International Journal of Gastrointestinal Intervention

journal homepage: www.ijgii.org

Review Article

Technical tips for endoscopic ultrasound-guided pancreatic duct access and drainage

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ABSTRACT

Endoscopic ultrasound (EUS)-guided pancreatic duct access and drainage can be achieved by EUS-guided rendezvous (EUS-RV) or EUS-guided pancreatic duct drainage (EUS-PD) by transmural stent placement. Although the procedure is utilized for further complex treatment such as intraductal lithotripsy in obstructive pancreatic duct stones, the procedure is technically difficult compared to other EUS-guided interventions. Recently, some devices are developed for EUS-guided pancreatic duct intervention. In this review, technical tips are reviewed in a step-by-step fashion from puncture, guidewire insertion, tract dilation to drainage. Given the advantage of EUS-guided approach, treatment algorithm of endotherapy for pancreatic indications should be further established especially in cases with surgically altered anatomy.

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Keywords: Endoscopic ultrasound; Pancreatic duct obstruction; Rendezvous; Transmural drainage

Introduction

The indication of endotherapy for pancreatic diseases is various from simple drainage of pancreatic fluid collection to complex procedures for post-surgical anatomy patients. Transpapillary approach via endoscopic retrograde cholangiopancreatography (ERCP) is still the mainstay but EUS-guided approach is increasingly utilized. EUS-guided pancreatic duct drainage (EUS-PD) is indicated for pancreatic duct obstruction, pancreatic leakage and disconnected pancreatic duct syndrome after failed or difficult ERCP.^{1–4} Recently, there are some technical updates for EUS-PD and in this review, we would like to focus on the technical issues of EUS-guided interventions for pancreatic diseases.

History of EUS-Guided Pancreatic Duct Interventions

About 50 years have passed since ERCP was first reported⁵ and it is now the mainstay for management of various pancreatic diseases. EUS has been into clinical practice for 40 years and both EUS-guided rendezvous (EUS-RV)⁶ and EUS-guided pancreatic duct drainage (EUS-PD)⁷ were first reported in 2002. While the pancreatic duct was punctured in a transduodenal approach and

a 22-gauge needle and a 0.018-inch hydrophilic guidewire were used during EUS-RV, transgastric puncture was performed and a 19-gauge needle and a 0.020-inch guidewire were used during EUS-PD. Interestingly enough, a proto type electric cautery dilator (Cysto-Gastro set; EndoFlex, Voerde, Germany) was used for the initial tract dilation, which is commercially available now and used for tract dilation in EUS-guided interventions. This device selection probably represents the differences of two procedures, EUS-RV and EUS-PD, which is discussed later.

Step-by-Step Technical Consideration

An increasing number of reports have been published on EUS-PD since 2002, and our previous review⁸ revealed the technical success rate of 78.7% and the adverse event rate of 21.8% when EUS-RV and EUS-PD were combined. Overall technical success rate appeared lower than that of EUS-BD.⁹ However, when looked into detail, in 12 studies on EUS-RV alone, the technical success rate was as low as 55.6% and the technical success rate was 93.8% in 11 studies of EUS-PD. A similar trend was also seen in EUS-RV for biliary access and EUS-BD. The technical success rate of EUS-RV for biliary access was 81%¹⁰ as compared to 95% in EUS-BD.⁹

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Received August 3, 2020; Revised September 7, 2020; Accepted September 8, 2020

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There are two technical hurdles in EUS-RV: Guidewire manipulation and scope exchange. To achieve EUS-RV, guidewire needs to be passed through the ampulla/anastomosis and the stricture. After guidewire placement, scope exchange from the echoendoscope to ERCP scope is the next step but guidewire loss can occur during this step. On the other hand, EUS-PD can be successfully achieved once the guidewire is placed in the pancreatic duct and drainage tube placement. The technical hurdle of EUS-PD lies in the tract dilation to allow drainage placement.

Puncture

A combination of 19-gauge needle and a 0.025-inch flexible guidewire are often used for EUS-guided intervention (Fig. 1A, 1B). However, the pancreatic duct can be non- or minimally-dilated and is difficult to puncture, especially in cases with pancreatic fistula. A combination of a 22-gauge needle and a 0.018- or 0.020-inch guidewire can be an option, and one small study was reported on the use of a 22-gauge with tract dilation by small gauge angioplasty balloon.¹¹ While this technique is useful for small PD, these small gauge guidewires are difficult to manipulate and the device insertion over this small, floppy guidewire is also technically difficult. If a flexible but stiff small guidewire is developed, a 22-gauge needle has advantages of easy manipulation and penetration compared to a 19-gauge needle, but may need dedicated tract dilation devices, too, since most of current devices are fit for 0.025- or 0.035-inch guidewires.

In addition to the size of the pancreatic duct, needle angle and the puncture site are also important for subsequent procedures. The needle should be headed for the ampulla or the anastomosis unless EUS-PD stent is meant to be placed towards the tail of pancreas. If the needle is faced for the tail of the pancreas or perpendicular to the pancreatic duct, guidewire insertion as well as subsequent device insertion is often technically difficult (Fig. 2). In EUS-RV, the puncture site can be close to the ampulla/anastomosis and the needle angle can be less perpendicular and guidewire insertion is relatively easy. Meanwhile, in EUS-PD the stent needs to be placed in the PD and the puncture site is often body/tail of the pancreas and the angle is close to perpendicular. In cases with surgically altered anatomy, the working space for the echoendoscope is limited in the remnant stomach or the jejunum and the puncture site is not always ideal. Therefore, guidewire insertion and subsequent intervention can be technically difficult in EUS-PD.

There are several fine needle aspiration (FNA) needles com-

mercially available for tissue acquisition right now, but there are no needs to procure specimen during EUS-guided interventions. Thus, we prefer FNA needles with a sharp tip, such as EZ shot3 plus (Olympus Medical Systems, Tokyo, Japan) and SonoTip Pro Control (Medi-Globe, Achenmühle, Germany), which allows easy penetration through the gastrointestinal wall and the pancreatic parenchyma and duct wall. A steerable access needle for EUS-guided intervention¹² was recently reported for biliary interventions but it is unclear whether this needle is useful in the limited space of the pancreatic duct. The development of a dedicated access needle which is easy to puncture the PD and less susceptible to guidewire shearing is needed.

The ductal pressure of non-dilated PD is often low and the duct can be easily compressed by the tip of the needle. There are two technical tips to handle this situation. One is two-step puncture and the other is the through-the-duct puncture. In the two-step puncture method, the PD is punctured using a 22-gauge needle, followed by contrast injection. Contrast injection can dilate

Fig. 2. Needle angle of endoscopic ultrasound-guided rendezvous (EUS-RV) and EUS-guided pancreatic duct drainage (EUS-PD). In EUS-RV, space for stent placement is not necessary and the pancreatic duct at pancreatic genu can be punctured. In EUS-PD, the body-tail of pancreas is punctured to place a stent and the angle is more perpendicular, which makes guidewire insertion difficult.

Fig. 1. Endoscopic ultrasound-guided pancreatic duct drainage (EUS-PD). (A) PD was punctured using a 19-gauge needle under EUS guidance. (B) After contrast injection, a 0.025-inch guidewire was coiled in PD. (C) Tract dilation was performed using a tapered balloon catheter. (D) A dedicated 7-Fr EUS-PD stent was placed.

the PD and facilitate subsequent puncture by a 19-gauge needle. Pancreatography by contrast injection is useful as a roadmap, too. In the through-the-duct puncture, a 19-gauge needle is advanced through the PD and then pulled back gradually until the needle tip is in the duct. This technique is useful to access non-dilated PD but caution is necessary for guidewire manipulation since the guidewire tends to go through the PD wall into the needle trajectory.

Guidewire insertion

Guidewire shearing should be avoided during guidewire manipulation through the FNA needle. We often use a 0.025-inch guidewire with a flexible hydrophilic tip (VisiGlide2; Olympus Medical Systems). An extreme caution should be paid when the guidewire is pulled back because guidewire shearing occurs on the tip of the needle during the guidewire pullback. Guidewire insertion is the most difficult part especially in cases with non-dilated PD and an experienced assistant or physician, who can notice the guidewire tactile, should manipulate the guidewire. Once the guidewire is inserted in the pancreatic duct, it should be advanced as far as possible to avoid guidewire loss and to support subsequent device insertion. In cases with failed passage through the ampulla or anastomosis, the guidewire should be coiled in the

PD. When the guidewire passage through the stricture, ampulla or anastomosis is difficult, persistent guidewire manipulation through the needle increases the risk of guidewire shearing and should be avoided. Once the guidewire is inserted deep enough for exchange, the needle should be exchanged to a tapered cannula or a dilation device to allow safe guidewire manipulation.

When the guidewire is advanced to the unintended direction, there are some technical tips to solve this situation. Firstly, if the guidewire tip is in the side branch of PD, the flexible tip can make a U-shape and sometimes be advanced to the intended direction (U turn technique; Fig. 3). When this U-shape is not formed and the guidewire tip is advanced further into the tail of pancreas, then double guidewire technique can be utilized. The FNA needle is removed with the guidewire left in the tail of pancreas, and then, an uneven double lumen catheter (Piolax Medical, Kanagawa, Japan)¹³ is advanced over the guidewire. Then, another guidewire is inserted through the side lumen and then is advanced into the right direction (Fig. 4). A cytology brush (RX Cytology Brush; Boston Scientific Japan, Tokyo, Japan) can be used for this technique once the brush is removed.¹⁴ This “double guidewire” technique is also useful for scope stabilization in cases with difficult anatomy.¹⁵

Fig. 3. Technical tips for guidewire insertion: U turn technique. (A) The flexible tip of the guidewire is stuck in the side branch. (B) The guidewire is gently pushed to make a U-shape with a flexible tip to the pancreas head direction. (C) The guidewire is further advanced until the stiff portion of the guidewire is inserted into the pancreatic duct.

Fig. 4. Technical tips for guidewire insertion: Double guidewire technique. (A) Uneven Double Lumen catheter (Piolax Medical) for double guidewire technique. Two guidewires can be inserted: A 0.025-inch guidewire from the tip and a 0.035-inch guidewire from the side lumen. (B) The guidewire is advanced deep into the pancreatic duct of the tail. (C) The needle is exchanged to the double lumen catheter. (D) Another guidewire is advanced through the side lumen and passed into the pancreatic duct of the head.

Fig. 5. Tapered tip devices for tract dilation. (A) A mechanical dilator (ES dilator; Zeon Medical). (B) A balloon catheter (Ren; Kaneka). (C) An electric cautery dilator (Fine 025; Medico's Hirata).

Tract dilation

For EUS-RV, tract dilation is unnecessary but for EUS-PD tract dilation is mandatory depending on the size of the drainage tube. There are three types of tract dilation devices, electric cautery, balloon dilator, and bougie dilator, and device selection is mostly dependent on the physician's preferences. There are two characteristics to be considered in device selection: One is cautery vs non-cautery, the other is stiffness. While cautery dilators are effective for tract dilation, there is a risk of delayed bleeding. While a stiff device can be easily pushed through the tract, it cannot follow the tract and PD if these are perpendicular. There are several dedicated devices for tract dilation (Fig. 5). Most of them are fit for a 0.025-inch guidewire and have tapered tip with less gap between the guidewire and the dilator. For example, a ultra-tapered mechanical dilator with a 2.5-Fr tip (ES dilator; Zeon Medical, Tokyo, Japan) was reported to be safe compared to the conventional electric cautery dilator.¹⁶ A tapered balloon catheter with a 3-Fr tip (Ren; Kaneka, Osaka, Japan), which was reported for EUS-BD,¹⁷ is useful for EUS-PD, too (Fig. 1C). While the 6-Fr electric cautery dilator (Cysto-Gastro set) was previously used for tract dilation in our institution, the risk of delayed bleeding or leakage has been recognized due to the burning effects. Recently, a fine gauge cautery dilator (Fine 025; Medico's Hirata, Osaka, Japan) was developed, which is fit for a 0.025-inch guidewire and has a 3-Fr metal-tip. The burning effects of this fine gauge cautery dilator are smaller than the conventional 6-Fr cautery dilator, and may possibly reduce the adverse events such as delayed bleeding.¹⁸

The difficulty and necessity of tract dilation might differ according to the hardness of pancreas. In cases with chronic pancreatitis, so called "hard pancreas," intense tract dilation is necessary and dilation by the electric cautery dilator is sometimes necessary. On the other hand, in cases with non-chronic pancreatitis, "soft pancreas," tract dilation might be easy but the risk of pancreatitis or pancreatic leakage is high due to preserved pancreatic function. For tract dilation device selection, the puncture angle should be considered, too. In cases with perpendicular puncture, stiff devices such as the electric cautery and mechanical dilators cannot be advanced deep into the PD due to the angulation. In those cases, multistep dilation is useful. The use of a stiff electric cautery or mechanical dilator just beyond the PD wall is first performed to allow subsequent insertion of the flexible balloon dilation catheter. Then, balloon dilation can be performed to achieve full tract dilation.

Procedure: RV or PD

In a previous review, the technical success rate of EUS-RV is lower than EUS-PD.⁸ However, in cases with normal anatomy

but failed ERCP, EUS-RV is selected for subsequent transpapillary pancreatic intervention such as stone and stricture management. As described above, guidewire passage through the ampulla or stricture is often difficult and sometimes time consuming and prolonged procedure can lead to adverse events such as pancreatic leakage. Since there is no need for tract dilation or other devices once the guidewire passage is successful, a small gauge hydrophilic guidewire can be used to allow precise guidewire manipulation. Or, in cases with difficult guidewire passage, RV can be performed as a two-step procedure. EUS-PD stent is placed in the first session and RV through the matured pancreatico-gastrostomy or -jejunostomy can be attempted in the second session without a risk of pancreatic leakage. Thus, the devices used for EUS-PD should be readily available in the procedure room even if EUS-RV is planned. Even in patients with successful EUS-PD, two-step approach can be applied, too. In the first session only stent placement is performed and complex procedures such as PD stone treatment and/or guidewire passage through the tight stricture can be performed in subsequent sessions.¹⁹ The similar technique has been widely used in the complex EUS-BD procedures.^{20,21}

Stent selection: Plastic or covered metal stents

There are two types of stents used for EUS-PD: Plastic stents and covered metal stents (CMSs). In EUS-BD, a CMS is often used since it theoretically reduces the risk of leakage.²² Due to the limited size of PD, however, plastic stents are more often used for EUS-PD. A dedicated stent for EUS-PD was reported.²³ This stent has a pigtail anchor in the proximal end and two flanges at both ends to prevent stent migration (Fig. 1D). There are no side holes in the middle part of the stent, which can prevent pancreatic juice leakage. Long-term outcomes of EUS-PD are scarce. Matsunami et al²³ reported the long-term outcomes of their dedicated stent with the median follow up of 23 months. Patients underwent either regular stent exchange (48%), stent dislodgement/removal (40%) or conversion to ERCP approach (12%). Two patients (8%) had recurrent symptoms: One stent dislodgement and one conversion to ERCP. Ergun et al²⁴ reported the rate of pain resolution was obtained in 72% during the median follow-up of 37 months but stent dysfunction was seen in 50% but was managed by stent exchange for stent occlusion or another EUS-PD for stent migration. Dalal et al²⁵ reported that stent occlusion was observed in 30.8% and spontaneous stent migration in 12.8%. Stent occlusion was managed by stent exchange and stent migration either by RV or stent placement.

There are limited data available on EUS-PD using a CMS. Oh et al^{26,27} reported both short- and long-term outcomes of EUS-PD using a CMS with anchoring flaps. They used a 6-mm or 8-mm CMS and the size of PD on pancreatography was relatively large with the median diameter of 8.9 mm. For those who received

permanent CMS placement, stent revision was performed including stent exchange. Thus, in cases with dilated PD, CMS can be a treatment option.

Interventions through EUS-PD Tract

In addition to the pancreatic duct drainage, recently, intra-pancreatic duct endotherapy through EUS-PD was reported by the application of new cholangiopancreatography. James and Baron¹⁴ reported a case series of antegrade pancreatoscopy via EUS-guided pancreaticogastrostomy for obstructive PD stones. Antegrade pancreatoscopy was performed eight weeks after EUS-PD and the digital cholangioscope (Spyglass DS; Boston Scientific Japan) was inserted through the EUS-PD tract and intraductal electrohydraulic lithotripsy was successfully performed without any adverse events. Although this procedure can be performed in cases with dilated PD, obstructive PD stone with upstream ductal dilation would be a good indication for this advanced technique. Peroral pancreatoscopy with intraductal lithotripsy is increasingly reported²⁸ and safety and efficacy of EUS-PD guided antegrade treatment should be further evaluated in comparison with conventional extracorporeal shock wave lithotripsy (ESWL), too.

Comparison with ERCP

While primary EUS-BD is discussed in comparison with ERCP in cases with malignant biliary obstruction,²⁹ EUS-PD has not been established enough to be discussed as a primary drainage technique. Thus, in normal anatomy patients, ERCP is still the first line treatment and EUS-PD is reserved for patients with failed ERCP. On the other hand, there is a debate on treatment selection in cases with surgically altered anatomy. In a multinational retrospective study,³⁰ the technical success rates of EUS-PD and enteroscopy-assisted ERCP were 92.5% and 20.0%, showing the usefulness of EUS-PD. However, the adverse event rate was higher in EUS-PD: 35% in EUS-PD and 2.9% in enteroscopy-assisted ERCP. A recent systematic review of ERCP-guided ($n = 89$) and EUS-guided ($n = 113$) pancreatic duct access in patients with pancreaticojejunal anastomotic stricture revealed a higher technical success rate in EUS-PD: Pancreatic duct cannulation (80% vs 20%), pancreatic duct opacification (86% vs 25%), and stent placement (73% vs 20%). Adverse events were not included in their analysis due to the insufficient data.³¹ Furthermore, most endoscopes used in previous studies are conventional duodenoscopes or forward viewing scopes. Recently, new short-type therapeutic endoscopes are commercially available and clinical outcomes of enteroscopy-assisted ERCP in patients with surgically altered anatomy have been markedly improved.^{32–34} In our institution, we utilized enteroscopy-assisted ERCP first and EUS-PD after failed ERCP.³⁵ A total of 40 cases underwent enteroscopy-assisted ERCP first ($n = 38$) and EUS-PD first due to severe adhesion from prior surgery ($n = 2$). If enteroscopy-assisted ERCP failed, then the patient underwent EUS-PD. Technical success rates of enteroscopy-assisted ERCP and EUS-PD were 70.7% and 100%. Adverse events were observed in 12.2% (perforation and pancreatitis) in enteroscopy-assisted ERCP and 55.6% (pancreatic leakage and abdominal pain) in EUS-PD, though most of them were mild. Overall clinical success rate was 85.0% when two approaches were combined. We believe both approaches are complimentary to each other and the utilization of both approaches are mandatory to achieve safe and effective management of pancreatic diseases in those patients.

Learning Curve

EUS-PD is now performed only in expert centers. Given the potential advantages of EUS-PD over ERCP-guided approach, generalization to other centers is important. In the Spanish national survey,³⁶ the technical success rate of EUS-PD was only 40% in the introduction phase of EUS-guided interventions. There was one study on a learning curve of EUS-PD. Tyberg et al³⁷ evaluated 56 EUS-PD in a single center and after 27 cases they reached the procedure time of 80 minutes, the median procedure time in their center. However, the number of cases undergoing EUS-PD in each center is very limited and to achieve this case load is quite difficult or even impossible. Furthermore, it is unclear whether the procedure time of 80-minutes is an appropriate parameter for the learning curve or not. There are some *ex vivo* models for hands-on training for EUS-BD but no specific model for EUS-PD has been published.³⁸ Although the procedure process is similar between EUS-BD and EUS-PD, the details are somewhat different, i.e., the resistance or the angle at puncture and the diameter of the target duct. Thus, the modification of the existing *ex vivo* model for EUS-PD is warranted.

Limitations

The lack of high quality evidence is the major limitation of this topic. Most reports are small, retrospective studies, focusing on the short-term outcomes (technical success, clinical success, and adverse events). Prospective comparative studies with a large cohort and long-term follow up are definitely necessary to establish the treatment algorithm in this population. In addition, recent development of dedicated devices for EUS-guided intervention reduces technical hurdles of EUS-PD but they are not globally available. Recently, the consensus guidelines³⁹ by the expert panel was published, including 12 statements on the indication, approach, preparation, procedures, complications, and training. Since the rate of adverse events was relatively high, the use of adjunctive treatment to reduce adverse events such as prophylactic antibiotics and non-steroidal anti-inflammatory drugs (NSAIDs) should be further evaluated and standardized.

Summary

The increasing data on EUS-PD are available but most of them are based on the expert opinions and high quality evidence is definitely lacking. EUS-PD itself is clinically useful and can be utilized for intraductal therapy but the procedure should be further standardized with more evidence. The appropriate treatment algorithm of combination of ERCP- and EUS-guided treatment should be established.

Conflicts of Interest

Yousuke Nakai received research grant from Boston Scientific Japan, Fujifilm Medical, Piolax Medical, Medicos Hirata, and Zeon Medical.

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