

# Comparison of long-term outcomes of endoscopic ultrasound-guided hepaticogastrostomy and choledochoduodenostomy for distal malignant biliary obstruction: a multicenter retrospective study

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## Abstract

**Background:** Endoscopic ultrasound-guided biliary drainage (EUS-BD), classified as choledochoduodenostomy (CDS) and hepaticogastrostomy (HGS), is a feasible and effective alternative for distal malignant biliary obstruction (MBO) in failed endoscopic retrograde cholangiopancreatography. However, the preferred technique for better outcomes has not yet been evaluated.

**Objectives:** We compared the long-term outcomes between the techniques.

**Design:** Retrospective comparative study.

**Methods:** We reviewed consecutive patients who underwent EUS-CDS or EUS-HGS with transmural stent placement for distal MBO between 2009 and 2022. The primary outcome was the stent patency. The secondary outcomes were technical and clinical success, adverse events (AEs) of each technique, and independent risk factors for stent dysfunction.

**Results:** In all, 115 patients were divided into EUS-CDS ( $n=56$ ) and EUS-HGS ( $n=59$ ) groups. Among them, technical success was achieved in 98.2% of EUS-CDS and 96.6% of EUS-HGS groups. Furthermore, clinical success was 96.4% in EUS-CDS and 88.1% in EUS-HGS groups, without significant difference ( $p=0.200$ ). The mean duration of stent patency for EUS-CDS was 770.3 days while that for EUS-HGS was 164.9 days ( $p=0.010$ ). In addition, the only independent risk factor for stent dysfunction was systematic treatment after EUS-BD [hazard ratio and 95% confidence interval 0.238 (0.066–0.863),  $p=0.029$ ]. The incidence of stent dysfunction of EUS-HGS was higher than EUS-CDS (35.1% *versus* 18.2%, 0.071), despite no significant differences even in late AEs.

**Conclusion:** In distal MBO, EUS-CDS may be better than EUS-HGS with longer stent patency and fewer AEs. Furthermore, systematic treatment after EUS-BD is recommended for the improvement of stent patency.

**Keywords:** endoscopic ultrasound, hepatico-gastrostomy, choledochoduodenostomy, biliary obstruction, patency

Received: 26 November 2023; revised manuscript accepted: 27 February 2024.

*Ther Adv Gastroenterol*

2024, Vol. 17: 1–13

DOI: 10.1177/  
17562848241239551

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## Introduction

Since the first announcement of endoscopic ultrasound-guided biliary drainage (EUS-BD)<sup>1</sup> in 2001, its indication has been expanding from rescue modality in cases of failed endoscopic retrograde cholangiopancreatography (ERCP) to primary drainage for distal malignant biliary obstruction (MBO).<sup>2-5</sup> Among various techniques, EUS-BD with transmural stent placement can be classified into choledochoduodenostomy (CDS) through the duodenal route and hepaticogastrostomy (HGS) through the gastric route. In EUS-CDS, the extrahepatic duct (EHD) and duodenum are anastomosed, whereas a fistula between the intrahepatic bile duct (IHD) and the stomach is created in EUS-HGS. Although a recent meta-analysis<sup>6</sup> reported similar efficacy and safety with high technical and clinical success in both the approaches and these two approaches may theoretically have different indications, most experts consider EUS-CDS to be easier and safer and thus recommend it as the first approach for EUS-BD especially in distal MBO.

The greatest advantage of EUS-CDS is the anatomical approximation between EHD and duodenum and the larger diameter of the target duct for easy puncture, which can result in higher technical success.<sup>1,7</sup> In a recent meta-analysis, Amato *et al.*<sup>8</sup> demonstrated that the pooled rates of technical success were 94.8% for lumen-apposing metal stents and 92.7% for self-expandable metal stents (SEMS), respectively.<sup>8</sup> Contrarily, EUS-HGS can boost its advantages in cases, which underwent failed ERCP because of surgically altered anatomy or gastric outlet obstruction (GOO).<sup>9,10</sup> However, despite the theoretical benefits, echoendoscopists can encounter difficulty in the puncture of non-dilated IHD. In addition, the long distance between the stomach and the IHD through hepatic parenchyma can lead to difficulty in tract dilation and even procedure-related adverse events (AEs).<sup>11</sup> Another big issue is the risk of stent migration into the peritoneal cavity due to movement of the liver during respiration and frequent peristalsis of the stomach.<sup>12</sup>

To date, despite the unique theoretical advantages of both approaches with similar technical success, there are only a few reports comparing the clinical efficacy and safety of EUS-CDS and EUS-HGS in distal MBO. Given these circumstances, we aimed to compare the clinical outcomes and patency between the two approaches

and determine which technique is associated with better outcomes.

## Methods

### *Patients*

This was a multicenter retrospective comparative study conducted at seven medical centers as members of the Research Group for Endoscopic Ultrasound in The Korean Society of Gastrointestinal Endoscopy (KSGE). Inclusion criteria were consecutive inpatients who underwent EUS-BD with transmural stent placement for distal MBO. Patients who underwent primary EUS-BD without any attempt at ERCP were also included, as well as those who underwent rescue intervention after failed ERCP. However, patients who underwent EUS-HGS with antegrade stent placement using the rendezvous approach combined with transmural stenting were excluded. Demographic, clinical, and endoscopic data were extracted from the computerized clinical information system for the previous 13 years (from October 2009 through August 2022) according to the two groups, EUS-CDS and EUS-HGS. Retrospective data collection for all included patients was performed from the initial procedure until death or the final follow-up. As a retrospective analysis, the study was conducted in accordance with the protocol of the Declaration of Helsinki and was approved by the Institutional Review Board of the Ethics Committee of the representative hospital (2022-08-012-001 for Hallym University Dongtan Sacred Heart Hospital), and the need for informed consent was waived. In addition, the reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.<sup>13</sup>

### *Endoscopic procedures for EUS-CDS and EUS-HGS*

All procedures were performed by eight expert endosonographers according to standard protocols. As the diagnosis of distal MBO was established, treatment with appropriate antibiotics, bowel rest, and intravenous fluids was administered to all patients.<sup>14</sup> EUS-BD was also performed under sedation using intravenous administration of midazolam, propofol, and meperidine.<sup>15</sup>

**EUS-CDS.** After identification of EHD in the duodenal bulb using a linear echoendoscope, puncture was performed using a 19-gauge standard fine-needle aspiration needle unmounted with a stylet to avoid puncturing the cystic duct. Thereafter, a contrast medium was injected to visualize the EHD under fluoroscopy. Then, a 0.025- or 0.035-inch guidewire was inserted through the needle into the bile duct. After the withdrawal of the needle, a standard catheter was inserted over the guidewire for track dilation. Then, a 4-mm balloon catheter was inserted over the guidewire, and track dilation was performed. The balloon catheter could be used initially without prior attempts using a standard catheter at the discretion of the endoscopist. If the catheter could not be inserted easily, a cystotome or needle-type knife was applied.<sup>16</sup> Finally, a metal or plastic stent was inserted into the EHD from the duodenum.

**EUS-HGS.** For EUS-HGS, the left IHD was punctured from the stomach, whereas the right IHD was punctured from the duodenum. After the injection of the contrast medium, the guidewire was inserted into the IHD with a maximal effort to pass across the biliary stricture to stabilize the guidewire. After withdrawal of the needle, tract dilation was performed using a standard catheter first and a sequential balloon catheter, or eventually a needle-type knife or cystotome if resistance to advancement of the standard catheter or balloon catheter was apparent. When sufficient tract dilation was achieved, a plastic or metal stent was inserted and deployed between the IHD and stomach. A conventional fully covered and modified partially covered SEMS with a bidirectional anti-migrating system was used in our study to prevent leakage alongside the stent, as well as to enable easy removal and prevention of tissue growth. The length of the stent was determined by approximating the distance between the IHD and bowel with an extra length (approximately 20 mm) on both sides.

#### *Definitions of outcomes*

The main outcomes evaluated in the study included (1) stent patency according to EUS-BD technique; (2) technical and clinical success rates of each technique for EUS-BD; (3) independent risk factors for stent dysfunction; (4) early AEs within 2 weeks after EUS-BD including

hemorrhage, perforation, pneumoperitoneum, or bile peritonitis; and (5) late AEs 2 weeks after EUS-BD, including bile peritonitis, abscess, or infected biloma.<sup>17</sup>

Technical success was defined as the successful placement of a transmural stent into the BD, as determined by smooth bile drainage endoscopically accompanied by appropriate positioning of the stent radiologically. Clinical success was defined as a decrease in total bilirubin level either to normal or by  $\geq 50\%$  within 2 weeks of EUS-BD.<sup>16</sup> Following the procedure, patients were monitored until follow-up loss or death, with evaluations focused on AEs and the patency of the stent. Assessments were conducted on the next day, as well as at 7, 14, 30, 60, and 90 days post-procedure, during scheduled consultations for clinical assessment and laboratory analysis. Early and late AEs were those occurring within 2 weeks of stent placement and later, respectively. Bile peritonitis after EUS-BD refers to the leakage of bile juice into the peritoneal cavity, resulting in inflammation and infection. This condition may manifest as signs of peritoneal irritation, accompanied by the identification of newly developed ascites or localized fluid collection through imaging modalities such as CT scans.<sup>18</sup> Stent patency was defined as the interval from the index procedure of EUS-BD to the first stent dysfunction with recurrent obstructive symptoms and signs accompanied by biliary obstruction and dilatation of the bile duct on imaging modalities.<sup>5</sup> Patients who died without stent dysfunction were considered censored. The survival period was calculated as the interval between EUS-BD stent placement and death.

#### *Statistical analysis*

Data are presented as frequency with proportion for categorical variables or means with standard deviation (SD) and medians with interquartile range (IQR) for continuous variables. For the comparison of categorical data, the  $\chi^2$  test was used as indicated, while the Student's *t*-test was used to compare continuous variables. Stent patency and patient survival were calculated using the Cox proportional hazards model, and the log-rank test was used to compare stent patency and survival curves, accounting for censored data. All reported *p* values were two-sided, and *p* values  $< 0.05$  were considered statistically significant.

All statistical analyses were conducted using R statistical software (version 4.0.2; R Foundation for Statistical Computing, Vienna, Austria).

## Results

### *Study population and baseline characteristics*

During the study period, 187 patients who underwent EUS-BD (EUS-CDS or EUS-HGS) with transmural stent placement for MBO were initially assessed for eligibility. Among these, 16 patients who underwent only antegrade stent placement using the rendezvous approach through EUS-HGS were excluded. Furthermore, 55 patients who underwent EUS-HGS for hilar MBO were also excluded. Finally, one patient who underwent EUS-HGS with antegrade stent placement using the rendezvous approach combined with transmural stenting was excluded. As a result, the remaining 115 patients with EUS-BD with transmural stent placement were included in the analyses and divided into the EUS-CDS ( $n=56$ ) and EUS-HGS ( $n=59$ ) groups according to the EUS-BD technique (Figure 1).

Table 1 presents the baseline characteristics of the enrolled patients according to group. The mean age and proportion of men were 72.5 years and 39.3% in the EUS-CDS group, and 72.0 years and 55.0% in the EUS-HGS group, respectively. In both groups, pancreatic cancer was the most common cause of distal MBO (EUS-CDS, 75.0%; EUS-HGS, 67.8%), while cholangiocarcinoma and gallbladder cancer were more common in EUS-HGS than EUS-CDS group. The proportion of primary EUS-BD without any attempt at ERCP did not differ between the groups (EUS-CDS *versus* EUS-HGS: 25.0% *versus* 37.3%,  $p=0.223$ ). The most common reason for EUS-CDS was cases of failed ERCP (57.1%), while the most common indication for EUS-HGS was GOO (49.2%). In particular, the proportion of acute cholangitis in the index procedure was significantly higher in the EUS-HGS group than in the EUS-CDS group. However, the proportion of enteral stent placement for GOO, presence of ascites, and systematic treatment after EUS-BD did not differ between groups.

### *Endoscopic findings between the groups*

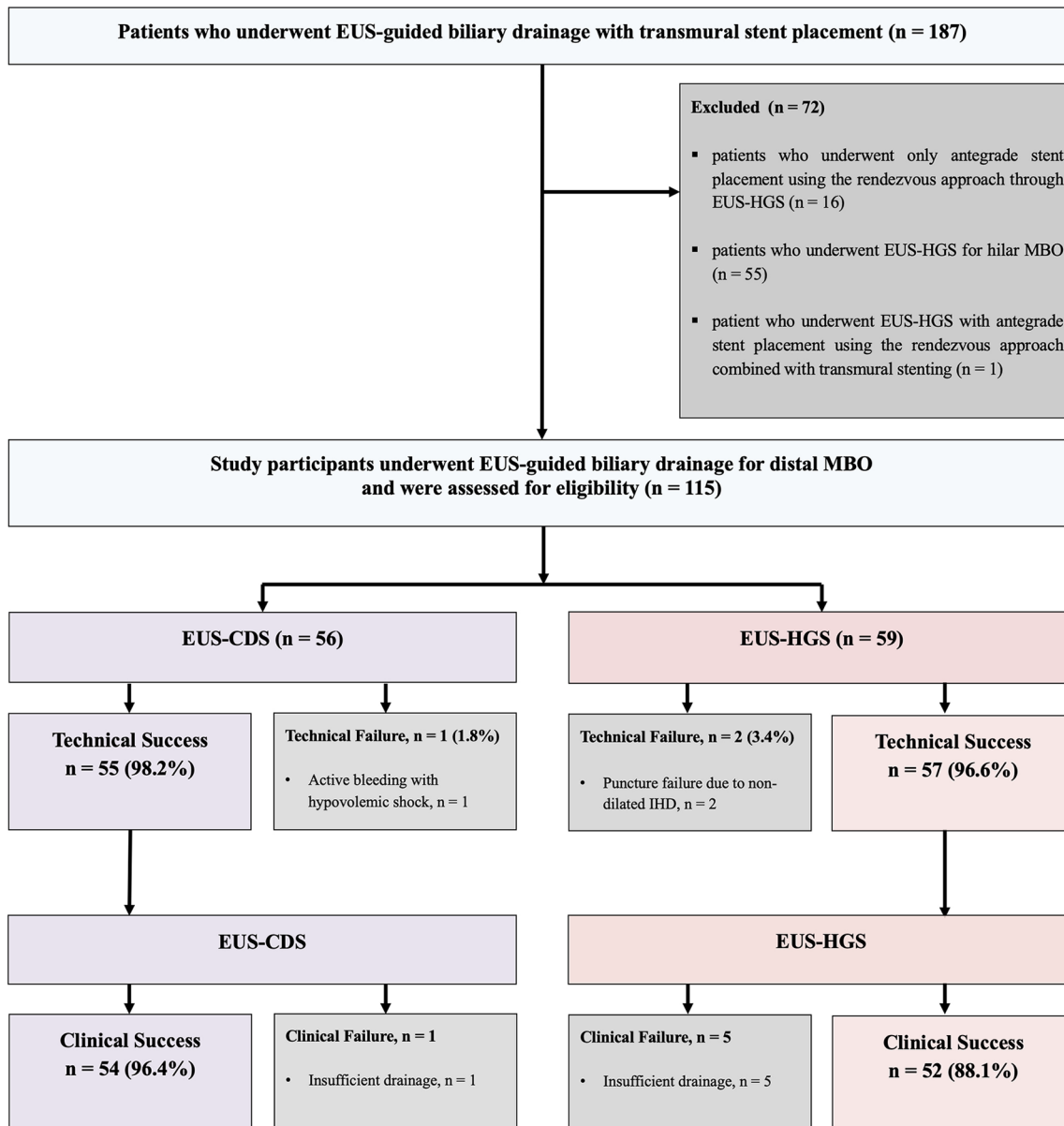
Supplemental Table S1 shows the endoscopic findings of EUS-BD in the patients with technical

success. SEMS was used in the majority of the EUS-CDS group (90.9%), while it was used in 53.4% of the EUS-HGS group. The diameter of the targeted duct was smaller in the EUS-HGS group than in the EUS-CDS group (EUS-HGS *versus* EUS-CDS, 6.8 *versus* 15.7 mm,  $p<0.001$ ) while the distance from needle tip to targeted duct was significantly shorter in the EUS-CDS group (1.1 *versus* 2.3 cm,  $p<0.001$ ). The most common target duct in the EUS-HGS group was B3. The balloon catheter was mainly used for tract dilation in the EUS-HGS group, while various devices were used in the EUS-CDS group. In addition, the stent length was significantly longer in the EUS-HGS than in the EUS-CDS group (10.8 *versus* 5.5 cm,  $p<0.001$ ). Also, the total procedure time was shorter in the EUS-CDS than in the EUS-HGS group with a significant difference ( $15.7 \pm 8.3$  min *versus*  $19.1 \pm 9.1$  min,  $p=0.045$ ). In the EUS-HGS group, one patient underwent simultaneous antegrade stent placement through the tract for EUS-HGS and transmural stent placement.

### *Comparison of clinical outcomes and AEs between the groups*

Technical success rates were 98.2% (55/56) in the EUS-CDS group and 96.6% (57/59) in the EUS-HGS groups (Table 2). The reason for technical failure in two patients from the EUS-HGS group was non-dilated IHD, while one case in the EUS-CDS group failed due to active bleeding at the puncture site. All patients with technical failures underwent rescue percutaneous transhepatic BD. A total of 107 patients showed clinical success rates of 96.4% and 88.1% in the EUS-CDS and EUS-HGS groups with significant differences ( $p=0.200$ ), respectively.

Regarding early AE, one case of stent dysfunction was noted in the EUS-CDS group, whereas two cases were noted in the EUS-HGS group. Three cases of bile peritonitis, one case of bleeding, and seven cases of pneumoperitoneum occurred in the EUS-CDS group. In the EUS-HGS group, four cases of bile peritonitis and three cases of pneumoperitoneum occurred. In terms of late AEs, one case of delayed bleeding was noted in the EUS-CDS group, while two cases of bile peritonitis and two cases of infected biloma due to stent-related occlusion of the other IHD beside the target duct occurred in the EUS-HGS group. Multivariate analysis using a logistic regression



**Figure 1.** Study flow diagram.

EUS-CDS, endoscopic ultrasound-guided choledochoduodenostomy; EUS-HGS, endoscopic ultrasound-guided hepaticogastrostomy; IHD, intrahepatic bile duct; MBO, malignant biliary obstruction.

model was performed for overall AEs except stent dysfunction (Supplemental Table S2). The only independent risk factor for overall AEs in the population with technical success was the previous drainage procedure [odds ratio and 95% confidence interval (CI) 0.23 (0.03–0.89),  $p=0.049$ ].

Overall, 10 cases of stent dysfunction were noted in the EUS-CDS group, and 18 cases were noted in the EUS-HGS group. Among these, complete

stent migration occurred in one patient in the EUS-CDS group and three patients in the EUS-HGS group. Furthermore, stent obstruction and sludge/food scraps were more common in the EUS-HGS group than EUS-CDS group (EUS-CDS *versus* EUS-HGS: 14.3% *versus* 18.6%,  $p=0.794$  and 3.6% *versus* 8.5%,  $p=0.529$ , respectively). The revision for any stent dysfunction was performed in 10 patients (18.2%) in the EUS-CDS group and 20 patients (35.1%) in the



**Table 1.** Baseline characteristics of enrolled patients.

Variable	EUS-CDS, n=56	EUS-HGS, n=59	p Value
Age (years), mean ± SD	72.5 ± 12.7	72.0 ± 11.0	0.822
Male gender, n (%)	22 (39.3%)	33 (55.0%)	0.110
BMI, mean ± SD	21.8 ± 3.8	20.6 ± 3.0	0.060
Cause of biliary obstruction, n (%)			0.507
Pancreatic cancer	42 (75.0%)	40 (67.8%)	
Cholangiocarcinoma	4 (7.1%)	7 (11.9%)	
Gallbladder cancer	0 (0.0%)	2 (3.4%)	
Ampullary cancer	4 (7.1%)	5 (8.5%)	
Duodenal cancer	0 (0.0%)	1 (1.7%)	
Other metastatic cancer	6 (10.7%)	4 (6.8%)	
Reason of procedure, n (%)			0.545
Failed ERCP	32 (57.1%)	28 (47.5%)	
Gastric outlet obstruction	23 (41.1%)	29 (49.2%)	
Insufficient drainage	1 (1.8%)	2 (3.4%)	
Indication of procedure, n (%)			0.223
Primary intervention	14 (25.0%)	22 (37.3%)	
Rescue intervention	42 (75.0%)	37 (62.7%)	
Previous drainage			0.009
Biliary stent only	9 (16.1%)	24 (40.7%)	
Percutaneous drainage only	4 (7.1%)	4 (6.8%)	
Both	0 (0.0%)	2 (3.4%)	
None	43 (76.8%)	29 (49.2%)	
Presence of cholangitis on procedure, n (%)	31 (55.4%)	45 (76.3%)	0.030
Presence of ascites, n (%)	5 (8.9%)	14 (23.7%)	0.059
Pyloric/duodenal stent placement, n (%)	22 (39.3%)	29 (49.2%)	0.381
Initial Lab findings (median [IQR])			
Initial WBC, /μL	7975.0 [6415.0–11,545.0]	8400.0 [5620.0–11,685.0]	0.687
Initial hemoglobin, g/dL	10.3 [9.1–11.1]	10.0 [9.0–11.0]	0.560
Initial platelet counts, ×10 <sup>3</sup> /μL	269.0 [200.0–351.0]	232.0 [187.0–314.0]	0.177
Initial AST, IU/L	112.5 [68.5–177.0]	80.0 [42.5–148.0]	0.050
Initial ALT, IU/L	95.0 [39.5–144.5]	65.0 [34.5–133.0]	0.437
Initial total bilirubin, mg/dL	6.7 [3.5–9.7]	4.6 [1.7–8.6]	0.065
Initial amylase, IU/L	66.0 [34.0–151.5]	56.5 [30.0–88.0]	0.283
CA 19-9, U/mL	349.0 [91.0–2288.0]	204.0 [42.1–1542.5]	0.251
Systematic treatment after procedure, n (%)	14 (25.0%)	23 (39.0%)	0.160

ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; ERCP, endoscopic retrograde cholangiopancreatography; EUS-CDS, endoscopic ultrasound-guided choledochoduodenostomy; EUS-HGS, endoscopic ultrasound-guided hepaticogastrostomy; IQR, interquartile range; SD, standard deviation; WBC, white blood cell.

**Table 2.** Clinical outcomes and adverse events in patients.

Variable	EUS-CDS, <i>n</i> =56	EUS-HGS, <i>n</i> =59	<i>p</i> Value
Technical success, <i>n</i> (%)	55 (98.2%)	57 (96.6%)	>0.999
Clinical success, <i>n</i> (%)	54 (96.4%)	52 (88.1%)	0.200
Early adverse events within 14 days, <i>n</i> (%)	9 (16.1%)	7 (11.9%)	0.702
Bile peritonitis	3 (5.4%)	4 (6.8%)	>0.999
Acute pancreatitis	0 (0%)	0 (0.0%)	>0.999
Hemorrhage	1 (1.8%)	0 (0.0%)	0.979
Pneumoperitoneum	7 (12.5%)	3 (5.1%)	0.280
Stent dysfunction	1 (1.8%)	2 (3.4%)	0.742
Obstruction	1 (1.8%)	0 (0.0%)	0.512
Migration	0 (0.0%)	1 (1.7%)	0.531
Sludges or food scraps	0 (0.0%)	2 (3.4%)	0.324
Unknown	1 (1.8%)	2 (3.4%)	>0.999
Late adverse events after 14 days, <i>n</i> (%)	10 (17.9%)	17 (28.8%)	0.375
Bile peritonitis	0 (0.0%)	2 (3.4%)	0.380
Focal infected biloma	0 (0.0%)	2 (3.4%)	0.380
Hemorrhage	1 (1.8%)	0 (0.0%)	0.581
Stent dysfunction	10 (17.9%)	18 (30.5%)	0.248
Obstruction	8 (14.3%)	11 (18.6%)	0.794
Migration	1 (1.8%)	3 (5.1%)	0.614
Sludges or food scraps	2 (3.6%)	5 (8.5%)	0.529
Unknown	3 (5.4%)	3 (5.1%)	0.991
Revision for stent dysfunction, <i>n</i> (%)	10 (18.2%)	20 (35.1%)	0.071
Number of revisions, median [IQR]	1 [1–1]	1 [1–2]	0.133
Duration of stent patency, days, mean (95% CI)	770.3 (475.8–1064.7)	164.9 (124.6–205.2)	0.010
Revision method			0.117
Endoscopic approach	10 (17.9%)	19 (32.2%)	
Percutaneous approach	0 (0.0%)	1 (1.7%)	
Death, <i>n</i> (%)	28 (50.0%)	31 (52.5%)	0.931
Duration of survival, days, median (95% CI)	165 (71.9–258.1)	162.0 (108.6–215.4)	0.682
Duration of survival, days, mean (95% CI)	297.3 (159.9–434.7)	401.7 (129.3–674.1)	0.682

CI, confidence interval; EUS-CDS, endoscopic ultrasound-guided choledochoduodenostomy; EUS-HGS, endoscopic ultrasound-guided hepaticogastrostomy; IQR, interquartile range.

**Table 3.** Cox proportional hazard model for stent dysfunction among patients with technical success.

Variable	Univariate analysis		Multivariate analysis	
	HR (95% CI)	p Value	HR (95% CI)	p Value
EUS-HGS ( <i>versus</i> EUS-CDS)	1.427 [0.623–3.271]	0.4004	2.023 [0.559–7.320]	0.2828
Age $\geq$ 70 years ( <i>versus</i> <70 years)	0.688 [0.317–1.496]	0.3458	0.691 [0.183–2.610]	0.5853
Male ( <i>versus</i> female)	1.241 [0.590–2.612]	0.5694	0.658 [0.216–2.006]	0.4618
SEMS ( <i>versus</i> DPPS)	1.223 [0.573–2.611]	0.6030	1.726 [0.561–5.311]	0.3411
Rescue intervention ( <i>versus</i> primary)	0.649 [0.268–1.572]	0.3384	0.512 [0.132–1.981]	0.3320
Previous drainage procedure	0.770 [0.367–1.614]	0.4886	0.513 [0.168–1.569]	0.2422
Previous cholangitis	1.692 [0.734–3.898]	0.2171	2.625 [0.830–8.310]	0.1006
Presence of ascites	1.590 [0.595–4.248]	0.3551	1.335 [0.323–5.513]	0.6901
Systematic treatment after EUS-BD	0.721 [0.573–2.611]	0.6030	0.238 [0.066–0.863]	0.0290

CI, confidence interval; DPPS, double pigtail plastic stent; EUS-BD, endoscopic ultrasound-guided biliary drainage; EUS-CDS, endoscopic ultrasound-guided choledochoduodenostomy; EUS-HGS, endoscopic ultrasound-guided hepaticogastrostomy; HR, hazard ratio; SEMS, self-expandable metal stent.

EUS-HGS group, without significant difference ( $p=0.071$ ). The median number of revisions for stent dysfunction was higher in the EUS-HGS than in the EUS-CDS group [median 1 IQR (1–1) *versus* median 1 IQR (1–2),  $p=0.133$ ] without significant difference. The mean duration of stent patency for EUS-CDS was mean 770.3 days (IQR 475.8–1064.7 days) while that of EUS-HGS was mean 164.9 days (IQR 124.9–205.2 days,  $p=0.010$ ).

A multivariate analysis using the Cox proportional hazards model was performed for stent dysfunction (Table 3). The only independent risk factor for stent dysfunction in the population with technical success was systematic treatment after EUS-BD [hazard ratio (HR) and 95% CI: 0.238 (0.066–0.863),  $p=0.0290$ ; Figure 2]. In the Kaplan–Meier plot for patients with technical success, the EUS-BD technique did not show a significant difference in stent dysfunction between EUS-CDS and EUS-HGS groups in univariate and multivariate analyses [HR: 2.023, 95% CI: (0.559–7.320),  $p=0.2828$ ] (Figure 2).

More than half of the patients (51.3%, 59/115) died by the end of the study period (Table 2). Furthermore, the median survival times were 165 (IQR: 71.9–258.1) and 162 (IQR: 108.6–215.4) days in the EUS-CDS and EUS-HGS

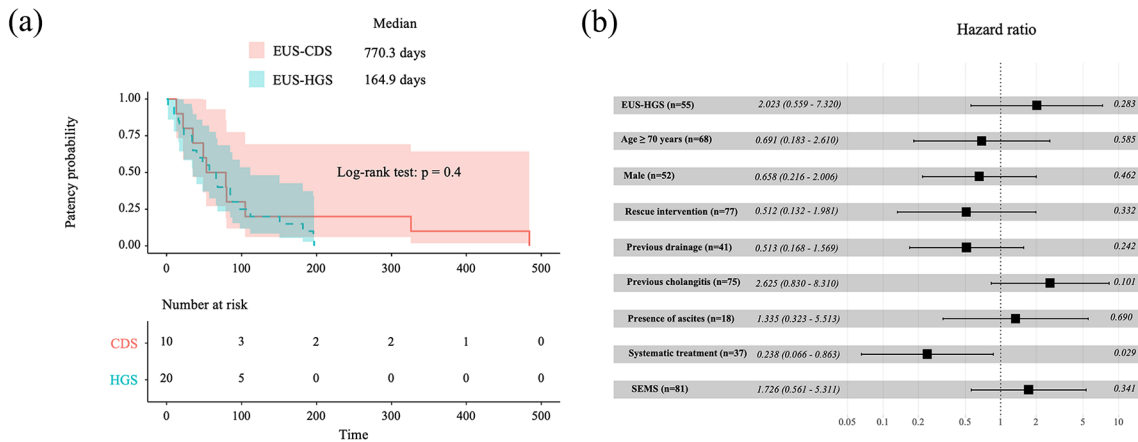
groups, respectively, as shown by per-protocol analysis.

### Discussion

The current study reported the long-term outcomes of EUS-BD in patients with distal MBO according to the interventional techniques received during the index procedure. This is the largest cohort study designed to compare EUS-CDS, which can be approached through the transduodenal tract, to EUS-HGS, which can be approached through the transgastric tract. Although both techniques were comparable with equivalent technical success, EUS-CDS showed higher clinical success accompanied by an improvement in cholestasis in the majority of patients. Furthermore, the overall late stent dysfunction occurred at a lower incidence of 17.9% in the EUS-CDS group and 28.8% in the EUS-HGS group; therefore, overall stent patency in EUS-CDS was significantly longer than that of EUS-HGS. These results are contrary to previous results from recent trials<sup>12,16,19</sup> and our belief that the patency of EUS-HGS is comparable with that of EUS-CDS.

The median duration of stent patency *via* EUS-CDS was longer than that *via* EUS-HGS in distal MBO with significant differences ( $p=0.010$ ).





**Figure 2.** Forest plot according to the Cox proportional hazard model for stent patency in the population with technical success. (a) Kaplan–Meier curve analysis revealed that the EUS-BD technique did not show a significant difference in stent dysfunction between EUS-CDS and EUS-HGS groups in univariate and multivariate analyses [HR 1.427, 95% CI [0.623–3.271],  $p=0.4004$ ]. (b) A multivariate analysis using the Cox proportional hazards model for stent dysfunction revealed that the only independent risk factor in the population with technical success was systematic treatment after EUS-BD [HR 0.238, 95% CI [0.066–0.863],  $p=0.0290$ ].

CI, confidence interval; EUS-BD, endoscopic ultrasound-guided biliary drainage; EUS-CDS, endoscopic ultrasound-guided choledochoduodenostomy; EUS-HGS, endoscopic ultrasound-guided hepaticogastrostomy; HR, hazard ratio; SEMS, self-expandable metal stent.

There is a plausible explanation that the smaller diameter of the IHD may not allow placement of large-diameter stents in EUS-HGS, whereas a larger diameter of the EHD may allow placement of a larger-diameter stent in EUS-CDS. Differences in the stent diameter may affect stent patency. Although the use of a larger covered SEMS can prevent bile leakage by complete sealing of the iatrogenic bilioenteric tract and provide longer stent patency than plastic stents, it is currently debatable whether plastic or metal stents should be placed during EUS-BD. Khashab *et al.*<sup>12</sup> reported that EUS-BD with a plastic stent showed a significantly higher incidence of cholangitis, resulting in shorter stent patency. Considering that the SEMS was placed in the majority of patients (91%) in the EUS-CDS group, the differences in stent patency between EUS-CDS and EUS-HGS may be due to the stent type, although in our study Cox proportional hazard model revealed that stent type (SEMS *versus* plastic stent) was not associated with stent patency. Contrary to ours, da Silva *et al.*<sup>20</sup> reported that there was no significant difference in terms of effectiveness and safety based on the stent type in EUS-CDS.

Our study showed similar results to those of previous single-center reports<sup>12,16,19,21</sup> in which

technical success was not statistically different between both the groups (EUS-CDS: 98.2% *versus* EUS-HGS: 96.6%,  $p > 0.999$ ). As opposed to the EHD for the puncture in EUS-CDS, the IHD is not always dilated enough for puncture, so it may be theoretically challenging to perform EUS-HGS in patients without bile duct dilation.<sup>22</sup> Along with the difficulty in puncture for non-dilated IHD, guidewire manipulation is more difficult and requires much more time than EUS-CDS. Although the technical success rate of EUS-HGS in the present study was 97%, we encountered two cases of technical failure in the EUS-HGS group as a result of difficulties in guidewire manipulation at non-dilated IHD. Contrary to theoretical belief, the initial prospective study<sup>23</sup> comparing these two approaches revealed that the technical success rate of EUS-HGS (96%) was higher than that of EUS-CDS (91%), although the difference was not statistically significant, suggesting the safety of both drainage routes when performed by experienced operators. Furthermore, they observed a slight trend favoring EUS-HGS (91.6%) over EUS-CDS (77.2%) in terms of clinical success. However, recent meta-analyses demonstrated that technical success was similar between both methods.<sup>24–26</sup> Our results were similar to those of

other reports. This may be explained by the refinement of the procedure and the increase in procedural competency as experience accumulates.<sup>6</sup>

In terms of AEs, conflicting data remains.<sup>6,19,21,24,27</sup> In two recent meta-analyses, the pooled AE of EUS-CDS was lower than that of EUS-HGS.<sup>24,28</sup> These results can be explained by possible theories that the tract of EUS-CDS is thinner and less resistant and has a close approximation between EHD and duodenum. In addition, the EHD and duodenum are relatively fixed in the retroperitoneum with less influence from respiration and peristalsis while excessive movement of the liver during respiration and peristalsis of the stomach can lead to bidirectional stent migration, resulting in fatal AEs, such as bilomas or bile peritonitis. By contrast, AE was not different between the two approaches in several randomized studies.<sup>16,27,29</sup> Similarly, a recent network meta-analysis revealed that there was no discernible difference in the AE rates across various comparisons.<sup>30</sup> In the present study, there were also no significant differences in both early and late AE between the two approaches. Different types of AE were reported between EUS-CDS and EUS-HGS, relating to technical differences in each technique. Immediate stent migration, which could lead to bile peritonitis, occurred in the EUS-HGS group in one case but not in the EUS-CDS group. Among the late AE in the present study, two cases of focal infected biloma, which occurred after EUS-HGS, were of particular interest. A focal infected biloma may be induced by branch duct obstruction by covering it during SEMS placement in IHD. Furthermore, contrary to what was expected, bile peritonitis was noted in two patients in the EUS-HGS group but not in the EUS-CDS group.

In a recent guideline, EUS-CDS has been recommended over EUS-HGS in distal MBO owing to its lower procedural AEs.<sup>31</sup> However, currently, there is no clear consensus on which method is optimal in distal MBO.<sup>19,23,25,32</sup> Based on previous reports and our experience, the therapeutic approach will be dependent on the patient's anatomy, GOO, or the presence of IHD dilatation. In patients with distal MBO, EUS-CDS can be considered prior to EUS-HGS if IHDs are not dilated. By contrast, EUS-HGS should be considered in patients with surgically altered anatomy or dilated IHD. Considering that there is no

difference in the technical success and safety between the two techniques, these approaches will be helpful for the standardization of EUS-BD, although the determination of which technique to employ, whether one over the other, the decision to use one technique over the other should be left to the discretion of the endoscopist.<sup>23</sup>

Although our study evaluated the long-term outcomes of the two techniques for EUS-BD in a large cohort, it had several limitations that might have influenced our conclusions. As this was not a randomized controlled study, the type of technique used in each patient was based on the presence of GOO, anatomical variations of the bile duct, or even the clinicians' discretion. For example, only EUS-HGS can be available in cases of failed ERCP because of surgically altered anatomy or GOO, or hilar MBO without communication between right and left IHD. Furthermore, the EUS-BD protocol was not standardized across patients. Regarding the heterogeneity in baseline characteristics, several parameters, including previous drainage, presence of cholangitis, and presence of ascites (with marginal significance), were found to be significantly different between the groups. These differences could potentially lead to misunderstandings, although it is important to note that we have adjusted for all these variables in the Cox proportional hazard model as well as logistic regression analysis. In addition, there is the possibility of incomplete data collection and potential selection bias, although great effort was made to collect accurate data according to the full medical chart review. Moreover, all procedures were performed by highly experienced endosonographers at highly specialized facilities; therefore, the results from our study cannot be generalized to facilities that are less experienced with EUS-BD. Lastly, it is essential to acknowledge that therapeutic strategies or procedural protocols may lack homogeneity over time due to ongoing technical and instrumental innovation. This stems from the fact that the present study utilized extensive historical data spanning the previous 13 years. Nevertheless, we believe that our retrospective study demonstrates the potential for real-world procedural protocols during EUS-BD.

Contrary to our belief that EUS-CDS and EUS-HGS showed similar clinical outcomes based on previous reports, EUS-CDS presented more favorable outcomes in distal MBO, including

improved stent patency. Therefore, for patients eligible for EUS-CDS, it may be a more effective treatment modality in terms of long-term effects. Further prospective randomized studies are required to compare the clinical outcomes between EUS-CDS and HGS.

## Declarations

### *Ethics approval and consent to participate*

As a retrospective analysis, the study was conducted in accordance with the protocol of the Declaration of Helsinki and was approved by the Institutional Review Board of the Ethics Committee of the representative hospital (2022-08-012-001 for Hallym University Dongtan Sacred Heart Hospital), and the need for informed consent was waived. In addition, the reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

### *Consent for publication*

Not applicable.

### *Author contributions*

**Dongwook Oh:** Data curation; Formal analysis; Methodology; Resources; Validation.

**Sung Yong Han:** Data curation; Formal analysis; Resources; Writing – original draft.

**Sang Hyub Lee:** Data curation; Formal analysis; Resources; Writing – original draft.

**Seong-Hun Kim:** Data curation; Formal analysis; Methodology; Software.

**Woo Hyun Paik:** Data curation; Formal analysis; Software.

**Hyung-Ku Chon:** Data curation; Formal analysis; Software.

**Tae Jun Song:** Data curation; Formal analysis; Software.

**Se Woo Park:** Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

**Jae Hee Cho:** Conceptualization; Methodology; Writing – original draft; Writing – review & editing.

## *Acknowledgements*

This was implemented as part of the research projects conducted by the ‘EUS-New Medical Technology Research Group’ in the Korean Pancreatobiliary Association and the ‘EUS Research Group’ in the Korean Society of Gastrointestinal Endoscopy.

## *Funding*

The authors received no financial support for the research, authorship, and/or publication of this article.

## *Competing interests*

The authors declare that there is no conflict of interest.

## *Availability of data and materials*

The data that support the findings of this study are available from the corresponding author, S.W.P., upon reasonable request.

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## Supplemental material

Supplemental material for this article is available online.

## References

1. Giovannini M, Moutardier V, Pesenti C, *et al.* Endoscopic ultrasound-guided bilioduodenal anastomosis: a new technique for biliary drainage. *Endoscopy* 2001; 33: 898–900.
2. Park DH, Koo JE, Oh J, *et al.* EUS-guided biliary drainage with one-step placement of a fully covered metal stent for malignant biliary obstruction: a prospective feasibility study. *Am J Gastroenterol* 2009; 104: 2168–2174.
3. Hara K, Yamao K, Niwa Y, *et al.* Prospective clinical study of EUS-guided choledochoduodenostomy for malignant lower biliary tract obstruction. *Am J Gastroenterol* 2011; 106: 1239–1245.
4. Park DH, Jang JW, Lee SS, *et al.* EUS-guided biliary drainage with transluminal stenting after failed ERCP: predictors of adverse events and

- long-term results. *Gastrointest Endosc* 2011; 74: 1276–1284.
5. Paik WH, Lee TH, Park DH, *et al.* EUS-guided biliary drainage versus ERCP for the primary palliation of malignant biliary obstruction: a multicenter randomized clinical trial. *Am J Gastroenterol* 2018; 113: 987–997.
  6. Uemura RS, Khan MA, Otoch JP, *et al.* EUS-guided choledochoduodenostomy versus hepaticogastrostomy: a systematic review and meta-analysis. *J Clin Gastroenterol* 2018; 52: 123–130.
  7. Hanada K, Iiboshi T and Ishii Y. Endoscopic ultrasound-guided choledochoduodenostomy for palliative biliary drainage in cases with inoperable pancreas head carcinoma. *Dig Endosc* 2009; 21(Suppl. 1): S75–S78.
  8. Amato A, Sinagra E, Celsa C, *et al.* Efficacy of lumen-apposing metal stents or self-expandable metal stents for endoscopic ultrasound-guided choledochoduodenostomy: a systematic review and meta-analysis. *Endoscopy* 2021; 53: 1037–1047.
  9. Park DH, Song TJ, Eum J, *et al.* EUS-guided hepaticogastrostomy with a fully covered metal stent as the biliary diversion technique for an occluded biliary metal stent after a failed ERCP (with videos). *Gastrointest Endosc* 2010; 71: 413–419.
  10. Giovannini M, Dotti M, Bories E, *et al.* Hepaticogastrostomy by echo-endoscopy as a palliative treatment in a patient with metastatic biliary obstruction. *Endoscopy* 2003; 35: 1076–1078.
  11. Boulay BR and Lo SK. Endoscopic ultrasound-guided biliary drainage. *Gastrointest Endosc Clin N Am* 2018; 28: 171–185.
  12. Khashab MA, Messallam AA, Penas I, *et al.* International multicenter comparative trial of transluminal EUS-guided biliary drainage via hepatogastrostomy vs. choledochoduodenostomy approaches. *Endosc Int Open* 2016; 4: E175–E181.
  13. von Elm E, Altman DG, Egger M, *et al.* The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007; 370: 1453–1457.
  14. Cho JH, Park SW, Kim EJ, *et al.* Long-term outcomes and predictors of adverse events of EUS-guided hepaticogastrostomy for malignant biliary obstruction: multicenter, retrospective study. *Surg Endosc* 2022; 36: 8950–8958.
  15. Park CH, Park SW, Nam E, *et al.* Comparative efficacy of stents in endoscopic ultrasonography-guided peripancreatic fluid collection drainage: a systematic review and network meta-analysis. *J Gastroenterol Hepatol* 2020; 35: 941–952.
  16. Minaga K, Ogura T, Shiomi H, *et al.* Comparison of the efficacy and safety of endoscopic ultrasound-guided choledochoduodenostomy and hepaticogastrostomy for malignant distal biliary obstruction: multicenter, randomized, clinical trial. *Dig Endosc* 2019; 31: 575–582.
  17. De Cassan C, Bories E, Pesenti C, *et al.* Use of partially covered and uncovered metallic prosthesis for endoscopic ultrasound-guided hepaticogastrostomy: results of a retrospective monocentric study. *Endosc Ultrasound* 2017; 6: 329–335.
  18. Kanno Y, Koshita S, Ogawa T, *et al.* EUS-guided biliary drainage for unresectable malignant biliary obstruction: 10-year experience of 99 cases at a single center. *J Gastrointest Cancer* 2019; 50: 469–477.
  19. Ogura T, Chiba Y, Masuda D, *et al.* Comparison of the clinical impact of endoscopic ultrasound-guided choledochoduodenostomy and hepaticogastrostomy for bile duct obstruction with duodenal obstruction. *Endoscopy* 2016; 48: 156–163.
  20. da Silva RRR, Facanali Junior MR, Brunaldi VO, *et al.* EUS-guided choledochoduodenostomy for malignant biliary obstruction: a multicenter comparative study between plastic and metallic stents. *Endosc Ultrasound* 2023; 12: 120–127.
  21. Kawakubo K, Isayama H, Kato H, *et al.* Multicenter retrospective study of endoscopic ultrasound-guided biliary drainage for malignant biliary obstruction in Japan. *J Hepatobiliary Pancreat Sci* 2014; 21: 328–334.
  22. Jagielski M, Zielinski M, Piatkowski J, *et al.* Outcomes and limitations of endoscopic ultrasound-guided hepaticogastrostomy in malignant biliary obstruction. *BMC Gastroenterol* 2021; 21: 202.
  23. Artifon EL, Marson FP, Gaidhane M, *et al.* Hepaticogastrostomy or choledochoduodenostomy for distal malignant biliary obstruction after failed ERCP: is there any difference? *Gastrointest Endosc* 2015; 81: 950–959.
  24. Khan MA, Akbar A, Baron TH, *et al.* Endoscopic ultrasound-guided biliary drainage: a systematic review and meta-analysis. *Dig Dis Sci* 2016; 61: 684–703.

25. Wang K, Zhu J, Xing L, *et al.* Assessment of efficacy and safety of EUS-guided biliary drainage: a systematic review. *Gastrointest Endosc* 2016; 83: 1218–1227.
26. Moole H, Bechtold ML, Forcione D, *et al.* A meta-analysis and systematic review: success of endoscopic ultrasound guided biliary stenting in patients with inoperable malignant biliary strictures and a failed ERCP. *Medicine (Baltimore)* 2017; 96: e5154.
27. Dhir V, Artifon EL, Gupta K, *et al.* Multicenter study on endoscopic ultrasound-guided expandable biliary metal stent placement: choice of access route, direction of stent insertion, and drainage route. *Dig Endosc* 2014; 26: 430–435.
28. Hedjoudje A, Sportes A, Grabar S, *et al.* Outcomes of endoscopic ultrasound-guided biliary drainage: a systematic review and meta-analysis. *United European Gastroenterol J* 2019; 7: 60–68.
29. Chan SM and Teoh AY. Endoscopic ultrasound-guided biliary drainage: a review. *Curr Treat Options Gastroenterol* 2015; 13: 171–184.
30. Facciorusso A, Mangiavillano B, Paduano D, *et al.* Methods for drainage of distal malignant biliary obstruction after ERCP failure: a systematic review and network meta-analysis. *Cancers (Basel)* 2022; 14: 3291.
31. van der Merwe SW, van Wanrooij RLJ, Bronswijk M, *et al.* Therapeutic endoscopic ultrasound: European Society of Gastrointestinal Endoscopy (ESGE) guideline. *Endoscopy* 2022; 54: 185–205.
32. Dhir V, Itoi T, Khashab MA, *et al.* Multicenter comparative evaluation of endoscopic placement of expandable metal stents for malignant distal common bile duct obstruction by ERCP or EUS-guided approach. *Gastrointest Endosc* 2015; 81: 913–923.

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