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REVIEW

EUS-Guided Biliary Drainage: A Review Article

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ABSTRACT

Context To demonstrate a comprehensive review of published articles regarding EUS-guided biliary drainage. **Methods** Review of studies regarding EUS-guided biliary drainage including case reports, case series and previous reviews. **Results** EUS-guided hepaticogastrostomy, choledochoduodenostomy and choledochoantrostomy are advanced procedures on biliary and pancreatic endoscopy and together make up the echo-guided biliary drainage. Hepaticogastrostomy is indicated in cases of hilar obstruction, while the procedure of choice is choledochoduodenostomy in distal lesions. Both procedures must be done only after unsuccessful ERCP. The indication of these procedures must be made under a multidisciplinary view while sharing information with the patient or legal guardian. **Conclusion** Hepaticogastrostomy and choledochoduodenostomy are feasible when performed by endoscopists with expertise in biliopancreatic endoscopy and advanced echo-endoscopy and should be performed currently under rigorous protocol in educational institutions.

INTRODUCTION

Endoscopic biliary stenting at ERCP is a well-established therapy for both benign and malignant biliary obstruction [1, 2, 3]. To overcome ERCP failures and improve outcomes over those afforded by more invasive alternatives (percutaneous transhepatic biliary drainage and surgery) EUS-guided ductal access techniques paired with standard ERCP drainage techniques have been developed in the last decade. This hybrid procedure is given a variety of names, but the more encompassing one is endosonographic cholangiopancreatography [4]. Based on the combination of the three possible access routes (intrahepatic bile duct, extrahepatic bile duct, and pancreatic duct) with the three possible drainage routes (transmural, transpapillary antegrade and transpapillary retrograde), endosonographic cholangiopancreatography admits nine variant approaches, six for the bile duct and three for the pancreatic duct [5, 6]. The six endosonographic cholangiopancreatography variant approaches to bile duct drainage are also referred to collectively as EUS-guided biliary drainage (EUS-guided biliary drainage). Transmural bile duct drainage under EUS effectively creates a biliodigestive anastomosis, since the stent is placed across the gastrointestinal tract wall and the bile duct.

This article discusses first the EUS-guided biliary drainage technique that provides transmural drainage from an extrahepatic bile duct access route, and is most commonly termed EUS-guided choledochoduodenostomy and the transmural intrahepatic EUS-guided biliary drainage (hepaticogastrostomy) is discussed below.

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EQUIPMENT AND DEVICES

Interventional Echoendoscopes

Around 1990, the Pentax Corporation (Tokyo, Japan) developed an electronic convex curved linear array echoendoscope (FG32UA) with an imaging plane in the long axis of the endoscope and aligned with the instrumentation plane. This echoendoscope, equipped with a 2.0 mm working channel, enabled fine-needle aspiration biopsy under EUS guidance (EUS-FNA). However, the relatively small working channel of the FG32UA was a drawback for therapeutic intervention. As an example, drainage of a non-bulging pseudocyst using this early instrument was soon reported, but it required exchanging the echoendoscope for a therapeutic duodenoscope in order to insert a stent [7]. To enable stent placement using an echoendoscope, interventional echoendoscopes (FG 38X, EG 38UT and EG 3870UTK) were developed by Pentax-Hitachi. The FG 38X has a working channel of 3.2 mm, which allows the insertion of an 8.5 French stent or nasocystic drain. The EG 38UT and EG 3870UTK have larger working channels of 3.8 mm and are equipped with an elevator, thereby allowing the placement of a 10 French stent [8, 9].

The Olympus Corporation (Tokyo, Japan) has also developed convex linear array echoendoscopes. The GFUC 30P has a biopsy channel of 2.8 mm, which enables the placement of 7 French stents or nasocystic catheters. This echoendoscope is also equipped with an elevator. A new prototype, the GFUCT 30, has a larger working-channel of 3.7 mm allowing the placement of a 10 French stent. The main drawback of convex linear array echoendoscopes is the more limited imaging field (120° using the Pentax and 180° using the Olympus) produced by an electronic transducer. The Olympus instruments are coupled with the Aloka (Tokyo, Japan) processor or with a smaller processor EUM-100-Suzie (Olympus, Tokyo, Japan).

Needles and Accessories for Drainage

As already described, needles used for bile duct access under EUS can be categorized into flexible, cautery needles (needle-knives or fistulotomes) and stiff, cutting needles (EUS-FNA needles). Needle knives can be difficult to visualize endosonographically. The “Zimmon” needle-knife (Wilson-Cook Corporation, Winston Salem, NC, USA) has a large gauge needle that is relatively easy to visualize compared to other needle-knives. Cautery is usually required to penetrate through the intervening structures into the bile duct when a needle-knife is used [10]. A cystotome is a more stable diathermic sheath and has a round cutting tip instead of a needle. Cystotomes are commonly used during pancreatic pseudocyst drainage [8]. The caliber used for pseudocyst drainage is usually 8.5 to 10 French. A modified small caliber cystotome (6 French), also referred to as “fistulotome” (Endolflex, Voerde, Germany) is more convenient for EUS-guided biliary drainage.

Standard EUS-FNA needles are well-visualized endosonographically and can be used for non-cautery access to the bile duct. The drawback of the most commonly used EUS-FNA needles is their small caliber (22 or 23 G) allowing only 0.018 inch guidewires. Using a larger 19G FNA needle (Wilson-Cook Corporation, Winston Salem, NC, USA), a 0.0035 inch guidewire can be inserted through the needle into the dilated bile duct. One of the main problems with EUS-FNA needle access to the duct is the difficulty in manipulating the guidewire through the needle. The main trouble is the “stripping” of the wire coating, which in turn risks leaving part of it into the patient. Furthermore, a strip-off or cut-off wire usually prevents stent insertion over it, which results in procedural failure unless a repeat puncture is attempted. As the intrahepatic bile duct rapidly collapses upon initial puncture, and the subsequent contrast or bile extravasation may substantially impair the endosonographic view, repeat puncture is not always feasible when EUS-guided hepaticogastrostomy is the approach to EUS-guided biliary drainage pursued.

EUS-GUIDED CHOLEDOCHODUODENOSTOMY

Rationale

As stated above, EUS-guided biliary drainage is divided by access route into EUS-guided intrahepatic bile duct drainage, where the intrahepatic bile duct is punctured from a transesophageal, transgastric or transjejunal approach, and EUS-guided extrahepatic bile duct drainage, where the common bile duct is punctured from a transduodenal or transgastric approach (usually from the distal antrum). The overall rationale for EUS-guided choledochoduodenostomy is shared by the alternative EUS-guided biliary drainage techniques, and it is threefold: 1) logistic advantage (it can be performed in the same session as the originally failed ERCP without further delay); 2) physiologic advantage (it provides immediate internal biliary drainage without the need for external drains); and 3) anatomic advantage (it can be tailored to the individual patient’s anatomy; the precise imaging afforded by EUS resulting in a potentially less invasive procedure than percutaneous transhepatic biliary drainage).

In addition to the underlying common rationale for EUS-guided biliary drainage implicit in EUS-guided choledochoduodenostomy, there is a specific rationale for it. The common bile duct is more easily imaged under EUS than the intrahepatic bile ducts, in contrast to what happens under transabdominal US. This means that it can be imaged and accessed under EUS without added risks even in patients with minimal or no bile duct dilation. In those patients with dilated bile ducts, the common bile duct is a much more obvious target for puncture than the intrahepatic ducts. This results in faster, cleaner access without repeated puncture attempts, thereby minimizing risks. The retroperitoneal location of the common bile duct makes it also an attractive access site for patients with ascites, in whom fluid around the liver makes transhepatic access (whether percutaneous or transgastric under EUS) more difficult and hazardous.

Besides the advantages of extrahepatic access over intrahepatic access, the specific rationale for EUS-guided choledochoduodenostomy is also derived from the transmural drainage route, as opposed to transpapillary EUS-guided biliary drainage (antegrade or rendezvous). As explained in more detail, antegrade stent insertion from an extrahepatic access site is challenging and has only been reported in two exceptional cases [11, 12]. The real choice between transmural and transpapillary drainage after extrahepatic bile duct access under EUS therefore lies between EUS-guided choledochoduodenostomy and rendezvous. Proponents of rendezvous argue that it may be less invasive than EUS-guided choledocho-duodenostomy since transmural intervention is usually limited to puncture and guidewire passage, then drainage is accomplished retrogradely via ERCP without the need for puncture tract dilation [13]. However, EUS-guided biliary drainage rendezvous carries a 20% failure rate (even in expert centers) because guidewire passage across the stricture and the papilla is often unsuccessful. The needle allows virtually no interplay with the guidewire, which cannot be manipulated across the stricture through a needle in the same way as it can be done at ERCP using flexible catheters. EUS-guided biliary drainage needle-rendezvous (that is, without creating a fistula to allow passage into the bile duct through the puncture tract of flexible devices to help manipulate the guidewire antegradely) may require repeat punctures with different angles or trying different types of guidewires, often resulting in a prolonged, labor-intensive procedure. The second part of rendezvous following antegrade guidewire passage involves scope exchange and guidewire retrieval, and it is also cumbersome and plagued with difficulties. In summary the advantages of EUS-guided choledochoduodenostomy over transpapillary rendezvous are its higher success rate and relative simplicity, which appear to make it a more reproducible approach, despite being perhaps more invasive. Nonetheless, both EUS-guided biliary drainage variant approaches can be considered complementary inasmuch as these procedures are used in a heterogeneous patient population. As we will discuss below, some indications are better suited for EUS-guided choledochoduodenostomy, whereas in other cases EUS-guided biliary drainage rendezvous is clearly advantageous. Similarly, even if rendezvous is the intended drainage technique, EUS-guided choledochoduodenostomy can be used as a second line approach to salvage the significant proportion of failed rendezvous cases [14, 15, 16]. This open-ended approach to EUS-guided biliary drainage (i.e. inclusive of both rendezvous and EUS-guided choledocho-duodenostomy) results in comparatively higher success rates than that of EUS-guided biliary drainage series limiting their approach to just rendezvous [13]. It is important to know that choledochoantrostomy, described by Artifon *et al.* [17], is a new technique that is useful for those patients with duodenal bulb infiltration and should be a new and feasible tool as a variant of choledochoduodenostomy.

Technical Data, Discussion of Possible Therapies and Recommendation of the Prosthesis, and Practical Recommendations for Proposed Endoscopic Techniques

Indication

In common with other EUS-guided biliary drainage techniques, EUS-guided choledochoduodenostomy should only be considered in patients with confirmed (not just suspected) biliary obstruction after failed ERCP despite maximal attempts by experienced operators. General patient, operator and equipment requirements are the same as for other EUS-guided biliary drainage techniques. However, EUS-guided choledochoduodenostomy has specific anatomic requirements differing from other EUS-guided biliary drainage alternatives. The first anatomic requirement is distal biliary obstruction. In other words, EUS-guided choledochoduodenostomy is not suitable for proximal (hilar) biliary obstruction, where intrahepatic EUS-guided biliary drainage approaches are clearly required. The second anatomic requirement is the ability to image under EUS the common bile duct. Since the common bile duct is typically imaged from the distal stomach or the duodenal bulb, this is difficult to impossible in patients with prior gastrectomy and gastrojejunostomy (e.g., Roux-en-Y) [18].

Finally, as with most other EUS-guided biliary drainage approaches, EUS-guided choledochoduodeno-stomy is predominantly used in patients with malignant biliary obstruction. But whereas alternative approaches such as rendezvous may rightly be considered after failed cannulation in patients with documented benign causes of biliary obstruction (e.g., common bile duct stones or papillary stenosis), EUS-guided choledocho-duodenostomy is less adequate in these distinct settings, where biliary drainage is usually accomplished by means of sphincterotomy (with or without stone removal) as opposed to stenting.

Procedure

As stated above, puncture of the common bile duct from the duodenum (EUS-guided choledochoduodeno-stomy) is the most common approach. A similar approach from the stomach (EUS-choledocho-gastrostomy or EUS-choledochoantrostomy) may also be used in selected instances depending on the patient’s anatomy (see below). The common 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 the long scope position is toward the hilar (proximal) bile duct. The direction of the needle in the short scope position is toward the lower (distal) bile duct. The correlation between scope position and needle orientation is not always straightforward. Anatomic distortion may make necessary additional fine adjustments involving torque of the echoendoscope shaft and/or the control wheels. The orientation of the needle can be checked with fluoroscopy before the puncture is actually carried out. It is relevant to do so, because an upward needle orientation makes EUS-CDS easier, since it tends to decrease the angle for transmural stent advancement over the guidewire into the bile duct. Conversely, a downward needle orientation is sought when rendezvous is intended as the initial drainage choice.

Two types of needle devices are available for access. Conducting flexible needles, commonly used at ERCP for pre-cut and pseudocyst drainage, using electrocautery (EndoCut ICC200, Erbe Elektromedizin GmbH, Tübingen, Germany). The so-called needle-knife (Zimmon papillotome, Cook Endoscopy, Winston-Salem, NC, USA), used for pre-cut, produces axial cutting with a thin wire extending 2 mm beyond the tip of the catheter. The so-called cystotome or fistulotome (Cook Endoscopy, Winston-Salem, NC, USA; Endoflex, Tubingen, Germany), traditionally used for pseudocyst drainage, has a blunt, round cutting piece at the tip that produces circumferential cutting. Cystotomes are slightly stiffer than needle-knifes and produce a larger burn on the duodenal and common bile duct walls. This larger, round cutting reduces the need for dilation before stent insertion. Therefore, cystotomes are particularly useful in cases where resistance to the advancement of flexible devices over the wire into the duct is met. Thinner caliber cystotomes (6 French) are preferable to larger caliber ones (10 French). On the other hand, needle-knives, being more flexible, can be used free hand under EUS as the initial access device. There are also non-conducting stiff cutting needles, commonly used for EUS-guided fine needle aspiration (EUS-FNA). EUS-FNA needles are available in several calibers. The two most commonly used are the large 19 gauge needle and the thin 22 gauge needle (EchoTip, Cook Endoscopy, Winston-Salem, NC, USA) (Figure 1). Whatever the needle choice, it is inserted transduodenally into the bile duct under EUS visualization. To confirm needle ductal access, the stylet is removed and bile is aspirated. If there is a bile return, contrast medium is injected into the bile duct for cholangiography, then, a 450 cm long, 0.035 inch, 0.021 inch, or 0.018 inch guidewire is inserted through the outer sheath and its position is confirmed fluoroscopically. We will comment below on differential guidewire features. If there is no return of bile or a bloody aspirate, the needle is removed, flushed with saline inside the gastrointestinal lumen to prevent clogging, and a repeat puncture attempted. Nonetheless, the problem of a needle apparently inside the duct under EUS but in actual fact on a different plane usually occurs when accessing very small ducts, which is hardly ever the case during EUS-guided choledochoduodenostomy. After guidewire access into the bile duct, some dilation of the puncture track is usually necessary, using either a dilating biliary catheter (Soehendra biliary dilator, Cook Endoscopy, Winston-Salem, NC, USA), a papillary balloon dilator (Maxpass, Olympus Medical Systems, Tokyo, Japan) or both sequentially (axial dilator first, then balloon dilator). This is aimed at dilating the duodenocholedochal fistula to facilitate stent insertion. The need for dilation is maximal when no cautery is used for initial entry under EUS, a stiffer (metal) or larger caliber plastic (10 French) stent is intended, and when the distance to the common bile duct or the resistance felt during the initial advancement of the needle are greater. Finally, a 5 to 10 French biliary pigtail or straight plastic stent or a fully covered self-expandable metal stent (Zeon Medical Co. Ltd., Tokyo, Japan) is inserted through the choledochoduodenostomy site into the common bile duct. Care should be taken to monitor by fluoroscopy the intraductal placement of the proximal end of the stent and to monitor by endoscopy the intraduodenal (or intragastric) position of the distal (closer to the scope) end of the stent. This latter aspect is of particular relevance when using self-expandable metal stent. Self-expandable metal stent tends to foreshorten upon full expansion, which takes place a few hours after the procedure. Early self-expandable metal stent dislodgment may be caused by foreshortening towards the common bile duct beyond the gastrointestinal wall. To prevent this serious complication an adequate length of self-expandable metal stent (15-20 mm) should be left inside the gastrointestinal lumen. This is longer than what is customarily done when placing self-expandable metal stent transpapillary at ERCP. Additional anchorage techniques to prevent dislodgment are forceful balloon dilation of the self-expandable metal stent up to 8-10 mm after initial deployment, or the use of a coaxial double pig-tail through the self-expandable metal stent, as reported for pseudocyst drainage using transmural self-expandable metal stent [19].

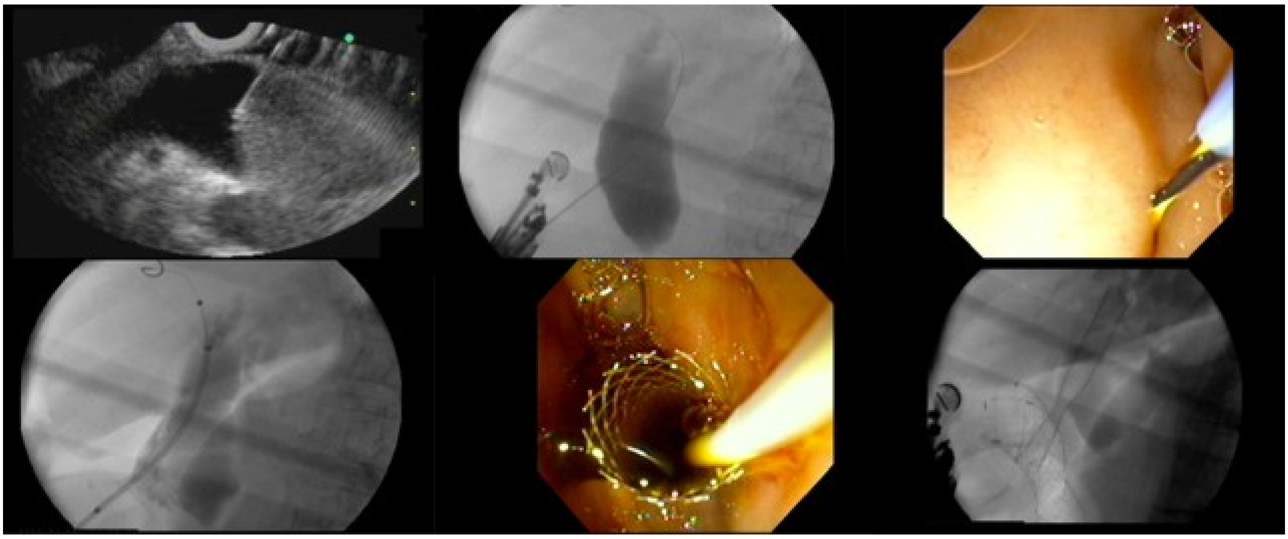

Figure 1. EUS-guided choledochoduodenostomy. It is demonstrated the step-by-step technique in which we can see the EUS images with the dilated common bile duct being punctured, cholangiography with guidewire placement, fistulization using a needle-knife catheter, deployment of partially covered self-expandable metal stent.

Despite the seemingly simple sequence of duct imaging and puncture under EUS, guidewire advancement and track dilation under fluoroscopy, and eventually stent insertion and deployment under combined fluoroscopic and endoscopic monitoring, EUS-guided choledochoduodenostomy is an invasive, complex procedure. Knowledge about the full array of needle devices, guidewires, dilators and stents as well as about the subtle variations in scope position (gastric or duodenal), scope orientation (upward and downward), and stent anchoring techniques is highly recommended to increase success rates and minimize complications. Operator confidence with specific devices also plays a role. Some authors feel that access without cautery is less prone to complications. These authors favor initial non-conducting needle access and then use cautery only selectively after failed mechanical dilation over the guidewire of the puncture tract [6, 20]. Mechanical dilation without cautery requires a stiffer 0.035 inch guidewire for support, which in turn involves the use of a 19 gauge EUS-FNA needle. Other authors find the stiffer 19 gauge EUS-FNA needles cumbersome to use in the relatively long position of the echoendoscope in the duodenum, and resort to either initial direct needle-knife access under EUS [21], or needle-knife access under a thinner 0.018 guidewire passed into the common bile duct after puncture with a 22 gauge EUS-FNA needle [22]. Finally, some other authors resort to both needle-knife and EUS-FNA needle access [23].

Literature Findings Based on the Perspective of Evidence-Based Medicine

EUS-guided choledochoduodenostomy was first reported by Giovannini *et al*. [24]. Some authors exchanged the echoendoscope over a catheter-protected guidewire for a duodenoscope, through which the stent was eventually inserted. As detailed earlier, the puncture needles available are conducting needles and non-conducting needles. About half the number of each has been used in published reports. This is in contrast to what is reported for intrahepatic EUS-guided biliary drainage, where non-conducting needle access is clearly preferred. The reason why cautery access (conducting needle) is favored during EUS-guided choledochoduodenostomy is probably fourfold. Firstly, for EUS-guided choledochoduodenostomy the echoendoscope is in a longer, curved position in the duodenum in comparison with the shorter distance to the subcardial region from where intrahepatic access is typically gained. This long position increases friction between the stent delivery system and the endoscope working channel, which impairs the transmission of the pushing force, thereby making transmural stent insertion more difficult. Secondly, the thicker, fibrous wall of the common bile duct is harder to penetrate mechanically than the relatively soft liver parenchyma (except in cases with underlying cirrhosis) and the wall of smaller bile ducts. Thirdly, the tendency to create a space by pushing until the bile duct wall yields is greater between the duodenal wall and the common bile duct than between the gastric wall and the liver. Finally, the common bile duct is larger and has the nearest vessels at a greater distance than the intrahepatic bile ducts (where vessels run closely in parallel), which offers some protection against severe bleeding, a feared complication of cautery access.

In most reported cases, a plastic stent has been placed. However, recently, the use self-expandable metal stent is increasingly been reported [20]. The success rate for the 105 cases reported to date is as high as 94.3%, with excellent results in all successfully drained patients (100% per-protocol clinical response rate) [11, 12, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 33]. There were some cases where stent insertion was too difficult and a nasobiliary drainage tube was placed instead [23, 29].

The close proximity between the bile duct to duodenum or antrum allows clear identification of this structure by EUS, even in patients without bile duct dilation. Obviously a gross dilation of the bile duct allows an easier access for puncture and also progression of the guidewire upwards. However, if the bile duct has a small caliber (less than 10 mm), successful EUS-guided biliary drainage becomes much harder to achieve especially due to technical difficulty of progressing the guidewire, therefore is not recommended. It is of crucial importance to emphasize that once contrast has been injected into the bile duct for cholangiogram, drainage has to be undertaken due to increased risk of cholangitis and sepsis. The procedure must be planned carefully and with all necessary equipment, including stents of different sizes, in order to reduce risks in a patient with enough dilation of the biliary tree.

Another interesting variation on EUS-guided choledochoduodenostomy is illustrated by a few cases where the extrahepatic bile duct was punctured from the stomach rather than the standard transduodenal approach [20, 34]. Although only 6 cases were reported, all were successful.

Expected Complications and Treatment Options

Complications can be divided into procedure-related complications and stent-related complications. Definitions of procedural complications are not well standardized. Most are related to bile (or just air) leakage into the retroperitoneum (with transduodenal access) or the peritoneum (with transgastric access to the common bile duct), with or without added infection. The severity ranges from a self-limiting condition that resolves within 48-72 hours with conservative measures, to full-blown peritonitis requiring emergency surgery. Most reported complications are mild. The need for emergency surgery is exceedingly rare. Other interventional measures that may be required in the event of complications, such as percutaneous drainage, are however not all that uncommon.

Peri-procedural leakage of bile into the abdominal cavity is most likely due to poor drainage. Poor drainage can be caused by factors such as too large a fistula, early stent clogging, and inappropriate positioning of the stent (including foreshortening of self-expandable metal stent).

Late stent-related complications, that is, once a mature fistula is formed, are similar to those seen with transpapillary stents placed at ERCP, namely, migration and stent occlusion. Stent migration or occlusion are managed in the same way as in stents placed at ERCP, by inserting a new stent. The technique for repeat stent placement differs from what is commonly done at ERCP. If a clogged plastic stent is in place across the fistula, a guidewire is advanced through the stent and the stent is grasped with a snare passed over-the-wire and removed over it. This somewhat more complex maneuver is aimed at keeping guidewire access to the duct after stent removal. After plastic stent removal, a self-expandable metal stent may be placed using a duodenoscope. If clogging of a self-expandable metal stent occurs, the debris occluding its lumen may be cleaned up. But just cleaning is probably not long-lasting in this setting. A new coaxial stent needs to be placed inside the clogged one, either a plastic stent, or a self-expandable metal stent, the so-called stent-in-stent approach.

Distal stent migration into the gastrointestinal tract lumen with a mature fistula only involves repeat biliary drainage, since migrated stents usually pass out spontaneously. Repeat biliary drainage may be attempted in several ways. The simplest one is placing a new stent through the same fistula, if it is still visible. If the fistula cannot be identified endoscopically, either repeat EUS-guided choledochoduodenostomy through a new puncture site or percutaneous transhepatic biliary drainage is required. If proximal stent migration to the retroperitoneum or the peritoneum occurs, recovery of the stent as well as emergency surgery should be considered. This serious complication, however, has not yet been reported for EUS-guided choledochoduodenostomy. Finally, even if the less serious distal migration occurs but the fistula is still immature (a fibrous track not yet formed), this may cause bile leakage into the abdomen. In the event of stent migration and leakage with an immature fistula, repeat EUS-guided biliary drainage (perhaps using a self-expandable metal stent), or percutaneous transhepatic biliary drainage need to be considered. Surgery should also be considered depending on the patient’s condition.

EUS-GUIDED HEPATICOGASTROSTOMY

General patient, equipment and operator requirements for EUS-guided biliary drainage are listed in further. We will further describe here the equipment and devices required for EUS-guided hepaticogastrostomy, common to most other EUS-guided biliary drainage approaches. A step-by-step description of EUS-guided hepaticogastrostomy will be presented next. Finally, the specific place of EUS-guided hepaticogastrostomy within the context of other EUS-guided biliary drainage approaches will be discussed and the published literature on it briefly reviewed.

Technique of EUS-Guided Hepaticogastrostomy

As in the alternative extrahepatic access EUS-guided biliary drainage technique for transmural drainage (i.e., choledochoduodenostomy), EUS-guided hepatico-gastrostomy is closely related to EUS-guided drainage of pancreatic pseudocysts [8]. In all these cases, the target is imaged under EUS and punctured with a needle. The puncture tract is then dilated (using cautery, mechanical devices, or both), and a stent is placed across the puncture tract to drain the duct or the pseudocyst into the gastrointestinal tract lumen.

EUS-guided hepaticogastrostomy was first reported in 2003. Burmester *et al.* used EUS-guided hepatico-gastrostomy in a Billroth II patient with unresectable pancreatic cancer and failed ERCP because of tumor infiltration of the papilla. In the same series, another patient with recurrent gastric cancer and total gastrectomy had a transmural stent placed across the jejunal wall below the gastrojejunostomy, i.e. EUS-guided hepaticojejunostomy [35]. Giovannini *et al.* reported in 2003 an EUS-guided hepaticogastrostomy in a patient with subtotal gastrectomy and recurrent malignancy. The left biliary system was inaccessible, because a metal stent had been previously placed percutaneously in the right hepatic duct across the confluence [36].

The procedural steps of EUS-guided hepatico-gastrostomy are as follows. Using an interventional echoendoscope, the dilated left hepatic duct (usually segment III) is well visualized. In most studies the procedure is performed when the intrahepatic bile duct has at least 7 to 8 mm in diameter. EUS-guided hepaticogastrostomy is then performed under combined fluoroscopic and ultrasound guidance, with the tip of the echoendoscope positioned such that the ultrasound transducer is either in the middle part of the small curvature of the stomach or slightly upwards, closer to the cardia. A needle (19 G, EchoTip® Access Needle, Cook Ireland Ltd., Limerick, Ireland) is inserted transgastrically into a peripheral branch of the left hepatic duct, and contrast medium is injected. Before contrast is injected, bile can be aspirated through the needle in order to confirm the intraductal position of the needle tip. Opacification delineates fluoro-scopically the dilated biliary tree down to the point of obstruction. The needle is exchanged over a guidewire (0.02 inch diameter, Terumo Europe, Leuven, Belgium) for a 6.0 French diathermic sheath (Cysto-Gastro set, EndoFlex, Voerde, Germany), which is then used to enlarge the channel between the stomach (or jejunum in patients with total gastrectomy) and the left hepatic duct. The diathermic sheath is advanced across the intervening liver parenchyma by using cutting current. After removing over a guidewire (TFE-coated 0.035 inch diameter, Cook Europe, Bjaeverskov, Denmark) the diathermic sheath, an 8.5 French, 8 cm long hepaticogastric stent) or an 8 cm long covered self-expandable metal stent (partially covered Wallstent or fully covered Wallflex, Boston-Scientific, Nattick, MA, USA) is placed transmurally. Fluoroscopy confirms adequate stent placement and function by showing contrast drainage through the stent into the stomach.

Bile leakage into the peritoneum is the major risk of EUS-guided hepaticogastrostomy. Several strategies are used by different authors to minimize this risk. A 6 or 7 French nasobiliary drain with mild aspiration or gravity drainage can be left in place through the metal stent during 48 hours, even if this is somewhat inconvenient to the patient. More recently we have developed a more patient-friendly approach to minimize the risk of leakage, by combining an uncovered metal stent with a covered metal stent inside. The uncovered stent is deployed initially, so as to provide anchorage and prevent migration, and then the covered stent is inserted coaxially and deployed within the first stent. Finally, in cases where the guidewire crosses the downstream stricture antegradely, hepaticogastrostomy can be combined with antegrade placement of an additional metal stent bridging the distal stricture, which further decreases the pressure gradient across the transmural stent by providing additional downstream decompression of the bile duct [37]. Alternative strategies used by other authors to prevent migration include the used of fully covered self-expandable metal stent with both ends flared [14] or forceful balloon expansion upon stent deployment (as opposed to gradual spontaneous self-expansion over several hours) - in order to monitor foreshortening - plus insertion of a double pig-tail stent through the expanded self-expandable metal stent - in order to provide additional anchorage [38] (Figure 2).

EUS-Guided Hepaticogastrostomy in Comparison with Other EUS-Guided Biliary Drainage Approaches

The rationale for all variant EUS-guided biliary drainage approaches, as a second-line option in select difficult cases where ERCP is not feasible is threefold. EUS-guided biliary drainage may be potentially more convenient (performed in the same session), more physiologic (allowing immediate internal biliary drainage) and less invasive (affording more accurate control as well as more access sites to the bile duct) than the classic alternatives of percutaneous biliary drainage or surgery.

The specific anatomic features of patients that may make EUS-guided hepaticogastrostomy preferable to other EUS-guided biliary drainage are based on the intrahepatic access route and the transmural drainage route. Intrahepatic access is the only choice in patients with proximal (hilar) biliary obstruction and is usually more convenient in patients with distal gastrectomy, since imaging the common bile duct under EUS is not always possible in the setting of postoperative altered anatomy [39]. One advantage of transmural drainage after intrahepatic bile duct access over transpapillary drainage is that the challenging step of antegrade guidewire passage (required for both rendezvous and antegrade stenting) is avoided. In addition to guidewire passage, rendezvous requires an accessible papilla, which is usually not the case in patients with surgically altered anatomy or tight duodenal stenoses. Antegrade stent insertion does not require an accessible papilla, but involves dilation of the puncture tract, just as EUS-guided hepaticogastrostomy. In patients with postoperative anatomy, antegrade transpapillary

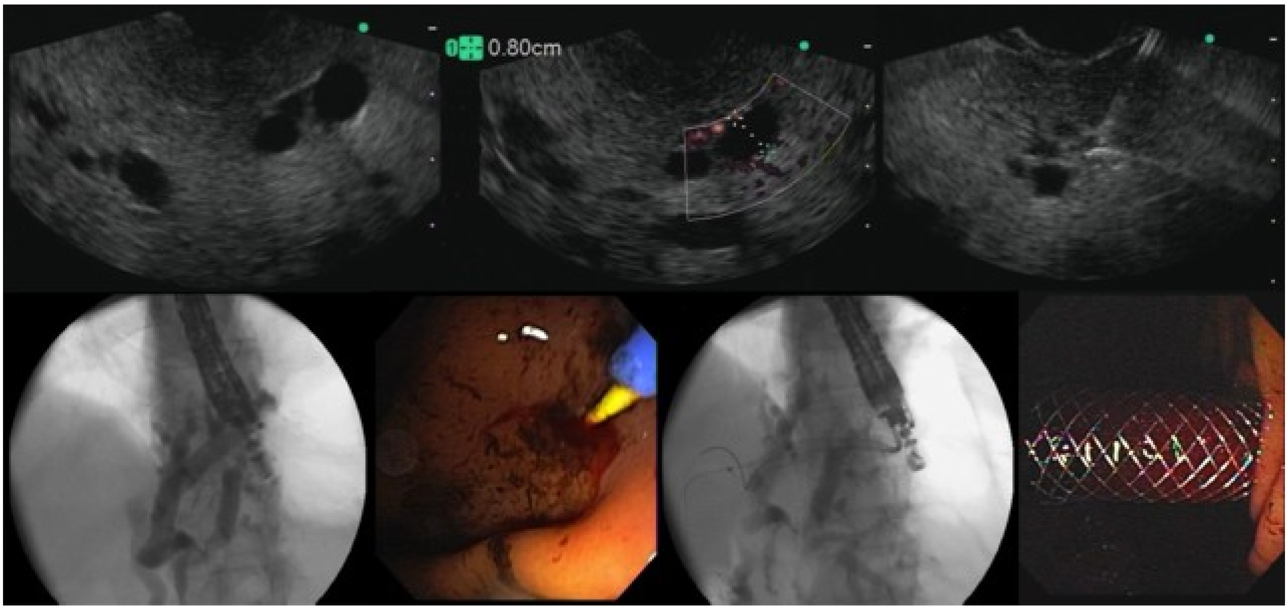

Figure 2. EUS-guided hepaticogastrostomy. It is demonstrated the step-by-step technique in which we can see the EUS images with the dilated intrahepatic duct, puncture, cholangiography, guidewire placement, fistulization using a needle-knife catheter, deployment of partially covered self-expandable metal stent.

stenting without combined hepaticogastrostomy is less convenient for stent revisions, since hepaticogastrostomy provides easy repeat access to the bile duct without the need for a repeat puncture. Stent revisions are not uncommonly required during follow-up. The advantages of EUS-guided hepaticogastrostomy over rendezvous or antegrade stent insertion are particularly relevant in patients with prior duodenal or biliary self-expandable metal stent who experience recurrent biliary obstruction [40].

These variant EUS-guided biliary drainage approaches must, however, be viewed as complementary rather than mutually exclusive. For example, as mentioned when discussing strategies to minimize the risk of bile leakage in EUS-guided hepaticogastrostomy, antegrade transpapillary stents can be combined with transmural stenting [37]. Puspok *et al*. performed antegrade transpapillary self-expandable metal stent insertion in a patient with recurrent gastric cancer after Roux-en-Y gastrectomy. They then left a transmural plastic stent across the puncture tract both to minimize the risk of leakage and to preserve access [7]. Dual drainage (antegrade and transmural) has also been used serially. Fujita *et al*. performed transesophageal EUS-guided biliary drainage by inserting a 7 French plastic stent into a peripheral left bile duct branch in a patient with advanced gastric cancer [41]. Ten days later, the plastic stent was cannulated with a guidewire and removed over it with a snare [42]. Then, using flexible devices through the mature fistula, the guidewire was manipulated under fluoroscopy across the malignant distal bile duct stricture, and a self-expandable metal stent passed antegradely over the wire was subsequently deployed across the stricture above the papilla.

Patients with distal bile duct obstruction without prior gastrectomy who have both intra- and extra-hepatic bile duct dilation (and no gross ascites) are the only ones in whom there is an issue about which access site for EUS-guided biliary drainage might be preferable, intrahepatic or extrahepatic. If the selection criteria for EUS-guided biliary drainage *versus* percutaneous transhepatic biliary drainage are broad (i.e., EUS-guided biliary drainage is favored as the initial second-line approach after failed ERCP), this type of patients may represent just 20% of the candidate population [43]. Operator preference plays a part in this small patient subset. The common bile duct offers a more obvious target for EUS puncture, the echoendoscope is in a more anchored position, and probably access to the common bile duct makes rendezvous easier than it is with intrahepatic access. On the other hand, intrahepatic EUS-guided biliary drainage is performed with the echoendoscope in a more straight position, which favors transmission of the pushing force during stent insertion. It is also probably easier to penetrate a small intrahepatic bile duct surrounded by liver parenchyma than the fibrotic, hard wall of the common bile duct.

LITERATURE REVIEW

To date, transmural intrahepatic EUS-guided biliary drainage has been reported in 51 patients, EUS-guided hepaticogastrostomy in 42 and other closely related variant approaches through a transjejunal or a transesophageal route in 9. In five patients with total gastrectomy, the left bile duct was similarly accessed under EUS from below the cardia and transmural stents were placed across the jejunal wall. In the remaining four patients a cephalad peripheral left bile duct branch

Table 1. Summary of the published literature on EUS-guided hepaticogastrostomy and related transmural intrahepatic EUS-guided biliary drainage techniques.

Author, year	Total EUS-guided biliary drainage	Intrahepatic-transmural		Success		Complications		Initial stent	
		EUS-HG	Non-HG	Technical	Clinical	No.	Type	Plastic	Self-expandable metal
Burmester, 2003 [35]	4	1	1	2	2	0	-	2	0
Puspok, 2005 [11]	6	0	1	1	1	0	-	1	0
Bories, 2007 [37]	11	11	0	10	10	4	2 cholangitis; 1 ileus; 1 biloma	7	3
Will, 2007 [44]	8	4	4	7	6	2	1 cholangitis; 1 pain	2	5
Artifon, 2007 [46]	1	1	0	1	1	0	-	0	1
Iglesias-Garcia, 2008 [48]	1	1	0	1	1	0	-	NS	NS
Maranki, 2009 [14]	49	3	0	3	3	0	-	3	0
Park, 2009 [20]	14	8	1	9	9	2	Pneumoperitoneum	0	9
Horaguchi, 2009 [29]	16	5	2	7	6	1	Cholangitis	7	0
Chopin-Laly, 2009 [47]	1	1	0	1	1	0	-	0	1
Park, 2010 [40]	5	5	0	5	5	0	-	0	5
Eum, 2010 [45]	3	1	0	1	1	0	-	0	1
Martins, 2010 [49]	1	1	0	1	0	1	Peritonitis and death	0	1
Total	**120**	**42**	**9**	**49**	**46**	**10**	**5 mild and 5 severe**	**22**	**26**

HG: hepaticogastrostomy; NS: not specified

Case reports from Giovannini *et al*. [36] and Fujita *et al*. [41] not tallied because already included in case series by Bories *et al*. [37] and Horaguchi *et al*. [29], respectively.

was selected for puncture, so that eventually the stent pierced the wall of the intra-abdominal esophagus slightly above the cardia. Approximately half of these patients come from three small series specifically dealing with transmural intrahepatic EUS-guided biliary drainage [37, 40, 44], whereas the other half comes from either mixed series in which EUS-guided hepaticogastrostomy is reported along extrahepatic EUS-guided biliary drainage [7, 10, 14, 24, 35, 45] or individual case reports [36, 41, 46, 47, 48, 49] (Table 1).

EUS-guided hepaticogastrostomy (or its variants) was technically successful in 49 out of these 51 patients, with clinical resolution of biliary obstruction in 46 cases. Therefore EUS-guided hepaticogastrostomy had a 94% per-protocol success rate and a 90.2% success rate on an intention-to-treat basis. These success rates are very high, considering the difficult patient population in which EUS-guided hepaticogastrostomy was attempted. However, three facts deserve consideration. First, these results come from highly experienced operators at referrals centers. Secondly, there is definitely a significant publication bias, i.e. since positive studies are more likely to be published, and this patient cohort is derived from small series and individual case reports, in real practice outcomes are probably somewhat less favorable. Finally, success was achieved at the expense of an overall 20% complication rate, twice as high as that of ERCP. Most complications were accounted for by inadequate biliary drainage, resulting in either peritoneal bile leakage or cholangitis (Table 1). Plastic stents caused cholangitis due to early migration [24] or early clogging [37]. Foreshortening of transmural self-expandable metal stent led to bile peritonitis or biloma, requiring percutaneous drainage and repeat EUS-guided biliary drainage [37], and caused the only reported death to date [49]. Half of the complications were nonetheless mild, manifested by transient abdominal pain with or without pneumoperitoneum that settled on conservative measures.

There is great consistency across all reports on EUS-guided hepaticogastrostomy regarding technical details. FNA needle access was used initially in all but two cases, in which cautery access using a prototype fistulotome was used instead [35]. Bougie or balloon dilation was performed before stent insertion in all but four cases, the two just mentioned in which a fistulotome was used, a case in which the tract was dilated after FNA-needle guidewire placement with the tapered tip of a wallstent [46], and finally another case in which apparently just cautery was used for access, since no mention of dilation is made [49]. One technical aspect in which there is less uniformity is the use of cautery, be it needle-knives or fistulotomes. Overall, any diathermy use was reported in just 39.5% of cases. Whereas some authors use it routinely [37], others resort to it selectively [14] (only after failure to advance a mechanical dilator over the guidewire) or do not use it at all [44].

From a clinical standpoint, however, the most relevant technical choice appears to be the type of stent. As detailed in Table 1, 7 to 8.5 plastic stents were placed in 46% of cases, whereas uncovered, partially covered or fully covered self-expandable metal stent were placed initially in 54%. It is difficult to draw significant conclusions from the published reports, since no formal comparisons have been made between the two types of stents. Self-expandable metal stents are appealing for three reasons. Firstly, upon full expansion self-expandable metal stent effectively seal the puncture/dilation tract, which would in theory prevent leakage more effectively. Secondly, their larger diameter provides better long-term patency, which would decrease the need for stent revisions. Finally, if dysfunction by ingrowth or clogging occurs, management is somewhat less challenging than with plastic stents, since a new stent (plastic or self-expandable metal stent) can easily be inserted through the occluded self-expandable metal stent in place. In contrast, exchanging a clogged plastic transmural stent usually requires over-the-wire replacement, because free-hand removal involves the risk of track disruption with subsequent guidewire passage into the peritoneum, hence requiring repeat EUS-guided biliary drainage (or percutaneous transhepatic biliary drainage) to re-establish drainage [42]. These presumed advantages of self-expandable metal stent must be balanced against the fact that transmural self-expandable metal stent insertion and deployment are somewhat more demanding than they are at ERCP. In particular, the serious risk of foreshortening and bile peritonitis should be prevented with careful attention to detail [49].

Bories *et al*. have recently reported their experience in 38 patients (11 with benign disease and 27 with malignancy) using transgastric EUS-guided biliary drainage with transmural, transpapillary (antegrade) or combined stent insertion. Thirty-six EUS-guided procedures were made with technical success of 97% and all successfully stented patients improved clinically. However, the complication rate was 25% (5 bile peritonitis, 3 stent migration, 1 liver abscess). There was one death caused by bile peritonitis, and the rest resolved under conservative management [50].

CONCLUSIONS

These techniques are invasive procedures that require careful patient selection and experienced operators backed by a multidisciplinary team. Further technical improvements are likely to reduce number of adverse events and will probably contribute to the more widespread adoption of these procedures as a second-line approach to biliary drainage after failed ERCP. Although multicenter trials aimed at standardizing the technique for performing EUS-guided biliary drainage would be desirable, the relatively few patient candidates for it and the wide spectrum of technical variations reported to date make this endeavor difficult to accomplish in the near future. Detailed prospective studies with homogeneous inclusion criteria and careful follow-up and dedicated hands-on training models will probably be more effective in advancing this burgeoning field of interventional endoscopy.

Conflict of interest The authors have no potential conflict of interest

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