through the stent

lumens which can easily become occluded over time. Thus, when a single transcystic stent is placed and becomes occluded patients are at a likely increased risk of recurrent cholecystitis.[7]

Prior studies have not compared the performance characteristics of DSET-GBD to EUS-GBD and, therefore, it remains unclear which is the optimal method of endoscopic gallbladder drainage for poor surgical candidates. The aim of this study is to compare outcomes in patients with cholecystitis who have undergone EUS-GBD or DSET-GBD.

**Methods**

2.1 Study Design

The study was approved by the Institutional Review Boards of the University of Massachusetts Chan Medical School and Mayo Clinic, Rochester. In this multicenter retrospective analysis, all consecutive patients who underwent endoscopic management of cholecystitis between January 2019 to January 2023 were evaluated. Demographic, medical, and procedural data were extracted from the electronic medical record. Inclusion criteria included patients with acute cholecystitis that were treated with ET-GBD or EUS-GBD with a minimum of 6-months follow-up. The electronic medical record as reviewed to evaluate the severity of cholecystitis (as defined by Tokyo criteria), patient demographics, presence or absence of concomitant malignancy, and clinical outcomes for all included patients.[8] Adverse events were graded and reported based on the ASGE lexicon.[9]

2.2 Endoscopic gallbladder drainage procedure:

At our institutions, ET-GBD is attempted in patients who are non-surgical candidates at the time of their admission but may be surgical candidates in the future. Alternatively, EUS-GBD is performed in patients with AC who will never be surgical candidates even once their acute illness resolves. Conversion from one endoscopic modality to the other was attempted in cases where one previously failed due to technical reasons. This includes issues such as the presence of large volume ascites, malignant obstruction, major papilla deformity, and a contracted gallbladder which could negatively impact an ET-GBD or EUS-GBD procedure. A flow chart diagram describing our approach to selecting ET-GBD or EUS-GBD techniques is described in **Figure 1.**

This approach is similar to that of previously published expert opinions regarding the non-operative management of AC.[10]

*DSET-GBD Procedure:* The DSET-GBD is a procedure conducted during ERCP. Typically, ERCP is performed using a 0.035-inch hydrophilic wire (Navipro, Boston Scientific, Marlborough MA). The cystic duct is identified through cholangiogram or cholangioscopy, and a wire is passed into the cystic duct using a sphincterotome, balloon catheter, or via a cholangioscope. The cystic duct is dilated using a 4 mm biliary dilating balloon (Hurricane, Boston Scientific, Marlborough MA). A cytology brush (Rx Cytology Brush, Boston Scientific, Malborough MA) is then advanced over the wire, across the cystic duct, and into the gallbladder. The brush is then removed leaving both the cytology sheath and the original guidewire in place. A second wire, usually a long 0.025-inch guidewire (Visiglide, Olympus America Inc., Lehigh Valley, PA), is passed into the gallbladder through now empty brush channel. The cytology brush sheath is then removed, leaving two wires in the gallbladder. A 7 Fr double pigtail plastic stent is then deployed with the proximal pigtail in the gallbladder and the distal pigtail in the duodenum. Stent lengths in this study were 20 cm (Contour, Boston Scientific, Malborough MA), 15 cm, and 12 cm. The cystic duct is dilated again with a 4 mm balloon over the second wire, and a second 7 Fr stent is advanced into the gallbladder and deployed (**Video 1**). If only one stent was placed during the index procedure, the patient returned within 3-6 months for a second stent placement. If two stents were placed during the index procedure, the patient was considered to have received destination therapy, and the stents were left in place indefinitely.

*EUS-GBD Procedure:* EUS-GBD is performed using a cautery-enhanced LAMS (AXIOS, Boston Scientific, Malborough MA) and can be conducted via a transgastric (cholecystogastrostomy) or transduodenal (cholecystoduodenostomy) approach. The approach is left to the discretion of the endoscopist and is usually determined by which location allows for an adequate window to access the gallbladder. The procedure involves placing various sizes of LAMS within the gallbladder. A double pigtail coaxial stent is then placed within the LAMS itself. Most often the stents are left in place indefinitely. Follow up procedures with lithotripsy and stone removal are usually not attempted.

2.3 Outcomes:

The primary outcome of this study was the rate of recurrent cholecystitis between DS ET-GBD and EUS-GBD within 6 months after the index procedure. The secondary outcome was unplanned reintervention. Tertiary outcomes were rates of technical success, immediate clinical success, adverse events (which were graded as mild, moderate, or severe), and all-cause mortality within 30 days of the procedure. Technical success was defined as the successful placement of at least one transcystic stent in the ET-GBD group or LAMS into the gallbladder in the EUS-GBD group. Immediate clinical success was defined as successful discharge from the hospital after the resolution of symptoms consistent with cholecystitis. DSET-GBD clinical success was only measured for patients who received two transcystic stents during the index procedure, whereas the rate of recurrent acute cholecystitis was measured for all patients who eventually had two transcystic stents placed. Patients who expired during the follow-up period for issues unrelated to cholecystitis were not evaluated for the primary outcome.

2.4 Statistical analyses:

Demographic and clinical variables are reported as percentages or median with interquartile range (IQR) and were compared between groups using chi-squared and Mann-Whitney U tests, as appropriate. The association between procedure type and outcome was assessed in two ways. First, associations were assessed in the baseline cohort using univariable logistic regression and multivariable logistic regression adjusting for age. Next, we evaluated for association between the procedure type and the primary outcome in a propensity matched cohort. Propensity score matching (PSM) was performed using several methods: nearest-neighbor, optimal, and full matching. The balance between groups was evaluated using standardized mean differences (SMD). Covariate balance before and after matching was assessed using SMDs and visualized with Love plots. Among the different matching techniques, full matching provided the best covariate balance which is a method that uses all control and treated units but applies weights to balance the covariates across the groups. After matching, two logistic regression models were run adjusting only for covariates with SMD > 0.25 to address residual imbalance. The strength of associations are reported as odds ratios (OR) with 95% confidence intervals (CI). All analyses were conducted using R. A p-value of $<0.05$ was indicative of a significant difference.

**Results:**

3.1 Patient Overview:

In total, 116 patients underwent 129 procedures (56 EUS-GBD procedures and 73 ET-GBD) procedures at our institutions during the study period. Technical success with the placement of ≥1 stent was achieved in 49 of 56 procedures (87.5%) where EUS-GBD was attempted and in 63 of 73 procedures (86.3%) where ET-GBD was attempted (p=1.000).

Patients who underwent successful EUS-GBD (n=49) were significantly older than patients who underwent successful ET-GBD (n=63) (median 79 years old vs. 70 years old, p <0.001). Co-morbidities including chronic obstructive pulmonary disease (p<0.001), congestive heart failure (p=0.037), and pancreaticobiliary malignancy (p=0.010) were more common in the EUS-GBD group while cirrhosis was more common in the ET-GBD group (p=0.018). There was a trend between ET-GBD and prior failed attempt at CCY (12.7% vs. 1.9% p=0.076), but no difference in prior percutaneous gallbladder drainage (17.9% vs. 9.1%, p=0.348). Demographics for patients with successful EUS-GBD or ET-GBD procedures are reported in **Table 1.**

3.2 Procedure details:

Reasons for technical failure in the EUS-GBD group (n=7) included contracted gallbladders (n=5) and the presence of ascites (n=2). The reasons for technical failure in the ET-GBD group (n=10) included impacted cholelithiasis (n=4), malignant obstruction (n=2), duodenal stenosis (n=1), and severe angulation / tortuous cystic duct (n=3).

Of the 63 patients that successfully underwent ET-GBD, 36 patients (57.1%) had two stents placed during the index procedure, and 27 patients (42.9%) had one stent placed during the index procedure. Cholangioscopy was used in 29.4% of the ET-GBD procedures. Of the 27 patients with one stent placed during the index procedure, 15 (55.5%) patients had a second transcystic stent placed during a follow up procedure. On average, a second transcystic stent was placed within 6 months of the index procedure.

Ultimately, 51 of the 63 ET-GBD patients (80.9%) successfully underwent DSET-GBD. Of the 12 ET-GBD patients who were only able to have one stent placed, 7 (58.3%) went on to CCY,

and 5 (41.6%) required routine stent exchange as two transcystic stents were never able to be placed (**Figure 2**).

For the patients undergoing DSET-GBD, 7 Fr x 20 cm double pigtail stents were placed 74.5% of the time (**Table 2).** In the EUS-GBD group, 38 patients (77.6%) underwent cholecystoduodenostomy, and 11 patients (22.4%) underwent cholecystogastrostomy. A 10 mm x 10 mm LAMS was placed in 37 patients (75.5%) and 35 (71.4%) had coaxial double pigtail placement at the time of the index procedure. Most coaxial pigtails were 7Fr x 4cm (**Table 2**).

3.3 Outcomes:

Immediate clinical success with resolution of AC was achieved in 98.1% of patients who successfully underwent EUS-GBD group and 100% of the patients who successfully underwent DSET-GBD during the index procedure. Thirty-day mortality was lower in patients undergoing ET-GBD compared to EUS-GBD (2.0% vs. 12.2%), but this was not significant on age-adjusted analyses (OR 0.17, 95% CI 0.02-1.55, p=0.117). The causes of death in the EUS-GBD group included septic shock (n = 1), out of hospital cardiac arrest (n = 2), death from underlying medical comorbidities (n = 2), and unknown causes (n = 1). In the ET-GBD group, one patient died from cardiac arrest. None of the deaths in this study were thought to be procedure related. Only one patient in the EUS-GBD group experienced an adverse event related to the procedure including a bile leak requiring intensive care admission.

3.4 Primary and secondary outcome:

The rate of recurrent cholecystitis did not differ in patients who underwent EUS-GBD and DEST-GBD (5.3% vs 8.2%, respectively; p = 0.692). A similar proportion of patients who underwent EUS-GBD and ET-GBD required an unplanned repeat procedure (8.2% vs. 10.0%, p-1.000). In the propensity matched cohort, multivariable logistic regression revealed no association between procedure type and unscheduled repeat procedure (OR **1.75, 95% CI 0.32-10.9, p=0.514**) or recurrent cholecystitis at 6 months (OR **1.26, 95% CI 0.16-10.8, p=0.20**) on adjusted analyses.

**Discussion**

Endoscopic gallbladder drainage has emerged as an alternative method to treat AC for patients who are not surgical candidates. Despite this, it remains unclear which endoscopic technique is best for managing AC. Published expert opinions have recommended EUS-GBD ahead of ET-GBD for the management of AC.[10] These opinions were based on prior research that demonstrated that EUS-GBD has lower rates of recurrent AC than ET-GBD. However, most comparative studies evaluated ET-GBD patients who only have a single transcystic stent placed.[11] Importantly, a study *by Storm et al*. demonstrated that patients undergoing DSET-GBD have much lower rates of recurrent AC.[7] Our study is the first to compare outcomes for patients undergoing EUS-GBD and DSET-GBD. In our study, our results show that EUS-GBD and DSET-GBD have similarly high rates of technical success and clinical success while maintaining a low incidence of adverse events and recurrent cholecystitis.

The outcomes from this study are quite different than what has been reported previously when EUS-GBD and ET-GBD have been compared. A study by *Siddiqui et al*. noted that patients undergoing EUS-GBD had significantly fewer instances of recurrent AC compared to ET-GBD, which may be explained by the patient population which primarily studied patients undergoing single transcystic stent placement.[4] Single transcystic stents placed into the gallbladder are likely to occlude over the long-term which can subsequently result in AC. When two transcystic stents are placed, bile can drain between the stents even if they become occluded, thus recurrent AC should be less common. This principle is similar to EUS-guided drainage of pancreatic pseudocysts, whereby the placement of two stents facilitates drainage better than a single stent.[12]

In the DSET-GBD group in this study, there were four events of recurrent AC. Two of these events occurred in patients in patients with prior biliary manipulation (e.g. PT-GBD). Our theory is that prior attempts at gallbladder manipulation increases the risk for cystic duct scarring which could limit the benefit of the DSET-GBD. Otherwise, DSET-GBD offers advantages such as the preservation of native anatomy, and simultaneous clearance of concomitant choledocholithiasis. Importantly, DSET-GBD is technically challenging. In our cohort, only 80.9% of patients undergoing ET-GBD could have two stents placed. Although DSET-GBD is difficult to perform,

DSET-GBD presents a viable alternative with favorable outcomes and performs well in situations where EUS-GBD is contraindicated, such as instances of cirrhotic patients with large-volume ascites.

Our study has several limitations. Inherent shortcomings arise from its retrospective design, which introduces selection bias, as the choice of endoscopic gallbladder drainage over alternative modalities was determined on a case-by-case basis by a multidisciplinary team of surgeons, interventional radiologists, and gastroenterologists. It is worth noting that patients who underwent EUS-GBD were significantly older compared to patients who underwent ET-GBD, likely because this approach is favored in non-surgical patients. The ET-GBD group included patients considered to never be surgical candidates as well as those who were not surgical candidates at the time of their presentation but could potentially be surgical candidates in the future. Additionally, it is important to consider that our procedures were conducted at high-volume centers and the technical success rate and safety profile of endoscopic gallbladder drainage observed in our study may not be generalizable to all healthcare centers.

Rates of acute cholecystitis continue to rise along with an aging population. Endoscopic modalities for gallbladder drainage have been proven as safe, feasible, and effective. We present data demonstrating DS ET-GBD has similarly low rates of recurrent acute cholecystitis compared to EUS-GBD. DS ET-GBD adds another technique to the endoscopists' arsenal for the management of AC in patients who are unable to undergo laparoscopic CCY while having the added benefit of maintaining future surgical candidacy. A randomized controlled trial should be considered to further demonstrate the comparative efficacy of EUS-GBD and DSET-GBD.

**Figures and Tables Legends**

Table 1: Demographics and clinical characteristics of patients that successfully underwent EUS-GBD or ET-GBD.
*EUS-GBD = endoscopic ultrasound-guided gallbladder drainage; ET-GBD = endoscopic transpapillary gallbladder drainage; PT-GBD = percutaneous cholecystostomy; Lap CCY = laparoscopic cholecystectomy; Open CCY = open cholecystectomy; T2DM = type 2 diabetes; COPD = chronic obstructive pulmonary disease; CHF=congestive heart failure.*
*1Missing values 32 (n*=17 EUS; n=15 ETGBD)

Table 2: Procedural detail and stent types for successful procedures (a) DSET ET-GBD and (b) EUS-GBD (a) Types of stents placed during dual transcystic stent endoscopic transpapillary gallbladder drainage procedure. (b) Lumen apposing metal stent frequency and stent size, and coaxial pigtail placement frequency and tube size placed during endoscopic-ultrasound guided GBD.

Table 3: Outcomes based on intervention from the unmatched study cohort, adjusted for patient age.

Table 4: Association between procedure and primary outcomes in propensity matched cohorts Multivariable logistic regression, adjusted for variables with SMD >0.25 (age, hypertension, Tokyo criteria). Odds ratios represent risk of outcome in patients with ET-GBD compared to EUS-GBD (reference).
)*1* OR = Odds Ratio, CI = Confidence Interval

**Supplementary data**

Supplemental Table 1. Table demonstrating logistic regression analysis for independent variables associated with need for an unplanned reintervention.

Supplemental Table 2. Table demonstrating logistic regression analysis for independent variables associated with need for recurrent cholecystitis at 6 months.

Supplemental Figure. Image of ERCP with double transcystic stent placement.

Video 1: Endoscopic transpapillary gallbladder drainage video describing tools and techniques for successful dual transcystic stent placement.

Figure 1: Study protocol for management of patients with non-operative management of acute cholecystitis
*EUS-GBD = endoscopic ultrasound-guided gallbladder drainage; ET-GBD = endoscopic transpapillary gallbladder drainage; PT-GBD = percutaneous cholecystostomy.*

*ET-GBD* = endoscopic transpapillary gallbladder drainage; *EUS-GBD* = endoscopic ultrasound-guided gallbladder drainage; *PT-GBD* = percutaneous cholecystostomy tube.

Figure 2: Patient flow diagram from initial procedure to index procedure. Index procedure refers to attempted procedures that achieved technical success.
*EUS-GBD = endoscopic ultrasound-guided gallbladder drainage; ET-GBD = endoscopic transpapillary gallbladder drainage; DSET = dual transcystic stent endoscopic transpapillary gallbladder drainage; SSET single trancystic stent endoscopic transpapillary gallbladder drainage.*

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Table 1:

| Characteristic | EUS-GBD (n=49) | ET-GBD (n=63) | p-value |
|---|---|---|---|
| Age, years, median (IQR) | 79 (71-88) | 70 (55-82) | <0.001 |
| BMI, median (IQR) | 26 (23-30) | 30 (26-34) | 0.009 |
| Male, n (%) | 30 (61.2%) | 41 (65.1%) | 0.674 |
| Race/Ethnicity, n (%) | | | |
| Caucasian | 46 (93.9%) | 49 (77.8%) | 0.097 |
| African American | 1 (2.0%) | 1 (1.6%) | |
| Asian | 1 (2.0%) | 1 (1.6%) | |
| Hispanic | 1 (2.0%) | 9 (14.3%) | |
| Other | 0 (0.0%) | 3 (4.8%) | |
| Sepsis criteria met, n (%) | 20 (40.8%) | 28 (44.4%) | 0.700 |
| Calculous cholecystitis, n (%) | 23 (46.9%) | 42 (66.7%) | 0.079 |
| Not reported | 17 (34.7%) | 15 (23.8%) | |
| Tokyo Grade, n (%) | | | |
| I | 14 (28.6%) | 11 (17.5%) | 0.429 |
| II | 16 (32.7%) | 19 (30.2%) | |
| III | 14 (28.6%) | 23 (36.5%) | |
| Did not meet criteria | 5 (10.2%) | 10 (15.9) | |
| Prior interventions | | | |
| Prior PT-GBD | 2 (9.1%) | 9 (17.6%) | 0.348 |
| Failed Lap CCY | 1 (1.9%) | 8 (12.7%) | 0.076 |
| Medical Co-Morbidities, n (%) | | | |
| Hypertension | 36 (73.5%) | 39 (61.9%) | 0.197 |
| Diabetes mellitus | 21 (42.9%) | 27 (42.9) | 1.000 |
| COPD | 15 (30.6%) | 4 (6.3%) | <0.001 |
| CH | 15 (30.6) | 9 (14.3) | 0.037 |
| Malignancy | 10 (20.4) | 3 (4.8) | 0.010 |
| Cirrhosis | 4 (8.2%) | 16 (25.4%) | 0.018 |

Table 2

| DSET-GBD (n=51) | |
|---|---|
| **Cholangioscopy, n (%)** | 15 (29.4%) |
| **Stent size n (%)** | 51 (100%) |
| 7 Fr x 7 cm, n (%) | 2 (3.9%) |
| 7 Fr x 10 cm, n (%) | 3 (5.9%) |
| 7 Fr x 12 cm, n (%) | 6 (11.8%) |
| 7 Fr x 15 cm, n (%) | 1 (1.9%) |
| 7 Fr x 20 cm, n (%) | 38 (74.5%) |
| Other, n (%) | 1 (1.9%) |
| EUS-GBD (n=49) | |
| **Cholecystoduodenostomy, n (%)** | 38 (77.6%) |
| **LAMS placement** | 49 (100%) |
| 10 mm x 10 mm, n (%) | 37 (75.5%) |
| 15 mm x 10 mm, n (%) | 3 (6.1%) |
| 15 mm x 15 mm, n (%) | 2 (4.1%) |
| 8 mm x 8 mm, n (%) | 4 (8.2%) |
| 8 mm x 6 mm, n (%) | 3 (6.1%) |
| **Coaxial pigtail placement, n (%)** | 35 (71.4)%) |
| 7 Fr x 3 cm, n (%) | 1 (2.9%) |
| 7 Fr x 4 cm, n (%) | 20 (57.1%) |
| 7 Fr x 5 cm, n (%) | 3 (8.6%) |
| 7 Fr x 7 cm, n (%) | 7 (20.0%) |
| 7 Fr x 10 cm, n (%) | 1 (2.9%) |
| 10 Fr x 1 cm, n (%) | 1 (2.9%) |
| 10 Fr x 6 cm, n (%) | 1 (2.9%) |
| Other | 1 (2.9%) |

Table 3

| | EUS-GBD (n=49) | DSET (n=51) | P | OR | p-value |
|---|---|---|---|---|---|
| **Adverse event** | 1 (2.0%) | 0 (0%) | 0.490 | -- | -- |
| **30-day mortality** | 6 (12.2) | 1 (2.0) | 0.044 | 0.17 (0.02-1.55) | 0.117 |
| **Repeated procedure** | 4 (8.2%) | 5 (10.0%) | 1.000 | 0.99 (0.23, 4.30) | 0.989 |
| **Recurrent cholecystitis** | 2 (5.3%) | 4 (8.2%) | 0.692 | 0.90 (0.18, 4.66) | 0.904 |

Table 4: Association between procedure and primary outcomes in propensity matched cohorts

| | Unadjusted | p-value | Adjusted | p-value |
|---|---|---|---|---|
| **Repeated procedure** | **1.99 (0.44, 11.4)** | **0.358** | **1.75 (0.32, 10.9)** | **0.514** |
| **Recurrent cholecystitis** | **1.93 (0.36, 14.2)** | **0.460** | **1.26 (0.16, 10.8)** | **0.820** |

Supplemental Table 1. Table demonstrating logistic regression analysis for independent variables associated with need for an unplanned reintervention.

| **Characteristic** | **Unadjusted Models** | | | **Adjusted Model** | | |
|---|---|---|---|---|---|---|
| | **OR**[1] | **95% CI**[1] | **p-value** | **OR**[1] | **95% CI**[1] | **p-value** |
| Procedure | | | | | | |
| EUS | — | — | | — | — | |
| DSET | 1.99 | 0.44, 11.4 | 0.385 | 1.75 | 0.32, 10.9 | 0.514 |
| Age | 0.97 | 0.92, 1.02 | 0.197 | 0.96 | 0.90, 1.02 | 0.167 |
| Sex | | | | | | |
| Female | — | — | | | | |
| Male | 0.45 | 0.09, 2.06 | 0.287 | | | |
| BMI | 1.06 | 1.00, 1.15 | 0.065 | | | |
| HTN | 2.32 | 0.42, 30.6 | 0.402 | 4.40 | 0.65, 68.4 | 0.186 |
| Heart failure | 2.14 | 0.19, 12.5 | 0.443 | | | |
| Diabetes | 3.06 | 0.68, 15.7 | 0.147 | | | |
| COPD | 4.67 | 0.61, 26.0 | 0.092 | | | |
| Pancreaticobiliary Cancer | 0.47 | 0.00, 7.76 | 0.721 | | | |
| Cirrhosis | 1.01 | 0.14, 4.84 | 0.991 | | | |
| Tokyo suspicion | 0.80 | 0.30, 2.58 | 0.667 | 1.01 | 0.35, 3.53 | 0.980 |
| Prior CCY surgery | 2.03 | 0.44, 9.60 | 0.351 | | | |

[1] OR = Odds Ratio, CI = Confidence Interval

DSET=dual transcystic stents; EUS = endoscopic ultrasound; BMI = body mass index; HTN; hypertension; COPD = chronic obstructive pulmonary disease CCY=cholecystectomy

Supplemental Table 2. Table demonstrating logistic regression analysis for independent variables associated with need for recurrent cholecystitis at 6 months.

| **Characteristic** | **Unadjusted Models** | | | **Adjusted Model** | | |
|---|---|---|---|---|---|---|
| | **OR**[1] | **95% CI**[1] | **p-value** | **OR**[1] | **95% CI**[1] | **p-value** |
| Procedure | | | | | | |
| EUS | — | — | | — | — | |
| DSET | 1.99 | 0.44, 11.4 | 0.385 | 1.75 | 0.32, 10.9 | 0.514 |
| Age | 0.97 | 0.92, 1.02 | 0.197 | 0.96 | 0.90, 1.02 | 0.167 |
| Sex | | | | | | |
| Female | — | — | | | | |
| Male | 0.45 | 0.09, 2.06 | 0.287 | | | |
| BMI | 1.06 | 1.00, 1.15 | 0.065 | | | |
| HTN | 2.32 | 0.42, 30.6 | 0.402 | 4.40 | 0.65, 68.4 | 0.186 |
| Heart failure | 2.14 | 0.19, 12.5 | 0.443 | | | |
| Diabetes | 3.06 | 0.68, 15.7 | 0.147 | | | |
| COPD | 4.67 | 0.61, 26.0 | 0.092 | | | |
| Pancreaticobiliary Cancer | 0.47 | 0.00, 7.76 | 0.721 | | | |
| Cirrhosis | 1.01 | 0.14, 4.84 | 0.991 | | | |
| Tokyo Suspicion | 0.80 | 0.30, 2.58 | 0.667 | 1.01 | 0.35, 3.53 | 0.980 |
| Prior CCY surgery | 2.03 | 0.44, 9.60 | 0.351 | | | |

[1] OR = Odds Ratio, CI = Confidence Interval

DSET=dual transcystic stents; EUS = endoscopic ultrasound; BMI = body mass index; HTN; hypertension; COPD = chronic obstructive pulmonary disease CCY=cholecystectomy

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