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Review Article

Endoscopic ultrasound-guided biliary drainage

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A B S T R A C T

Endoscopic ultrasound-guided biliary drainage (EUS-BD) is emerging as a safe and effective alternative for endoscopic BD. The advantage of multiple access points from stomach and duodenum allows EUS-BD in patients with altered surgical anatomy and duodenal stenosis. EUS-BD is also useful in patients with failed endoscopic retrograde cholangiopancreatography or difficult biliary cannulation. Depending on the access and exit route of the stent, a variety of EUS-BD procedures have been described. Trans-papillary as well as trans-luminal stent placements are possible with EUS-BD. Recent studies have shown a clinical success rate in excess of 90% and complication rates of < 15%. Prospective studies are needed to know the long-term results and relative efficacy of this technique.

Keywords: Bile duct diseases; Biliary tract neoplasms; Endoscopic retrograde cholangiopancreatography; Endosonography; Jaundice, obstructive

Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) is the current gold standard for endoscopic biliary drainage (BD). Successful cannulation of the biliary tree can be achieved in > 90% of ERCPs.[1] However, access to the biliary system is not possible in a minority of patients either due to altered anatomy after surgeries or due to obstructing tumors or an unfavorable trajectory of the papilla.[2] Conventionally when ERCP has failed or is not technically possible, patients are referred for BD through a percutaneous route. Surgery is a less favorable option especially in cases with unresectable pancreatic or peripancreatic tumors. When compared to an endoscopic approach, surgery has a lower rate of recurrent biliary obstruction (relative risk, 0.14; 95% confidence interval, 0.03–0.63) but it is associated with a prolonged hospital stay.[3]

A more recent method utilized to achieve access to the biliary system and facilitate a subsequent ERCP or as a mode of direct BD is endoscopic ultrasound-guided BD (EUS-BD). This article will review different aspects pertaining to EUS-BD including; EUS-guided transluminal BD including EUS-guided choledocoduodenostomy (EUS-CDS) or hepaticogastrostomy (EUS-HGS); the EUS-guided rendezvous technique (EUS-RV), EUS-guided antegrade (EUS-AG) interventions as well as EUS-guided gallbladder drainage (EUS-GBD).

Potential Advantages of EUS-BD

EUS-BD has evolved both in technique as well as nomenclature to its current form today and will likely improve with designated accessories as well as applications in the future.[4] EUS-BD has the advantage of being performed at the same session when an ERCP is not successful. Furthermore, percutaneous drainage procedures usually require multiple sessions while EUS-BD is usually successful in a single setting with no further intervention and the added advantage of having an internal drain as opposed to an external one. External drains could be cumbersome to patients and caregivers and requires care and frequent flushing.[4,5] Also,

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EUS-BD has an advantage in cases where a percutaneous drain could be self removed due to dementia.[6]

Indications

BD is indicated when patients with obstructive jaundice develop itching or cholangitis. Even in the absence of these indications, a randomized controlled trial (RCT) found that endoscopic BD has been associated with an improved quality of life.[7] EUS-BD is an option when access to the biliary system is not possible due to the papilla being inaccessible from tumor infiltration, gastric outlet obstruction, the presence of a duodenal stent, or altered anatomy[2] in cases with prior surgeries like Roux-en-Y, Billroth II, biliopancreatic diversion, or after bariatric bypass surgeries. As for EUS-RV when cannulation fails for any reason, a wire can be passed through the papilla in an antegrade fashion and then the wire is grasped through a duodenoscope and the procedure is continued as a regular ERCP.

The technical and clinical success, as well as the complication rates rate for EUS-BD in cases with altered surgical anatomy is 89.18%, 91.07%, and 17.5%, respectively.[2]

Accessories

EUS-BD is performed using a linear echoendoscope with a 3.8-mm working channel to facilitate the insertion of stents and catheters. Also, a duodenoscope is used when a EUS-RV is planned. A 19-gauge fine needle aspiration (FNA) is used as it can accommodate 0.035-inch guidewires. To dilate the tract between the gastrointestinal lumen and the biliary system after access with an FNA needle, a bougie dilator, a cystotome, or dilating balloon can be used with tapered tips that are either 6 or 7 Fr. Hydrophilic 0.035-inch guidewires are used as they have the required stiffness to support the insertion of different instruments during the procedure. Furthermore, long guidewires (400 cm) are used to allow exchange of accessories, shorter wires (260 cm) can be used for the procedure utilizing an exchange technique during withdrawal of the scope during EUS-RV.[8] For manipulating of the wires, a rotatable sphincterotome or bending catheter is used to redirect the wire to the desired location.

General Principles for the Technique

It should be emphasized that it is important to approach patients undergoing EUS-BD as a team where all the required accessories are available and proper trained personnel work as a team, as manipulation of the wires and exchange of the accessories in a smooth manner without much delay is important for the success of these procedures. Also, adequate sedation should be provided as these procedures could be prolonged and unplanned movements could be detrimental with loss of access of the needle or wires, this would be based on institution-based protocols. Furthermore, patients undergoing EUS-BD should receive antibiotics either before[9–18] or immediately after the procedure.[15]

There are several variations of EUS-BD depending on access and exit route (Table 1). The biliary tree is accessed either through the left biliary system or the common bile duct (CBD) and the access of the scope is aligned under fluoroscopy in a manner that the FNA needle is pointing caudad if accessing from the duodenal bulb is intended to manipulate the instruments towards the papilla. After ensuring that there are no intervening blood vessels in the projected track of the FNA needle using Doppler the targeted biliary duct is punctured and bile is aspirated to ensure access to the biliary system. Of note, the distance between the probe and the targeted duct should be no more than 1 to 2 cm.[19] A cholangiogram is then obtained by injecting contrast into the biliary tree and the needle is flushed with water to facilitate insertion of a guidewire. A guidewire is advanced into the biliary system and manipulated to cannulate the intended area (traversing the papilla in cases of EUS-RV or EUS-AG, or the liver hilum in cases of EUS-CDS and EUS-HGS). If negotiating the guidewire is difficult with the FNA needle, then it is removed with the guidewire left in place and a bougie dilator or cystotome is inserted and manipulation of the guidewire reattempted. For dilatation of the tract after puncture with a EUS needle, either a cystotome or a graded catheter or balloon-based dilatation is used. The graded approach has the advantage of the axial force used to introduce the catheter creating a smaller tract and potentially less leakage and/or bleeding. However, it is more difficult to perform and might require more than one exchange for the catheter as well as guidewire and it is possibly more difficult to insert a stent.[19]

Table 1 Variations of EUS-BD

- Biliary stent placement
  - Trans-hepatic
    - Trans-luminal: hepatico-gastrostomy (EUS-HGS)
    - Trans-papillary: antegrade procedure (EUS-AG)
  - Trans-duodenal
    - Trans-luminal: choledocho-duodenostomy (EUS-CDS)
- Biliary access for ERCP completion
  - Rendezvous procedure (EUS-RV)

EUS-BD, endoscopic ultrasound-guided biliary drainage; EUS-HGS, endoscopic ultrasound-guided hepaticogastrostomy; EUS-AG, endoscopic ultrasound-guided antegrade intervention; EUS-CDS, endoscopic ultrasound-guided choledocoduodenostomy; ERCP, endoscopic retrograde cholangiopancreatography; EUS-RV, endoscopic ultrasound-guided rendezvous technique.

The manipulation of the guidewire is done under fluoroscopic guidance and care should be taken during manipulation of the guidewire through an FNA needle not to sheer it with repeated advancement and withdraw. After it is determined that the wire has traversed the papilla, in cases of EUS-RV or EUS-AG, the wire is advanced further to achieve 2 to 3 loops and care should be taken during exchange of the instruments to maintain the position of the wire.

EUS-RV (Fig. 1) is utilized in cases where a duodenoscope can be advanced to the level of the papilla. The point of puncture of the biliary system to facilitate the EUS-RV is of importance. Three areas can be punctured; the extrahepatic biliary system from the second part of the duodenum (D2); the extrahepatic biliary system from the duodenal bulb (D1); or the transhepatic approach.[20] Accessing the CBD from D2 has the advantage of a shorter distance between the puncture site and the papilla thus increasing the ease of the manipulation of the wire and probability of traversing any area of resistance.[20] On the other hand, an approach utilizing the transhepatic system would require the advancement of the wire from the intrahepatic biliary system toward the ampulla and might result in difficulty in manipulating the guidewire through any areas of resistance.[20]

To retrieve the guidewire, a snare or a forceps is used and then the procedure is carried out as a usual ERCP. Another possible method is to cannulate the CBD alongside the protruding guidewire through the CBD without the need to retrieve the distal end through the working channel of the duodenoscope. If a short guidewire (260 cm) is used for a EUS-RV, it might not be long enough to enable the endoscopist to grasp both ends of the wire

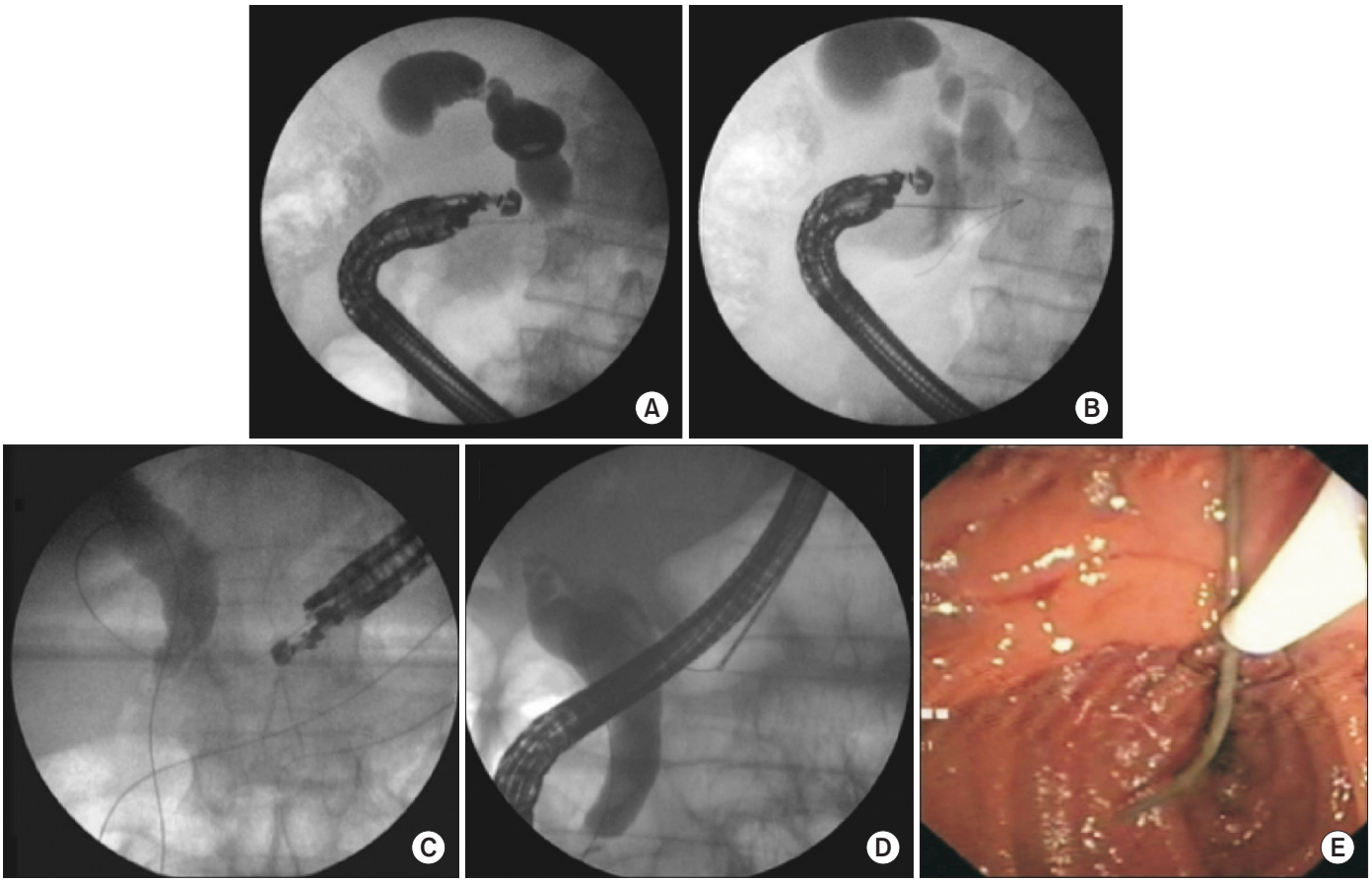

Fig. 1. Endoscopic ultrasound-guided rendezvous technique. (A) It shows needle puncture of the common bile duct with injection of contrast to obtain a cholangiogram. (B) It shows wire manipulation across the papilla. (C) It shows the echo-endoscope withdrawal leaving the wire in place. (D) It shows the duodenoscope in position with the wire still in common bile duct. The gastric end of the wire is caught with a biopsy forceps. (E) It shows capture of the wire exiting the papilla with a snare passed down the duodenoscope biopsy channel.

during the exchange of the scopes. In such a case, when withdrawing the echoendoscope and the FNA needle as one unit and the guidewire is exchanged till its proximal end is in the FNA needle. Then a 12 mL syringe is attached to the FNA needle and water is flushed to maintain its position during withdrawal of the needle, this is designated as the "float the wire" technique.[8,12] Again when the wire is retrieved through the accessory channel of the duodenoscope, the distal end of the short wire is feed through the mouth of the patient while it is grasped with a rat tooth forceps.[8] It is worth noting that in EUS-RV, there is no need to dilate the tract after puncturing the bile duct with the FNA needle.[21]

EUS-CDS (Fig. 2) and EUS-HGS (Fig. 3) are used in cases where a guidewire cannot be manipulated through the papilla in EUS-RV. The EUS-HGS procedure utilizes a trans-hepatic approach through the puncture of a dilated biliary radical either from the cardia of the stomach or the lesser curvature. However, EUS-CDS uses an extrahepatic approach where the FNA needle is advanced through the duodenum directly into the CBD. In either approach the enterobiliary tract is dilated after the FNA needle is withdrawn and a guidewire left in place using a 4 to 6 mm wire-guided balloon dilator or a cystotome. Then either a plastic or self expandable metallic stent (SEMS) is inserted to drain the biliary system based on the clinical indication.

When puncturing the CBD in EUS-CDS, care should be taken not to puncture through a fold of duodenal mucosa and then enter the CBD as this would cause the stent to traverse through a mucosal fold and then through the duodenal wall.[22] Also, puncturing the cystic duct should be avoided.[22]

EUS-HGS is the only option in cases of hilar biliary obstruction. Although the left biliary system is easy to drain, the right system could be drained through manipulating a wire from the left hepatic duct into the right biliary system via the junction of both. Then, an uncovered SEMS is deployed to bridge the right to left system drainage and a EUS-HGS is continued in the usual fashion.[16]

In the case where drainage of the right biliary system is needed but the wire could not be manipulated from the left biliary system via a EUS-HGS, then utilizing the right biliary system as an access point for a EUS-HGS has been described.

In this approach the echoendoscope is advanced into the antrum or the duodenal bulb and is rotated in a counter-clockwise manner and when the dilated right biliary system is visualized, it is punctured using the same technique described for the left side. The left side is drained using the similar bridging method described earlier and a "locking stent" method is used to prevent leaks or migration.[16]

EUS-AG is utilized in cases where access to the papilla is difficult or impossible and it has the advantage of avoiding a non-natural fistula between the gastrointestinal track and the biliary system. After the guidewire has been manipulated through the pa-

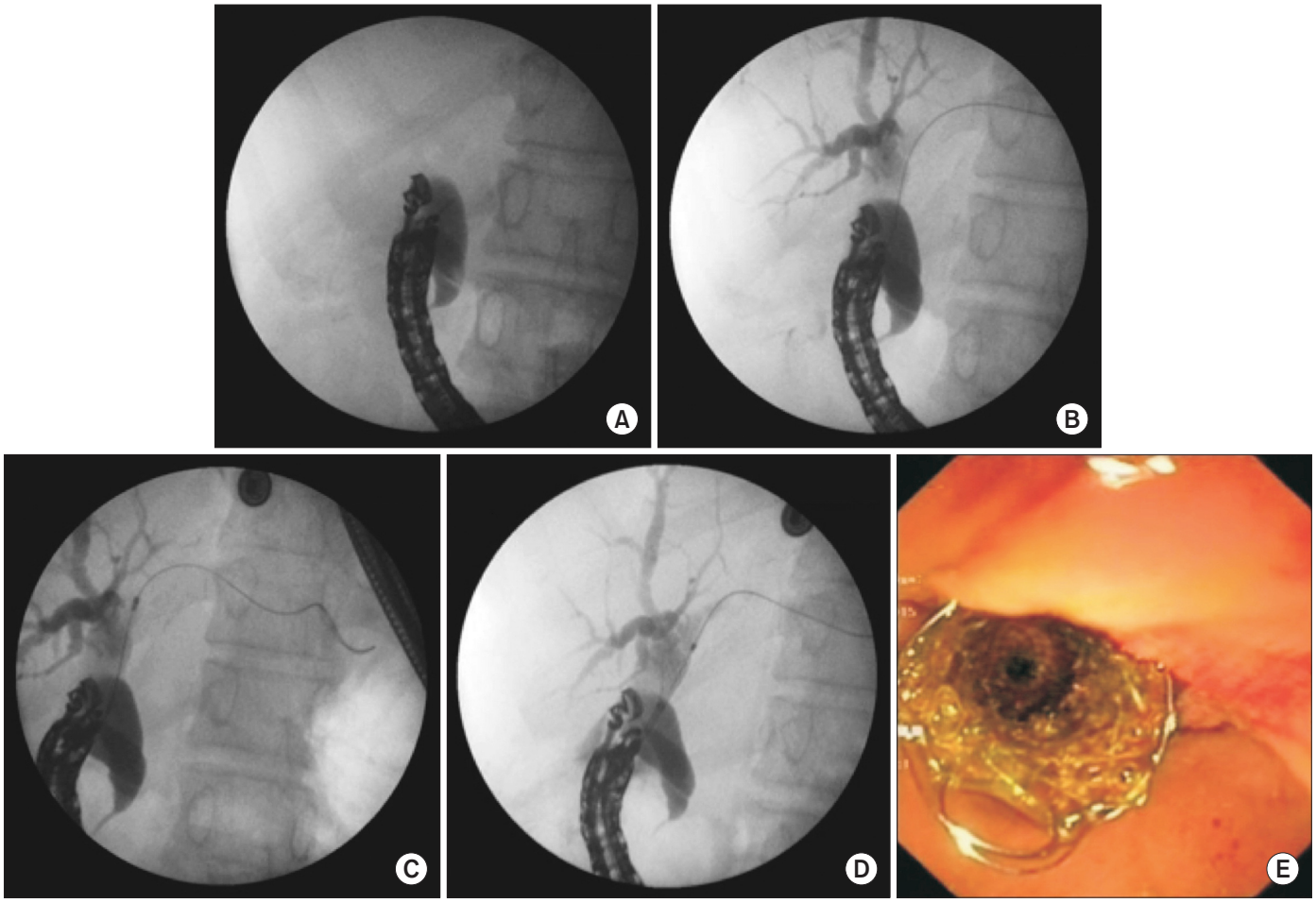

Fig. 2. Endoscopic ultrasound-guided choledocoduodenostomy. (A) It shows needle puncture and contrast injection. (B) It shows the guidewire being manipulated to the left biliary system. (C) It shows track dilation with a cystotome. (D) It shows an expandable metal stent being deployed. (E) It shows a deployed expandable stent.

pilla, a SEMS is advanced through the enterobiliary tract and advanced in an antegrade manner in to the duodenum. The sheath of the stent is then partially withdrawn and contrast is injected through the stent to insure that the distal end of the SEMS is in the duodenum and to estimate the length of the SEMS that would be protruding through the papilla. After the position of the SEMS is optimized the SEMS is deployed. In certain conditions, a biliary balloon is used to dilate the site of the stricture after traversing the area with the wire and prior to insertion of the SEMS.[15]

EUS-GBD is utilized in cases where patients have acute cholecystitis and are considered non-surgical candidates for reasons that include comorbidities or the presence of neoplasia. In such cases the standard approach has been a percutaneous transhepatic GBD procedure. EUS-GBD has been performed more frequently lately and is performed with the EUS scope in the long position either in the antrum of the stomach or the bulb of the duodenum. The gallbladder is punctured using a 19-guage needle and bile is aspirated to confirm correct position of the needle, and contrast is injected to delineate the gallbladder fluoroscopically. Either a dilatation catheter or a biliary balloon is used to dilate the gastrocholecystic or duodenocholecystic tract. Either a nasogallbladder tube is inserted or a plastic double pigtail or a SEMS is used to establish long term drainage.[23]

More recently, the use of fully covered tissue apposing SEMS like the AXIOS™ stent (Boston Scientific, Marlborough, MA, USA) has simplified the procedure. These SEMS have a 10 to 15 mm diameter and a 6 to 10 mm length between the bilateral anchoring flanges and a silicone covering that potentially prevents bile leakages and tissue ingrowth that would facilitate removal at will in a later date if deemed unsuitable.[24] The older version required a standard puncture and dilatation of the tract between the gallbladder and the gastrointestinal lumen and subsequent stenting. However, a more recent version has a thermal system within the stent deployment catheter making it both a puncturing device with the tip of the catheter, then deploying the stent under EUS visualization directly without even the need of fluoroscopy.

Contraindications

In general, patients who cannot tolerate an endoscopic procedure due to associated comorbidities should not undergo EUS-BD and also any coagulopathy should be corrected.

Outcome

Recent studies[8,13,18,25–28] have shown high success rates with various EUS-BD procedures (Table 2). Complication rates appear variable with some studies showing higher complication rates,

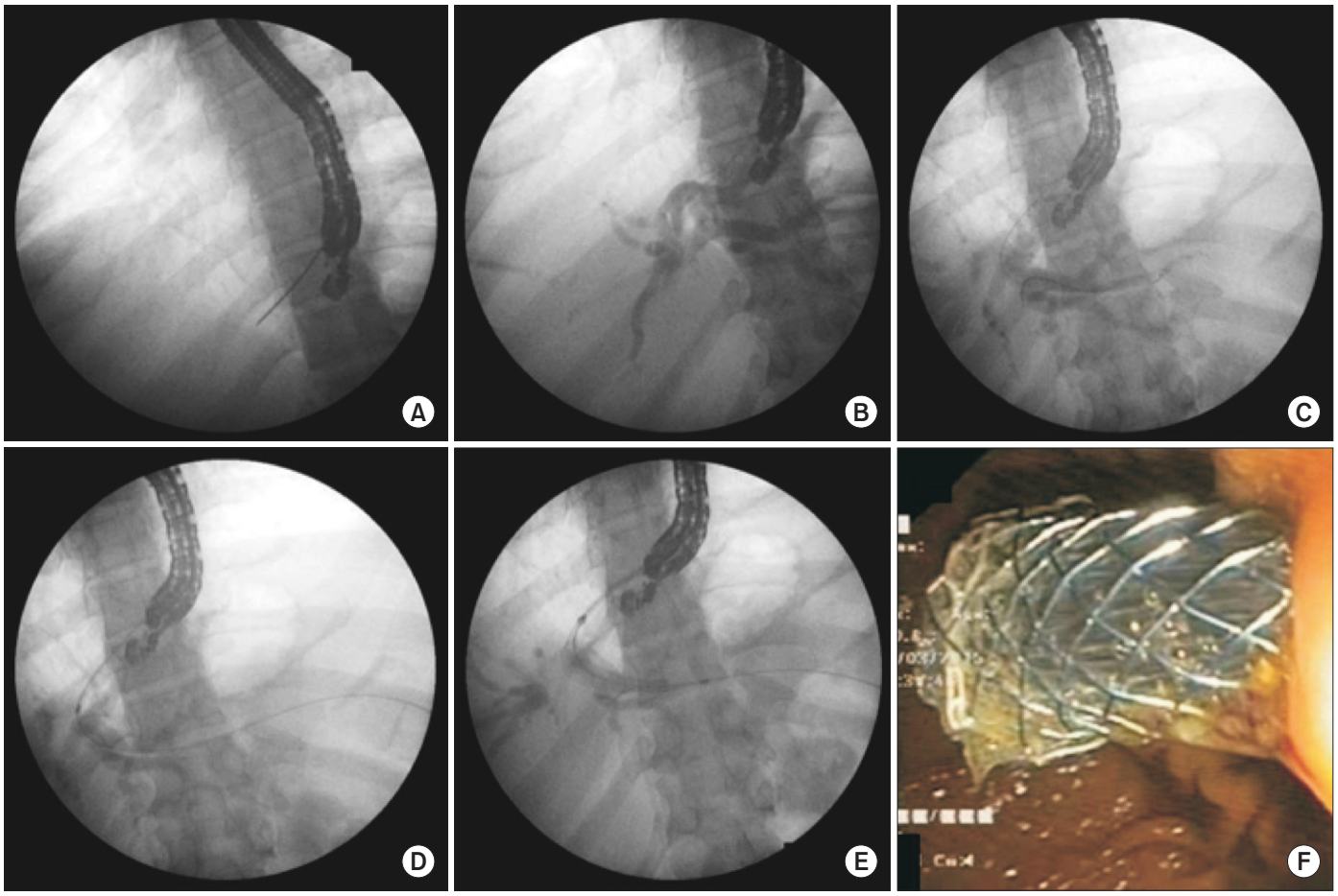

Fig. 3. Endoscopic ultrasound-guided hepaticogastrostomy. (A) It shows needle puncture of the intrahepatic ducts from the stomach. (B) It shows contrast injection and the demonstration of a cholangiogram. (C) It shows wire manipulation. (D) It shows track dilation with cystotome. (E) It shows stent being positioned with part of the stent in the biliary tree and the other end into the stomach. (F) It shows the fully deployed metal stent in the proximal stomach.

Table 2 Outcomes of EUS-BD*

First author	Year	Procedures	Success	Complication
Poincloux[18]	2015	101	99 (98.0)	12 (11.9)
Dhir[13]	2015	104	97 (93.3)	9 (8.7)
Kawakubo[25]	2014	64	61 (95.3)	12 (18.8)
Dhir[26]	2014	68	65 (95.6)	14 (20.6)
Gupta[27]	2014	248	209 (84.3)	81 (32.7)
Vila[28]	2012	106	84 (79.2)	29 (27.4)
Dhir[8]	2012	58	57 (98.3)	2 (3.4)
Total		749	672 (89.7)	159 (21.2)

Values are presented as number only or number (%).
EUS-BD, endoscopic ultrasound-guided biliary drainage.
*Published studies with > 50 patients.

while others describing complication rates equivalent to ERCP or percutaneous transhepatic biliary drainage (PTBD). Large prospective studies are needed to know the long-term patency of stents.

Should a Transhepatic or Extrahepatic Approach Be Used?

In cases where the blockage is at the hilum the transhepatic approach is the only option available but in cases with more distal obstruction both approaches are possible.

In a retrospective study comparing the transhepatic to the extrahepatic approach for EUS-RV, they were equally effective (94.1% vs 100%, $P = 0.49$). However, the transhepatic route had a longer procedure time (34.4 vs 25.7 minutes, $P < 0.01$), higher post procedure pain requiring admission (44.1% vs 5.5%, $P = 0.02$), and duration of hospitalization (2.52 vs. 0.17 days, $P = 0.02$). There was no difference in the incidence of bile leak (11.7% vs 0%, $P = 0.23$), and air under the diaphragm (11.7% vs 0%, $P = 0.23$).[10] Of note, this study had a small sample size and might have been underpowered to detect differences in the secondary endpoints of the study. A second multicenter retrospective study that included 68 patients found that although the success rate was similar in both the transhepatic and transduodenal routes, there was a higher complication rate in the transhepatic approach (30.5% vs 9.3%, $P = 0.03$). The only factor associated with complications after logistic regression was the use of the transhepatic access.[26] This was again seen in a single center retrospective study of 101 patients where the transhepatic approach had a 9.9% mortality rate compared to 3.3% for the extrahepatic approach, but again this did not reach clinical significance.[18] The authors attributed the high mortality rate in this study to the use of a needle knife for the dilatation of the puncture tract due to lack of other devises during the study period.[18]

In contradistinction, a multicenter retrospective study that included 240 patients found no difference between the extrahepatic or transhepatic approaches in success (84.3% vs 90.4%; $P = 0.15$), or complications (32.6% vs 35.6%; $P = 0.64$) regardless of whether the underlying cause was malignant or benign.[27] In this study the complications included bleeding (11%), bile leak/peritonitis (10%), pneumoperetoneum and cholangitis (each was 5%).[27]

More recently, a randomized trial that compared EUS-HGS to EUS-CDS in patients with malignant distal biliary obstruction found that the technical success was similar in both (96% vs 91% respectively, $P = 0.61$). While EUS-HGS group had higher clinical success rate, it did not reach statistical significance (91% vs 77%, $P = 0.23$). Also it had a higher immediate adverse event rate, but again it did not reach statistical significance (20% vs 12.5%, $P = 0.70$).[17] Furthermore, the survival was similar in both groups ($P = 0.60$) as well as the quality of life scores. Of note, in this study, there was use of a needle knife as means of dilating the tract that might have contributed to the complication rates seen.[17]

The apparent differences in the conclusions of these studies could be attributed to the retrospective design that is prone to selection biases that might sway the results in favor of either approach; thus, prospective randomized trials are needed. Nonetheless, a review comparing the two access routes in published studies with 25 or more cases and included 211 transduodenal cases and 138 transhepatic cases found that the complication rate was higher in the transhepatic group (21.7% vs 9.9%, $P \leq 0.01$).[26]

Possible explanations for a higher complication rate in the transhepatic rout include; the puncture of the peritoneal cavity from the esophageal or proximal gastric wall and into the capsule of the liver,[25] also the movement of the liver with respiration with a higher likelihood of bile leaks and pain. Other limitations include risk of mediastinitis with a transesophageal approach, difficulty of puncturing the liver in patients with cirrhosis, as well as the risk of injuring the portal vein.[29]

The advantages of the extrahepatic approach are due to the CBD being punctured via a retroperitoneal approach and the proximity of the duodenum to the CBD. In addition to the fixed motion of the CBD relative to the duodenum making it an attractive approach, this approach is also advantageous in patients with ascites where a transhepatic approach is more difficult.[4]

Antegrade or retrograde insertion of stents

In a retrospective multicenter study there was a higher rate of complications associated with the antegrade insertion of stents compared to retrograde insertion but that difference did not reach statistical significance (32% vs 13.9%, $P = 0.07$).[26]

Is the Segment 2 Intrahepatic Duct (B2) or Segment 3 Intrahepatic Duct (B3) Approach Preferred?

In some studies, B2 was preferentially used[9] while other experts prefer B3.[18,22]

Advantages and limitations of the transduodenal approach

When a transduodenal approach is planned, the scope could have either a long or short position. In a short position, the EUS scope tip is in the second portion of the duodenum aligned at the level of the CBD. Although manipulating the scope is difficult due to limited space and the endoscopic position is somewhat unstable, it is easy to pass the guidewire antegradely through the papilla as the needle is aligned in that direction.[9] In a long position, the tip of the EUS scope is in the duodenal bulb and is near the proximal extrahepatic biliary system. Although it is easy to puncture the biliary system from this location, negotiating a guidewire towards the papilla can be challenging as the FNA needle is aligned to the hepatic hilum.[9]

Challenges

In some situations when manipulation of the guidewire through the papilla fails, even after exchanging the wire for different sizes and/or stiffness, a nasobiliary drain can be inserted through the enterobiliary tract due to the large diameter of the bile duct and the guidewire is removed. The nasobiliary drain is left in place for a few days till the biliary system is decompressed and a second attempt is made. For the exchange of the nasobiliary drain in the second attempt of EUS-BD, a guidewire is inserted through the nasobiliary drain till it is seen in the biliary system under fluoroscopic guidance, and then the wire is exchanged.

Trouble Shooting

When puncturing the CBD is difficult from the short transduodenal approach then changing to the long position could result in success.[9]

During an EUS-RV procedure if a short guidewire is used after the puncture of the biliary system with the EUS-FNA needle and the EUS scope is withdrawn, the proximal end of the wire can be held with a forceps and advanced into the EUS scope channel while withdrawing the scope till the wire is secured at the tip of the scope outside the body of the patient.

The guidewire might get sheered while manipulated through the FNA needle thus uncoated guidewires might be preferred or exchanging the needle for a catheter prior to further manipulation[15,19] as well as the use of blunt tipped EUS needles.[30] Some have also advocated the use of guidewires that have a coil cover that would prevent sheering.[22] The same issue is true when the wires form a knot.[19] It is not uncommon (up to 57%)[9] that the guidewire needs to be exchanged to negotiate through a stricture or the papilla. During a EUS-RV if grasping the guidewire and retrieving it through the channel of the duodenoscope is difficult then cannulating the CBD with a sphincterotome alongside the wire placed by the EUS-RV could be attempted.[15] If that fails,the guidewire is grasped, either with a forceps or snare, and pulled out through the mouth with the duodenoscope as one unit. The duodenoscope is then back loaded over the guidewire outside the patient's body and then advanced to the ampulla and the procedure is carried out in a normal fashion.[20]

In cases of EUS-AG where the EUS-BD puncture site is small or in cases where the biliary duct is tortuous a SEMS with a small introducer might be used to ease its manipulation.[15]

When the EUS-BD procedure is non-successful an immediate attempted ERCP or PTBD might decrease potential complication.[15,31]

Metal vs Plastic Stents

It has become more common to use metal stents (either fully or partially covered) rather than plastic ones as they tend to have a longer patency as well as the large diameter after expansion and can possibly decrease the occurrence of biliary leaks as well as pneumopertoneum but have the risk of migration.[32] In a multicenter Japanese study, they found that there was a higher rate of leaks when plastic stents were used as opposed to SEMS (11.4%

vs 3.8%).[25]

There has been a newly developed plastic stent designed specifically for the use in EUS-HGS with a tapered distal end, a pigtail proximal configuration and flanges on both ends of the stent[6] as well as a SEMS with dual flaps.[33] Also, there have been developments with the use of dedicated metal stents for EUS-BD including the lumen opposing AXIOS™ stents.[24,34–36]

Uncovered, Partially or Fully Covered SEMS

The use of fully covered SEMS has the advantage of possibly decreasing the incidence of bile leaks but at the same time could potentially cause side branch biliary obstruction. In such a cases, a partially covered SEMS might be preferable especially when the distance between the point of access of the EUS-CDS is close to the hilum of the liver.[22] When a fully covered SEMS is used, care should be taken that the proximal portion of the SEMS does not extend into the hilum.[18] The use of uncovered SEMS has the potential of causing bile leaks that could have a significant morbidity and possible mortality.[37]

There is a randomized trial underway to assess the efficacy and safety of EUS-BD using a partially covered SEMS with a dedicated introducer for EUS-BD or a fully covered anti-migration SEMS in malignant biliary obstruction.

Length of the Stents

Paik et al[33] derived a formula to estimate the required stent length for use during a EUS-HGS;

SEMS length = (length of the EUS needle between gastric wall and punctured left hepatic duct on the EUS in cm × 2) + 1

The length of the needle represents the intrahepatic portion of the stent while the duplication accounts for the intraluminal part and the addition of one centimeter is for potential stent shortening.

Managing Blocked Stents

Plastic stents

When a EUS-CDS is occluded it can be exchanged by using an ERCP catheter to insert a 0.035-inch guidewire into the CBD through the blocked stent. The ERCP catheter is then removed keeping the guidwire in place. A snare is then advanced over the wire after inserting the wire through the loop of the snare prior to inserting it into the channel of the scope. The occluded stent is then grasped and removed while keeping the guidewire in place and a new stent is inserted into the CBD over the guidewire.[38]

Complications

Potential complications to these EUS-BD procedures include; Infections (this includes peritonitis, pancreatitis, as well as cholangitis), bleeding, pneumoperitoneum, bile leaks, pain, as well as pancreatitis.[9,14]

In the case of EUS-GBD potential complications include bile leakage, migration of the stent either into the gallbladder or the intra-abdominal cavity, deviation of stent from the gallbladder, hemorrhage, and perforation.[23] Late potential adverse events include stent occlusion causing acute cholecystitis.[23]

Factors associated with a higher complication rate, although statistically insignificant, include proximal biliary obstruction compared to distal obstruction (38.4% vs 16.3%, $P = 0.09$) as well as a direct BD procedure as compared to EUS-RV (22.9% vs 15%, $P = 0.35$).[26]

One complication of EUS-HGS is the migration of stents out of the stomach and into the peritoneum, which could have a fatal outcome. A locking stent method has been used in an attempt to avoid that whereby an uncovered SEMS is initially deployed from the proximal CBD till the periphery of segment B3 and then a second end-bare covered SEMS is coaxially deployed into the first SEMS and extends into the stomach.[39] Although none of the patients who had the locking stent method used had complications compared to the standard technique, this study was retrospective and had a small number of patients.[39] Another development to prevent the same complication is a newly developed partially covered SEMS with a silicone-covered distal portion and a covered proximal portion with anti-migrating flaps to prevent proximal or distal migration.[40]

EUS–BD Compared to PTBD

An RCT comparing PTBD and EUS-CDS found that they were similar in success, complications as well as cost, but this study had a small sample size and might have been underpowered to detect these differences.[41]

In a single-center retrospective study that compared EUS-BD with PTBD in patients with malignant biliary obstruction, the success rate for insertion of an internal biliary stent was higher with an EUS-BD compared to PTBD (92% vs 46%, $P < 0.05$).[42] Furthermore, when an internal drain was planned, the procedure was completed in a single session more often in the EUS-BD group compared to the PTBD group (92% vs 27%, $P < 0.05$).[42] Of note, there was a death in the EUS-BD group due to biliary sepsis and peritonitis while two deaths from infected ascites in the PTBD group and the overall complication rate was higher in the PTBD compared to EUS-BD (46% vs 20%, $P < 0.05$).[42] The low success rate for the PTBD procedure in the aforementioned study could be related to complex biliary tumors as well as concomitant duodenal obstruction which is more challenging and could be affected by limited experience in PTBD in that center.[42] In this study the investigators preferred a EUS-CDS over an EUS-HGS or EUS-AG when possible.[42] A retrospective study comparing EUS-BD to PTBD found that PTBD had a higher technical success (100% vs 86.4%, $P < 0.01$), but a higher adverse event during the index and reinterventions procedure (70.6% vs 18.2%, $P < 0.01$).[11] Furthermore, PTBD had a similar clinical success rate to EUS-BD (92.2% vs 86.4%, $P = 0.4$)[11] but the total charges were two times higher in the PTBD group compared to EUS-BD (9,218 ± 3,772 USD vs 18,261 ± 16,021 USD, $P < 0.01$).[11] In a narrative review, the overall success and complication rates for EUS-CDS is 95% and 19%, EUS-HGS is 87% and 27%, EUS-RV is 81% and 11%, while for EUS-AG it is 77% and 5%, respectively.[32] In the same review it was noted that the success rate for EUS-RV that utilized an extrahepatic approach was higher (87%) compared to when a transhepatic approach was used.[32]

Distal biliary obstruction is a predictor for stent blockage ($P = 0.02$) in cases of PTBD and thus reintervention.[43] In such cases, EUS-BD might be a favorable procedure.[26]

Some randomized trials are currently underway comparing percutaneous drainage to EUS-BD as well as a large multicenter cohort study.

There is a current randomized trial underway comparing EUS-GBD to percutaneous cholecystostomy in cases of inoperable acute cholecystitis and a second one that has already been completed.

EUS–RV Compared to Precut Papillotomy

In a retrospective study by Dhir et al,[8] the success rate of EUS-RV was higher than that of a precut papillotomy after five failed attempts of cannulation (98% vs 90.3%, $P = 0.03$) and the rate of complications was not different (3.4% vs 6.9%, $P = 0.27$). Notably, when comparing the overall success of the precut papillotomy after a second ERCP attempt to EUS-RV there was no difference (95.8% vs 98.3%, $P = 0.35$). One of the strengths of this study is that it included different causes of biliary obstruction like malignant and benign strictures as well as CBD stones. Nonetheless, the study did have limitations including that it was a single center study with experienced endoscopists as well as the EUS-RV population was compared to a historical cohort of patients.[8,44]

EUS–BD Compared to a Difficult ERCP

In a multicenter retrospective study the insertion of SEMS in patients with distal malignant biliary obstruction, there was no difference in the technical and clinical success rate when comparing ERCP to EUS-BD, (94.2% vs 93.3%, $P = 1.0$) and (91.3% vs 89.4%, $P = 0.81$), respectively.[13] Furthermore the adverse events in both groups did not differ (8.7% in both). Although no cases of pancreatitis had occurred in the EUS-BD group compared to 4.8% in the ERCP group, this difference did not reach statistical significance ($P = 0.59$). In this study, the EUS-BD procedures included either EUS-AG or EUS-CDS and were performed in those who had failed at least one ERCP, while the ERCP group was composed of those with difficult cannulation (defined as the use of a precut or double wire technique to gain access or requiring a pancreatic stent to be inserted).[13] Although this study does have limitations (performed by highly experienced centers and the use of multiple centers for cases and a single center for controls), nonetheless the results are encouraging for adopting EUS-BD with stenting in this selected population. This is even more evident in cases with duodenal stenosis where EUS-BD is clearly better than ERCP (technical success 91.7% vs 57.1%, $P = 0.03$).

EUS–AG Stenting Compared to ERCP

There is a randomized trial that is underway to assess the difference in stent patency as well as the complications between these methods.

Who Should Perform These Procedures?

The consortium meeting that was held in 2011 recommended that these procedures should be performed by endoscopists who perform pancreatobiliary EUS and FNA for 4 to 5 years with a volume of 200 to 300 EUS and ERCP procedures a year and a success rate of 95% to 98% for standard ERCPs.[4] In a study by Park et al,[15] there was no difference in the success or complication rates or in the procedure time for EUS-BD over a pre-designated number of cases suggesting that proficiency in EUS and ERCP might suffice in performing these procedures. In contradistinction, a retrospective study by Poincloux et al[18] found that their first 50 cases had 5 mortalities as compared to one in the subsequent 51 cases. Also, it is a prerequisite to have an interventional radiology as well as hepatobiliary surgery service.[4] Although Vila et al[28] demonstrated that the performance of EUS-BD was possible in community hospitals with a low volume of cases, which came with the expense of a lower technical and clinical success rate, 67.2% and 63.2% respectively, as well as a higher complications rate 23.2%.

Conclusion

EUS-BD is a promising alternative in this well-defined population of patients. The benefits obtained and the possible drawbacks are augmented by proper choice of indications and planning and by having an established team and proper supportive services. There still remains challenges in the form of development of specifically designed accessories[40] and possibly echoendoscopes.[45]

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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