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TOPICS

Recent advances in visualization and imaging in HBP sciences

Endoscopic ultrasonography-guided biliary drainage

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Abstract
Background and purpose Endoscopic ultrasonography-guided biliary drainage (EUS-BD) has been developed as an alternative drainage method in patients with obstructive jaundice. EUS-BD is divided into EUS-guided choledochoduodenostomy (EUS-CDS), EUS-guided hepaticogastrostomy (EUS-HGS) and EUS-guided gallbladder drainage (EUS-GBD). The aim of this review is to focus on the current status and limitations of EUS-BD.
Methods A systematic review was performed to evaluate EUS-BD. MEDLINE, EMBASE and manual searches were performed to identify the pertinent English language full articles.
Results The high success rate without fatal adverse events for EUS-CDS (93%; 28/30) and EUS-HGS (97%; 28/29) suggest the feasibility and safety of the procedures in high-volume endoscopic centers adopting various procedural techniques. Although the number of reported cases was very small, the success rate of EUS-GBD was high (100%; 14/14), without serious adverse events.
Conclusions Although all procedures require further assessment in a larger cohort of patients, including comparative studies between EUS-CDS or EUS-HGS versus PTBD, and EUS-GBD versus PTGBD, EUS-BD may be a promising procedure for the treatment of obstructive jaundice. However, dedicated devices for EUS-guided drainage are needed for reliable procedures.

Keywords Endoscopic ultrasonography-guided biliary drainage · Endoscopic ultrasonography-guided choledochoduodenostomy · Endoscopic ultrasonography-guided hepaticogastrostomy · Endoscopic ultrasonography-guided gallbladder drainage

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Introduction

Endoscopic transpapillary biliary drainage has been established for treatment of biliary decompression in patients with biliary obstruction [1–3]. Even if skillful endoscopists perform these procedures, there are some patients in whom failure to achieve bile duct access still occurs because of failed biliary cannulation or inaccessible papilla due to severe duodenal stenosis caused by tumor invasion. In these cases, percutaneous transhepatic biliary drainage (PTBD) or surgical intervention is required [4]. On the other hand, to date, percutaneous transhepatic gallbladder drainage [5] and endoscopic transpapillary gallbladder drainage [6, 7] are among the palliative therapies for the treatment of acute cholecystitis. Recently, endoscopic ultrasonography-guided biliary drainage (EUS-BD), which is divided into EUS-guided choledochoduodenostomy [8–18], EUS-guided hepaticogastrostomy [8, 9, 11, 18–21] and EUS-guided gallbladder drainage [22–25], has been reported as an alternative biliary drainage technique. The aim of this article is to focus on the role of and approach to interventional EUS for biliary drainage.

EUS-guided choledochoduodenostomy

EUS-guided choledochoduodenostomy procedure

The extrahepatic bile duct is visualized from the duodenal bulb by using a curved linear array echoendoscope in a long or a short scope position. The direction of the needle in long and short scope positions is toward the hilar and lower bile duct portion, respectively. Needle knives (Zimmon Papillotomy Knife, Cook Endoscopy, Winston-Salem, NC), a catheter using electrocautery (EndoCut ICC200, Erbe Elektromedizin GmbH, Tübingen, Germany), or a 19- or 22-gauge needle (EchoTip, Cook Endoscopy) is inserted transduodenally into the bile duct under EUS visualization (Figs. 1, 2). After the stylet is removed, first, bile is aspirated, and contrast medium is injected into the bile duct for cholangiography (Fig. 2). Then, a 450-cm, 0.035-cm, 0.021-cm or 0.018-inch guidewire is inserted into the outer sheath. If necessary, a biliary catheter for dilation (Soehendra Biliary Dilator, Cook Endoscopy) or papillary balloon dilator (Maxpass, Olympus Medical Systems, Tokyo, Japan) is used for dilation of the duodenocholedochal fistula. Finally, a 5- to 10-Fr biliary plastic stent or self-expandable metallic stent (SEMS) is inserted through the choledochoduodenostomy site into the extrahepatic bile duct (Fig. 3a, b).

Review of published data

Ten studies have assessed the role of EUS-guided choledochoduodenostomy [8–18]. EUS-guided choledochoduodenostomy was carried out in 30 cases, including 18 pancreatic cancers, 6 papilla of Vater cancers, 2 bile duct cancers, 1 pancreatic lymphoma, 1 hepatoma, 1 gastric cancer and 1 bile duct stone (Table 1). Various types of needle knives were used for puncture. The procedure was successful in all but 2 cases (total success rate; 93%, 28/30). With the exception of six SEMS cases and one naso-biliary drainage case, all others used 7–10-Fr plastic stent placement. Once the stents were placed, all patients had successful resolution of obstructive jaundice. The rate of procedure-related complications was 17% (5/30); there were 2 cases of focal bile peritonitis and 3 cases of pneumoperitoneum without fatal adverse events. Recently, Yamao et al. [26] have reported that the mean stent patency of 7- to 8.5-F plastic stents for EUS-guided choledochoduodenostomy was 211.8 days in long-term follow-up cases.

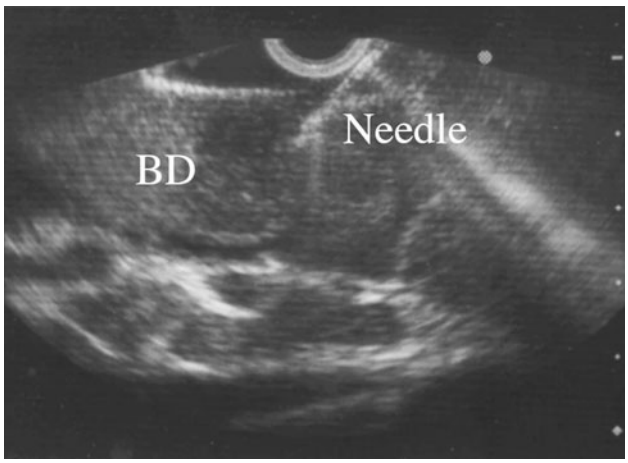

Fig. 1 A needle knife was inserted into the bile duct under real-time EUS visualization

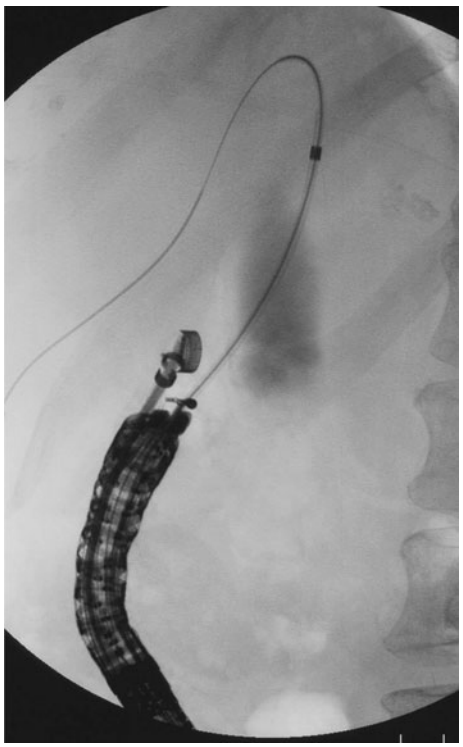

Fig. 2 After EUS-guided puncture, contrast medium is injected into the bile duct for cholangiography

Limitations of the EUS-guided choledochoduodenostomy

First, the extrahepatic bile duct is not necessarily right next to the duodenal wall, although EUS reveals the extrahepatic bile duct to be next to the duodenal wall. Therefore, there is a certain displacement between the puncture site of the duodenal wall and bile duct, resulting in possible failure of accomplishing this procedure. Second, since the extrahepatic bile duct is very close to the portal vein in the first and second portion of the duodenum, the puncture is sometimes risky, especially in patients with mild dilation of the extrahepatic bile duct. Third,

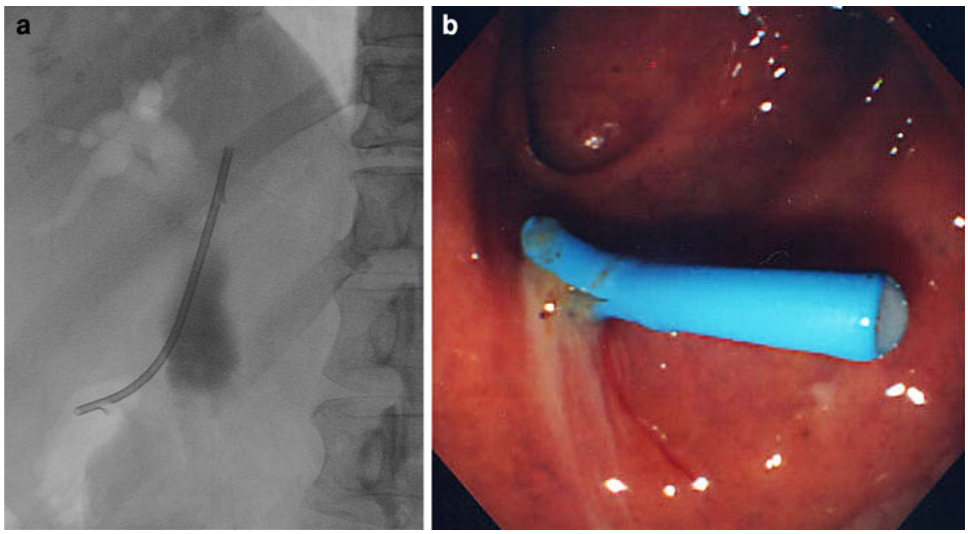

Fig. 3 **a** Choledochoduodenostomy was accomplished using a 7-F plastic stent. **b** Endoscopic imaging showed the stent visible in the duodenal bulb

Table 1 Summary of published studies on EUS-guided choledochoduodenostomy

Reference	No. of cases	Device for puncture	Technical success (%)	Treatment success (%)	Initial stent (no. of cases)	Complication (no. of cases)
Giovanini et al. [8]	1	NK	100	100	10 F PS	None
Burmester et al. [9]	2	19G FT	50	100	8.5 F PS	Bile peritonitis (1)
Puspok et al. [10]	5	NK	80	100	7–10 F PS	None
Kahaleh et al. [11]	1	19G FN	100	100	10 mm SEMS	Pneumoperitoneum (1)
Ang et al. [12]	2	NK	100	100	7 F PS	Pneumoperitoneum (1)
Yamao et al. [13, 14, 26]	5	NK	100	100	7–8.5 F PS	Pneumoperitoneum (1)
Fujita et al. [15]	1	19G FN	100	100	7 F PS	None
Tarantino et al. [16]	4	19G/22G FN[a]	100	100	PS[b]	None
Itoi et al. [7, 17]	4	NK/19G FN	100	100	7 F PS (3), NBD (1)	Bile peritonitis (1)
Park et al. [18]	5[c]	NK/19G FN	100	100	10 mm CSEMS	None

NBD nasobiliary drain, *G* gauge, *NK* needle knife, *FT* fistulotome, *FN* fine needle, *PS* plastic stent, *SEMS* self-expandable metallic stent, *CSEMS* covered SEMS

[a] Guidewire type NK used after first puncture with FN

[b] Stent diameter is not described

[c] Including the transantral approach to the common bile duct

currently, the diameter of the working channel of the linear echoendoscope is narrow, necessitating the use of small-caliber stents or SEMS with a small-diameter delivery device. Fourth, there are no commercially available one-step devices yet, leading to bile leakage during the replacement of each device.

EUS-guided hepaticogastrostomy

EUS-guided hepaticogastrostomy procedure

By using a curved linear array echoendoscope in a short scope position, the intrahepatic bile duct is visualized via the stomach. The direction of the needles is toward the hilar bile duct portion. Needle knives (Zimmon Papillotomy Knife or Cystotome, Cook Endoscopy, Winston-Salem, NC), a catheter using electrocautery (EndoCut ICC200, Erbe Elektromedizin GmbH, Tübingen, Germany), or a 19- or 22-gauge needle (EchoTip, Cook Endoscopy) is inserted transgastrically into the bile duct under EUS visualization. After the stylet is removed, first, bile is aspirated, and contrast medium is injected into the bile duct for cholangiography. Then, a 450-cm, 0.035-cm, 0.021-cm or 0.018-inch guidewire is inserted into the outer sheath. If necessary, a biliary catheter for dilation (Soehendra Biliary Dilator, Wilson-Cook) or papillary balloon dilator (Maxpass, Olympus Medical Systems, Tokyo, Japan) is used for dilation of the duodenocholedochal fistula. Finally, a 5- to 10-Fr biliary plastic stent or

covered or uncovered SEMS is inserted through the hepaticogastrostomy site into the extrahepatic bile duct.

Review of published data

Seven studies have evaluated the role of EUS-guided hepaticogastrostomy [8, 9, 11, 18–21]. Twenty-nine patients underwent EUS-guided hepaticogastrostomy, including 7 pancreatic cancers, 1 papilla of Vater cancer, 1 bile duct cancer, 5 hilar bile duct cancers, 5 gastric cancers, 3 gallbladder cancers, 2 colon cancers, 1 duodenal cancer, 1 bladder cancer and 3 biliary benign diseases (Table 2). Various types of needle knives were used for puncture. The procedure was successful in all but one case (total technical success rate 96%). Various types of stents, including plastic stents and SEMS, were used for the drainage. Once the stents were placed, all but one patient (total treatment success rate 96%) had successful resolution of obstructive jaundice. The rate of procedure-related complications was 21% without mortality: 1 case of plastic stent ileus, 1 case of biloma, 1 case of cholangitis, 1 case of stent migration and/or shortening and 1 case of pneumoperitoneum.

Limitations of the hepaticogastrostomy

First, the intrahepatic bile duct is not necessarily right next to the gastric wall, although EUS reveals that the intrahepatic bile duct is close to the gastrointestinal wall. Therefore, there is a certain displacement between the puncture site of the gastric wall and intrahepatic bile duct, resulting in possible failure of carrying out this procedure. In addition, there is the possibility of the transesophageal approach [27]. Second, since the bile duct is included in the liver, the puncture may be difficult in case of a very fibrous liver, such as in the case of liver cirrhosis. Third, since the intrahepatic bile duct is close to the intrahepatic portal vein, the puncture is sometimes risky, especially in patients with mild dilation of the intrahepatic bile duct. Fourth, currently, the diameter of the working channel of the linear echoendoscope is narrow, necessitating the use of small-caliber stents or SEMS with a small-diameter delivery device.

EUS-guided gallbladder drainage

EUS-guided gallbladder drainage procedure

The gallbladder is visualized from the duodenal bulb or the antrum of the stomach by using a curved linear array echoendoscope in a long scope position. Needle knives (Zimmon Papillotomy Knife or Cystotome, Cook Endoscopy, Winston-Salem, NC), a catheter using electrocautery or a 19-gauge needle (EchoTip, Cook Endoscopy) is inserted transduodenally or transgastrically into the gallbladder under EUS visualization. After the stylet is removed, first, the bile is aspirated, and contrast medium is injected into the gallbladder for cholecystography. Then, a 450-cm or 0.035-inch guidewire is inserted into the outer sheath. If necessary, a biliary catheter for dilation (Soehendra Biliary Dilator, Cook Endoscopy) or papillary balloon dilator (Maxpass, Olympus Medical Systems, Tokyo, Japan) is used for dilation of the duodenocholedochal fistula. Finally, a 5- to 10-Fr biliary plastic stent or SEMS is inserted through the cholecystoduodenostomy or cholecystogastrostomy site into the gallbladder.

Review of published data

Four studies have evaluated the role of EUS-guided gallbladder drainage for treatment of acute cholecystitis [22–25]. Nine patients underwent EUS-guided cholecystoduodenostomy or cholecystogastrostomy (Table 3).

Table 2 Summary of published studies on EUS-guided hepaticogastrostomy

Reference	No. of cases	Device for puncture	Technical success (%)	Treatment success (%)	Initial stent (no. of cases)	Complication (no. of cases)
Burmester et al. [9]	1	19G FN/FT	100	100	8.5 F PS	None
Giovanini et al. [8]	1	19G FN/NK	100	100	10 F PS	None
Kahaleh et al. [11]	2	19G/22G FN	100	100	10 F PS	None
Artifon et al. [19]	1	19G FN	100	100	10 mm CSEMS	None
Bories et al. [20]	11	19G/22G FN, CT	91	100	7 F PS, 10 mm CSEMS	PS (2), SEMS (4)[a]
Will et al. [21]	4	19G FN	100	75	10 mm UCSEMS, CSEMS	Cholagitis[b] (1)
Park et al. [18]	9	NK/19G FN	100	100	10 mm CSEMS	None

NK needle knife, *FT* fistulotome, *FN* fine needle, *CT* cystotome, *PS* plastic stent, *SEMS* self-expandable metallic stent, *CSEMS* covered SEMS, *G* gauge

[a] PS: ileus (1), stent occlusion (1); SEMS: stent migration (1) and/or shortening (2); biloma (1); cholangitis (1)

[b] CSEMS

Table 3 Summary of published studies on EUS-guided gallbladder drainage

Reference	No. of cases	Device for puncture	Puncture route	Technical success (%)	Treatment success (%)	Initial stent (no. of cases)	Complication (no. of cases)
Baron and Topazian [22]	1	19G FN	Transduodenal	100	100	7 F PS	None
Kwan et al. [23]	3	19G FN/FT/CT	Transduodenal	100	100	8.5 F NBD	None
Lee et al. [24]	9	19G FN	Transduodenal	100	100	5 F NBD	Pneumoperitoneum (1)
Takasawa et al. [25]	1	NK	Transgastric	100	100	7.2 Fr PS	None

NK needle knife, *FT* fistulotome, *FN* fine needle, *CT* cystotome, *PS* plastic stent, *NBD* naso-gallbladder drain

Various types of needle knives were used for puncture. The procedure was successful in all cases (total success rate 100%). Either a naso-biliary drainage catheter or plastic stent was placed. Once the stents were placed, all patients had successful resolution of obstructive jaundice. The rate of procedure-related complications was 7%; there was 1 case of pneumoperitoneum.

Limitations of the EUS-guided gallbladder drainage

First, the gallbladder is not necessarily right next to the duodenal wall or gastric wall, although EUS reveals that the gallbladder is close to the duodenal wall or gastric wall at the antrum. Therefore, there is a certain displacement between the puncture site of the duodenal wall or gastric wall and gallbladder, resulting in possible failure of accomplishing this procedure. Second, since the gallbladder is usually movable, the stent placement, in particular of a pig-tail type stent, is sometimes difficult. Third, currently, the diameter of the working channel of the linear echoendoscope is narrow, necessitating the use of small-caliber stents or SEMS with a small-diameter delivery device.

Current status of EUS-guided biliary drainage

The high success rate and low complication rate without fatal events in the EUS-guided choledochoduodenostomy and EUS-guided hepaticogastrostomy suggest the feasibility and safety of the procedures in high-volume endoscopic centers adopting various procedural techniques. However, as we have described [28], deciding whether this procedure can be recommended as a standard treatment alternative for patients following a failed ERCP, EUS-guided choledochoduodenostomy or EUS-guided hepaticogastrostomy requires further assessment in a larger cohort of patients. As the number of procedures currently performed is small, multi-center trials may be required using a standard procedural technique to best evaluate the technical and treatment outcomes. Also, long-term clinical follow-up and issues pertaining to stent exchanges in this patient population need to be evaluated further. EUS-guided gallbladder drainage and EUS-guided bile duct drainage require further evaluation in a larger cohort of patients because an extremely small number of procedures has been performed at this time.

Furthermore, comparative studies of EUS-guided choledochoduodenostomy or EUS-guided hepaticogastrostomy versus PTBD are required to identify the best modality for relieving biliary obstruction following a failed ERCP since PTBD is currently the standard of care following a failed ERCP at most institutions with fairly high technical success rates and acceptable rates of complications. In particular, PTGBD is the most reliable treatment of acute cholecystitis when an emergency operation is not a good indication. Therefore, multi-center collaboration is required to compare the technical and treatment outcomes between PTGBD and EUS-guided gallbladder drainage.

The biggest issue in EUS-guided biliary drainage is that no dedicated EUS-specific device or kit is commercially available. For the progress of EUS-guided biliary drainage, a dedicated needle, with or without electrocautery, and an all-in-one type stenting system are needed. To minimize the possibility of a bile leak, studies comparing different stents (covered metal versus plastic) for this indication are required.

Also, the role of the prototype forward-view echoendoscope for performing EUS-guided choledochoduodenostomy needs to be investigated [28]. Nonetheless, EUS-guided biliary drainage has great potential as one of the interventional EUS procedures [29].

In conclusion, EUS-guided biliary drainage has great potential as an alternative biliary decompression procedure. Multi-center trials aimed at standardizing the procedural technique for performing EUS-guided biliary drainage are needed in the future as the present data are limited.

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