REVIEW

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Advances in Endoscopic Ultrasound-Guided Biliary Drainage: A Comprehensive Review

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Endoscopic retrograde cholangiopancreatography (ERCP) has become the first-line therapy for bile duct drainage. In the hands of experienced endoscopists, conventional ERCP results in a failed cannulation rate of 3% to 5%. This failure can occur more commonly in the setting of altered anatomy or technically difficult cases due to either duodenal or biliary obstruction. In cases of ERCP failure, patients have traditionally been referred for either percutaneous transhepatic biliary drainage (PTBD) or surgery. However, both PTBD and surgery have higher than desirable complication rates. Within the last decade, endoscopic ultrasound-guided biliary drainage (EUS-BD) has become an attractive alternative to PTBD after failed ERCP. Many groups have reported on the feasibility, efficacy and safety of this technique. This article reviews the indications for ERCP and the currently practiced EUS-BD techniques, including EUS-guided rendezvous, EUS-guided choledochoduodenostomy and EUS-guided hepaticogastrostomy. **(Gut Liver 2013;7:129-136)**

Key Words: Endoscopic retrograde cholangiopancreatography; Endoscopic ultrasound; Self expanding metal stent

INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) is considered first line therapy for drainage of the biliary tree.[1] When ERCP is unsuccessful, the next step is referral to a more experienced endoscopist.[2,3] Repeat ERCP at a referral center is successful in 85% to 98% of cases when initial ERCP was unsuccessful. Failed biliary cannulation in the hands of an experienced endoscopist is usually due to either anatomical variation after surgery or from tumor infiltration.[1] Traditionally those patients have been managed with percutaneous transhepatic biliary drainage (PTBD) or surgery.[4-6] The potential complications associated with these procedures, along with the patient dissatisfaction associated with external drainage make these options less desirable.[7,8]

In recent years, endoscopic ultrasound (EUS) has evolved from a purely diagnostic procedure to a therapeutic one. Wiersema *et al*.[9] first reported EUS-guided cholangiopancreatography in 1996. Subsequently, EUS-guided cholangiopancreatography followed by biliary drainage (BD) has been performed with many case reports and series confirming both the success and safety of this technique.

EUS-BD offers several advantages over both PTBD and surgery. First, EUS-BD can be performed at the time of the initial ERCP, without a need for further delay or additional procedures. In addition, EUS-BD provides internal drainage as opposed to the external biliary drain that accompanies PTBD and has been associated with significant patient dissatisfaction.

Surgery to provide BD can also have considerable negative consequences on a patient's health and recovery. Indeed, surgery requires a longer recovery time. In patients with malignant biliary obstruction who already have a poor prognosis and short life expectancy, the invasive nature, longer recovery and delay in chemotherapy make surgery a less attractive option.

INDICATION

While many investigators have reported that EUS-BD can be utilized when standard ERCP is unsuccessful, indications for EUS-BD have not been established.[10] Consideration for EUS-BD should be given any time successful cannulation of the bile duct cannot be achieved. In the hands of a skilled endoscopist, the most frequent causes of unsuccessful cannulation of the bile duct are surgically altered anatomy or obstruction of the

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intestine or bile duct.[11,12] Common reasons for surgically altered anatomy can be encountered in patients after bariatric surgery or after intestinal diversion for pancreatic cancer or other diseases and include Billlroth II, Roux-en-Y, and biliopancreatic diversions.

Obstruction of the gastrointestinal (GI) tract is most often due to malignant causes. Tumor infiltration can preclude successful cannulation of the bile duct either at the level of the duodenum, such as is seen in a patient with gastric outlet obstruction, or at the level of the ampulla or bile duct itself.

Another situation where EUS-BD may prove to be useful is with an unusually difficult cannulation associated with a periampullary diverticulum. In this case, a EUS-guided "rendezvous" can be performed resulting in passage of a transpapillary guidewire and then conversion to and completion of ERCP by the conventional route. Briefly, the following are the indications for EUS-BD: 1) failed conventional ERCP; 2) altered anatomy; 3) tumor preventing access into the biliary tree; 4) contraindication to percutaneous access (i.e., ascites, etc.).

MATERIALS AND INSTRUMENTS

It is important to ensure that all required equipment is in the room prior to puncture of the bile duct. Once the bile duct has been accessed via EUS, it is crucial to proceed in an expeditious manner without any additional or unnecessary manipulation of the guidewire or needle to decrease the chances of losing of access and complications.

1) Fluoroscopy: This should be set up prior to start of procedure. Fluoroscopy can be used to facilitate angle of bile duct puncture, which should be as much in the direction of cephalad to caudad as possible to facilitate transpapillary passage of guidewire. The fluoroscopy image should be centered with the tip of the scope, bile ducts, and duodenum all in view.

2) Contrast for cholangiography

3) Plenty of water to flush catheters and hydrophilic wires

4) Echoendoscopes with a 3.8-mm working channel to avoid being limited in catheters and stents diameter. In addition, duodenoscope if possibility of rendezvous technique and conversion to retrograde procedure.

5) Fine needle aspiration (FNA) needles: 19 gauge (G) FNA needles are preferred over 22 G since they allow manipulation of 0.035-inch guidewires.

6) Hydrophilic 0.035-inch guidewires are preferred due to their ease of manipulation and ability to support a variety of catheters and stents. In addition, it is important to use uncoated wires when possible due to the "shearing" effect that the FNA needle can have on the coating of the guidewire.

7) Bougie catheters and dilating balloons: Either a 4 to 6 mm wire-guided hydrostatic dilating balloon catheter or a 6 to 7 Fr dilating bougie.

8) A rotatable sphincterotome or bending catheter with ability to bend and change direction should be available in the event that the wire needs to be redirected to facilitate transpapillary passage of wire.

9) Stents (refer to discussion below regarding placement of plastic versus metal stents)

TECHNIQUES

1. EUS-guided rendezvous

EUS-BD is typically performed utilizing either the EUS-guided rendezvous technique or by creating a tract from either the stomach or the duodenum into the bile ducts. When the duodenoscope can be advanced to the level of the ampulla it is preferable to attempt an EUS-guided rendezvous. In this procedure, under EUS and Doppler guidance, a needle is inserted into either a left intrahepatic duct or common bile duct. We find it most helpful to have the scope in the duodenal bulb and then under

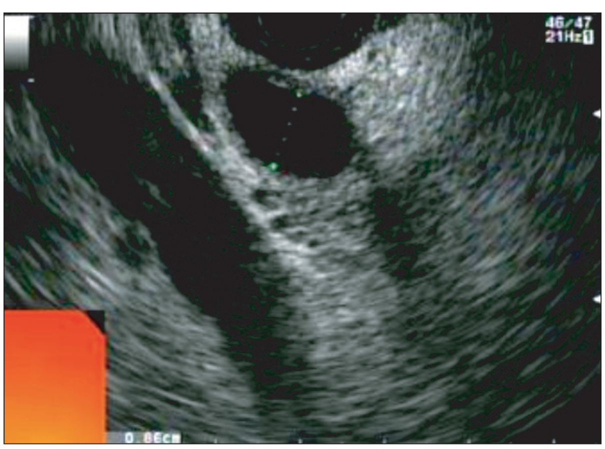

Fig. 1. Measurement of the common bile duct (8.6 mm) by ultrasonography prior to puncture.

Fig. 2. Fluoroscopic image of the guidewire advanced antegrade into the common bile duct.

fluoroscopic guidance to visualize the FNA needle pointing caudad toward the ampulla prior to accessing the duct with the FNA needle (Fig. 1). This "caudad" position of the FNA needle facilitates advancing the guidewire distally into the duodenum (Fig. 2). Once insertion into the duct is suspected by EUS imaging, a syringe is attached to the FNA needle and bile aspiration is performed to confirm position. Next, injection of contrast through the FNA needle provides a cholangiogram. Following cholangiogram, the FNA needle is flushed water and then the guidewire is inserted through the FNA needle with the goal being to advance the wire beyond the ampulla, into the duodenum and to convert to conventional ERCP in a retrograde fashion. It is crucial to flush the FNA needle with water prior to insertion of the guidewire and to carefully manipulate the wire to avoid unnecessary friction between the guidewire and FNA needle. When the wire is being advanced, it should be advanced with enough speed to maximize likelihood of crossing the stricture. If the wire must be pulled back, this should be done cautiously and aborted at the moment any resistance is met. Once the wire is in the bile duct, if transpapillary passage is not achieved, the FNA needle should be exchanged for a sphincterotome or dilating bougie (Fig. 3). At this point, the wire can be manipulated back and forth safely to facilitate passage beyond the ampulla.

If the rendezvous technique is chosen, one end of the guidewire wire is left in the duodenum during subsequent endoscope exchange. The EUS scope is then removed leaving the guide wire in place (Fig. 4). Following removal of the echoendoscope, a duodenoscope is advanced to the ampulla. The guidewire in the duodenum is then grasped with a snare or forceps and pulled back through the working channel of the duodenoscope for subsequent over-the-wire cannulation. Since access to the common bile duct is now achieved, the procedure can be converted and completed by conventional endoscopic retrograde cholangiography (ERC) with stent placement in retrograde manner (Figs 5 and 6). Alternatively, the guidewire can be left in place, the echoendoscope can be removed, and a duodenoscope can be used to cannulate next to the prior placed guidewire.

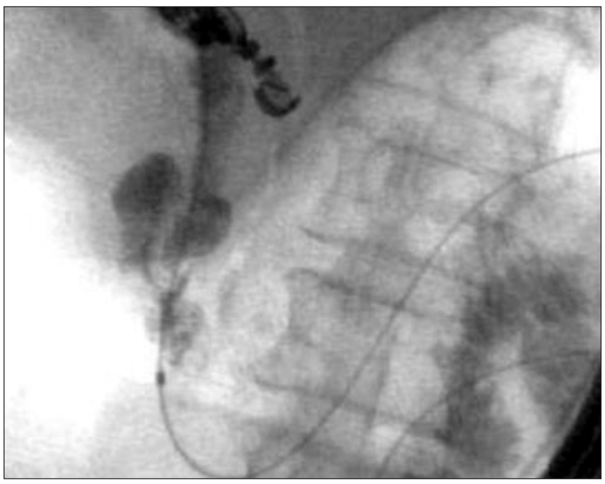

Fig. 3. Fluoroscopic image of a dilating catheter advanced across the distal biliary stricture.

Fig. 5. Endoscopic images of the guidewire crossing the ampullary orifice hidden in a diverticulum.

Fig. 4. Fluoroscopic images of the guidewire left in place after removal of the echoendoscope to permit a rendezvous.

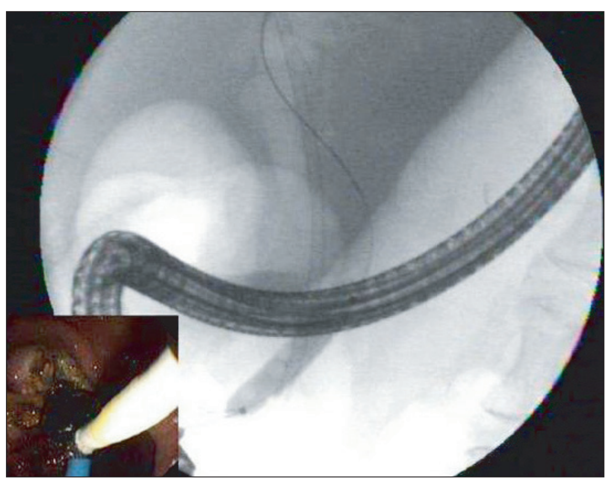

Fig. 6. Fluoroscopic images of stenting and dilation in a retrograde manner after rendezvous.

If during this "rendezvous" technique, however, the guidewire cannot be advanced beyond the ampulla and into the duodenum, a transenteric tract must be created into the bile duct. This can be accomplished by dilating over the guidewire with a 4 to 6 mm wire-guided balloon catheter or a 6 to 7 Fr dilating bougie followed by stent placement in an anterograde manner.[13]

2. EUS-guided choledochoduodenostomy (EUS-CDS) and EUS-guided hepaticogastrostomy (EUS-HGS)

When the transpapillary approach utilizing an EUS guided rendezvous procedure cannot be performed, either the transgastric-transhepatic (intrahepatic) or transenteric-transcholedochal (extrahepatic) approach must be used. In these cases, EUS is used to guide the creation of a tract between the bile ducts and digestive tract by either performing an EUS-CDS or an EUS-HGS.[14]

The intrahepatic approach is performed via the neighboring GI tract (usually the cardia or in the lesser curvature of the stomach) to allow visualization of the left intrahepatic bile ducts.[15] After checking local vasculature with color flow Doppler (Fig. 7) the EUS needle is then advanced into an intrahepatic duct. This is followed once again by bile aspiration, cholangiogram, and advancement of guidewire with fluoroscopic guidance across the ampulla and into the duodenum (Figs 8 and 9). Then in an antegrade manner, a 6 or 7 Fr bougie or dilating catheter is inserted over the guidewire to dilate the tract followed by antegrade stent deployment with drainage into the stomach (Fig. 10).

In the extrahepatic approach, the EUS needle is inserted directly into the common bile duct and the guidewire is advanced in an antegrade fashion across the ampulla and into the duode-

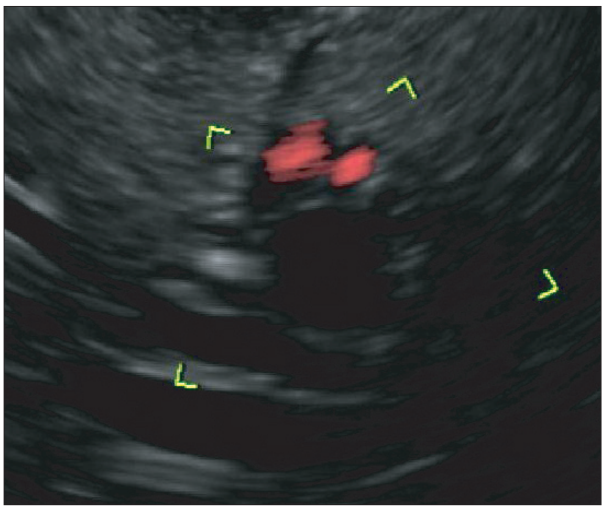

Fig. 7. Color-flow Doppler of the left hepatic duct prior to puncture.

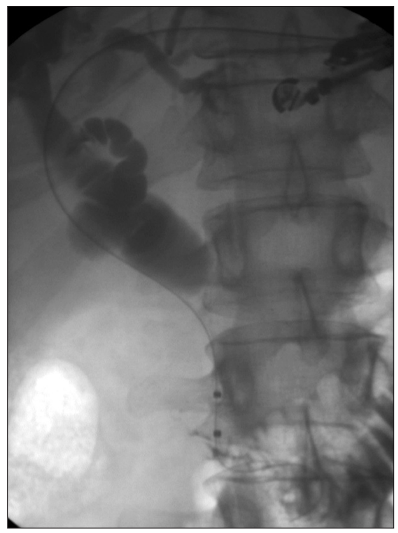

Fig. 9. Advancement of the guidewire across the ampullary orifice after crossing a distal biliary obstruction.

Fig. 8. Access into the left hepatic duct using a hydrophilic guidewire.

Fig. 10. Deployment of a metal stent across the obstruction.

Table 1. Published Data on Endoscopic Ultrasound-Guided Biliary Drainage Using an Extrahepatic Approach

Author (yr)	No./Total sample	Method	Disease	Approach	Initial stent	Success rate, %	Complication
Giovannini *et al*. (2001)[15]	1/1	Direct (1)	Malig. (1)	Duodenum	PS (1)	100	None
Burmester *et al*. (2003)[16]	3/4	Direct (4)	Malig. (4)	Duodenum (2), stomach (1) Jejunum (1)	PS (3)	75	Bile leak (1)
Mallery *et al*. (2004)[23]	2/2	Rendezvous (2)	Malig. (2)	Duodenum (2)	MS (2)	100	None
Lai *et al*. (2005)[24]	1/1	Rendezvous (1)	Malig. (1)	Duodenum (1)	MS (1)	100	None
Puspok *et al*. (2005)[11]	6/6	Direct (6)	Malig. (5), Benig. (1)	Duodenum (5) Jejunum (1)	PS (5), MS (1)	83	Subacute phlegmonous cholecystitis (1)
Kahaleh *et al*. (2006)[13]	10/23	Direct (2), rendezvous (7)	Malig. (8), Benig. (2)	Duodenum (5) Jejunum (5)	PS (4), SEMS (5)	90	Bile leak (1) Pneumoperitoneum (2)
Will *et al*. (2007)[25]	8/8	Direct (8)	Malig. (7), Benig. (1)	Stomach (4), jejunum (3), esophagus (1)	PS (2), MS (5)	88	Slight pain (2), cholangitis (1)
Tarantino *et al*. (2008)[26]	8/8	Direct (4), rendezvous (4)	Malig. (7), Benig. (1)	Duodenal (8)	PS (8)	100	None
Yamao *et al*. (2008)[27]	5/5	Direct (5)	Malig. (5)	Duodenal (5)	PS (5)	100	Pneumoperitoneum (1)
Brauer *et al*. (2009)[28]	12/12	Direct (4), rendezvous (7)	Malig. (8), Benig. (4)	N/A	PS (5), SEMS (5)	92	Pneumoperitoneum (1), respiratory failure (1)
Hanada *et al*. (2009)[29]	4/4	Direct (4)	Malig. (4)	Duodenal (4)	PS (4)	100	None
Horaguchi *et al*. (2009)[12]	9/16	N/A	Malig. (9)	Duodenal (8) Stomach (1)	PS (14), plastic PT (1), nasobiliary tube (1)	100	Peritonitis (1)
Maranki *et al*. (2009)[22]	14/49	Direct (6), rendezvous (8)	Malig. (9), Benig. (5)	N/A	N/A	86	Biliary peritonitis (1), abdominal pain (1), and oneumoperitoneum
Kim *et al*. (2010)[30]	15/15	Rendezvous (15)	Malig. (10), Benig. (5)	Duodenum (15)	PS (4), MS (8)	80	Pancreatitis (1)
Nguyen-Tang *et al*. (2010)[18]	1/5	Rendezvous (1)	Malig. (1)	N/A	SEMS (1)	100	None
Park do *et al*. (2011)[17]*	31/57	Direct (31)	Malig. (51) Benig. (6)	Duodenum (31)	PS (6), SEMS (25)	87	Pneumoperitoneum (6), mild bleeding (2)
Fabbri *et al*. (2011)[19]	16/16	Direct (13), rendezvous (3)	Malig. (16)	Duodenum (15) Stomach (1)	SEMS (12)	75	Pneumoperitoneum (1)
Hara *et al*. (2011)[20]*	18/18	Direct (18)	Malig. (18)	N/A	PS (17)	94	Peritonitis (2), bleeding (1)
Ramírez-Luna *et al*. (2011)[32]	9/11	Direct (9)	Malig. (9)	Duodenum (9)	Plastic DPT (9)	89	Biloma (1)

PS, plastic stents; PT, pigtail; DPT, double pigtail; SEMS, self-expanding metal stents; MS, metal stents; Malig., malignant; Benig., benign; N/A, not applicable.
*Prospective study.

num. The remainder of the procedure at this point is the same as that performed with the intrahepatic approach,[16] with deployment of the stent in the duodenum.

3. Plastic versus metal stents

Both plastic and metal stents have been used during EUS-BD. Initially, plastic stents were primarily used, but more recently reported cases have been published using self-expandable metallic stents (SEMSs).[17-20] Although no comparative studies exist, a metal stent with a larger diameter is expected to offer longer lasting patency than that of a plastic stent in EUS-BD procedures.[17] If there is concern regarding stent migration, a double pigtail plastic stent can be placed inside of the metal stent, with the pigtails functioning as anchors. Based on the same principle, double pigtail stents should also be used if plastic stents are being placed without SEMS.

In cases of stent malfunction, stent exchange is required. After maturation of the fistula, the stent can be exchanged if necessary. One option is to remove the prior stent and then to recannulate the hole of the sinus tract with a guidewire, and then place a stent over the guidewire. Fujita *et al.*[21] reported a new method (the snare-over-the-wire technique) for safe exchange of a stent deployed by EUS-BD.

RESULTS OF PUBLISHED DATA

To date the data for EUS-BD is limited by mostly retrospective studies including small numbers of patients, the results are promising. The overall success rate for EUS-BD is around 90% (range, 75% to 100%). Major complications such as perforation, peritonitis and bleeding requiring surgery are uncommon. While post procedural pneumoperitoneum and pain were seen, these were also relatively uncommon and were able to be managed conservatively.[22]

The results of published data are summarized in Tables 1 and 2.[11-13,15-20,22-32]

1. Adverse events

The following EUS-BD related adverse events have been reported in the literature: 1) infection (peritonitis, pancreatitis, cholangitis, etc.); 2) bleeding; 3) pneumoperitoneum (which can be managed conservatively); 4) bile leak; 5) pain.

Potential adverse events include perforation and sepsis. The adverse events have not been observed or reported, but could occur due to technical aspects or comorbidities.

Based on published studies, the overall rate of complications related to EUS-BD seems lower than alternate treatment options. However, a larger sample size or a multicenter trial (preferably with randomization) is needed to confirm the complications rates.

Table 2. Published Data on Endoscopic Ultrasound-Guided Biliary Drainage Using an Intrahepatic Approach

Author (yr)	No./Total sample	Method	Disease	Approach	Initial stent	Success rate, %	Complication
Burmester *et al.* (2003)[16]	1/4	Direct (1)	Malig. (1)	Stomach (1)	PS (1)	100	Bile leak (1)
Kahaleh *et al.* (2006)[13]	13/23	Direct (1), rendezvous (12)	Malig. (9), benig. (4)	Stomach (13)	PS (6), SEMS (6)	92	Minor bleeding (1)
Bories *et al.* (2007)[31]	11/11	Direct (9) Transpapillary (2)	Malig. (3), benig. (8)	Stomach (3), duodenal (3), stenosis (5)	PS (7), MS (3)	91	Transient ileus (1), biloma (1), Cholangitis (1)
Horaguchi *et al.* (2009)[12]	7/16	N/A	Malig. (7)	Stomach (5), esophagus (2)	PS (2), SEMS (5)	100	None
Maranki *et al.* (2009)[22]	35/49	Direct (9), transpapillary (24)	Malig. (26), benig. (9)	N/A	N/A	83	Self-resolving bleeding (1), pneumoperitoneum (3), aspiration pneumonia (1)
Nguyen-Tang *et al.* (2010)[18]	4/5	Rendezvous (4)	Malig. (3), benig. (1)	Duodenum (1) Stomach (3)	SEMS (5)	100	None
Park do *et al.* (2011)[17]*	31/57	Direct (31)	Malig. (51) Benig. (6)	Duodenum (31)	PS (6), SEMS (25)	87	1 Pneumoperitnoeum 2 Bile peritonitis
Ramirez-Luna *et al.* (2011)[32]	2/11	Direct (2)	Malig. (2)	Stomach (2)	Plastic DPT (2)	100	Stent migration (1)

PS, plastic stents; PT, pigtail; DPT, double pigtail; SEMS, self-expanding metal stents; MS, metal stents; Malig., malignant; Benig., benign; N/A, not applicable.
*Prospective study.

DISCUSSION

EUS-guided cholangiopancreatography holds promise as a technique for gaining access and draining the bile ducts when conventional ERCP has failed. In experienced hands EUS-BD is a safe, feasible, and effective alternative to PTBD in cases with malignant and benign biliary tract obstruction.

Since this is a technique in evolution, several issues still need to be established. Currently it remains uncertain whether the intrahepatic approach or extrahepatic approach is preferable. Our group demonstrated that the extrahepatic approach carried a greater risk of complications in comparison to the intrahepatic approach.[13] The results in Tables 1 and 2, however, suggest that the extrahepatic approach has higher success rates compared with the intrahepatic approach without additional risk. The transbulbar route is easier and safer because the distance between the duodenum and the bile duct is short, the duodenal wall is thin and without any major intervening vascular structures, and the direction of the puncture is caudal towards.

Itoi *et al*.[33] reported that the limitations of the intrahepatic approach technique included, 1) nonapposed gastric wall and left liver lobe, resulting in possibility of procedure failure, 2) risk of mediastinitis with a transesophageal approach, 3) difficulty of puncture in case of liver cirrhosis, 4) risk of injuring the portal vein, and 5) the use of small-caliber stents or SEMS with a small-diameter delivery.

EUS-guided rendezvous with conversion to conventional ERC should always be attempted when ERC fails but the duodenoscope can be advanced to the ampulla. When a EUS-guided rendezvous is unsuccessful or not able to be performed, a transduodenal (extrahepatic) or transgastric (intrahepatic) method can be performed.

EUS-BD is contraindicated in patients who have intolerance to endoscopy, or uncorrected coagulopathy. EUS-BD may not be feasible if there is a poor angle for endosonograpphy access.

In conclusion, the high success rates reported in the literature would support that EUS-BD is a technically feasible and effective procedure. This technique offers a clear alternative to both the percutaneous and surgical approaches in patients in whom conventional ERCP is unsuccessful or not possible. This procedure, however, should be reserved for endoscopists who are highly skilled at both EUS and ERCP at tertiary centers. Multiple questions remain related to this technique as to what nomenclature to use, how training should be offered, how to capture all cases performed, how to grant privileges, and how to secure reimbursement. A consortium meeting was held in Chicago in May 2011 and has started shaping the discussion of this technique.

CONFLICTS OF INTEREST

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

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