EUS-guided pancreatic duct drainage: a single-center observational study

Elodie Romailler, MD,[1] Anouk Voutaz, MD,[2] Sarra Oumrani, MD,[1] Mariola Marx, MD,[1] Maxime Robert, MD,[1] Fabrice Caillol, MD,[3] Alain Schoepfer, MD,[1] Sébastien Godat, MD[1]

Lausanne, Yverdon-les-Bains, Switzerland; Marseille, France

Background and Aims: Pancreatic duct obstruction can cause pain and atrophy of the pancreatic parenchyma. Endoscopic drainage is the first-line treatment, usually by means of ERCP. However, in some patients, the classic transpapillary approach cannot be performed owing to anatomic inability to access the papilla, rupture of the main pancreatic duct, intracanal stones that cannot be crossed, or tight stenosis of the main pancreatic duct due to extrinsic compression by parenchymal calcifications. EUS-guided pancreatic duct drainage is an efficient and minimally invasive therapeutic alternative for these patients. We aimed to evaluate clinical success of EUS-guided pancreatic duct drainage in our center.

Methods: Data of patients who underwent EUS-guided pancreatic duct drainage in our center from 2016 to 2022 were retrospectively reviewed. Clinical success was defined as pain $\leq$2 on the pain visual analog scale (VAS; 0-10) and no recurrence of obstructive pancreatitis after successful stent placement. If the indication for the procedure was chronic pancreatitis with painless weight loss, then clinical success was defined as weight stabilization or weight regain after the procedure.

Results: Forty-six patients (mean age 58 years, 69.6% male) were included. One indication of EUS-guided pancreatic duct drainage was chronic pancreatitis in 69.6% of patients (78.1% due to alcohol abuse). Other indications included postoperative adverse events, rupture of pancreatic duct, and pancreatic cancer. Technical success was achieved in 93.5% of patients. Forty patients had pancreaticogastrostomy and 3 patients pancreaticoduodenostomy. The mean hospital stay was 2 days. Clinical success was 93% in patients who achieved technical success. Remaining pain (VAS >2) occurred in 9.3% of patients and obstructive pancreatitis recurrence in 6.9%. Adverse events occurred in 5 patients (11.6%). Eighteen stent dysfunctions, 16 stent migrations, and 2 stent obstructions were observed. No patients died from the procedure.

Conclusions: EUS-guided pancreatic duct drainage showed a high clinical success rate. It is therefore a good minimally invasive alternative to avoid pancreatic surgery in patients with symptomatic pancreatic duct stenosis of benign or malignant etiology who failed ERCP. (iGIE 2024;3:237-46.)

Main pancreatic duct (MPD) obstruction can cause disabling upper abdominal pain and progressive atrophy of the pancreatic parenchyma.[1] As a result, patients can develop symptoms secondary to exocrine and endocrine pancreatic insufficiency,[2,3] such as malabsorption and diabetes mellitus. Pain is probably multifactorial but in part due to increased intraductal pressure secondary to pancreatic outflow obstruction.[4] Asymptomatic strictures can be left untreated if malignancy has been ruled out.[2,3] Endoscopic drainage is the first-line treatment in symptomatic patients, usually by endoscopic retrograde cholangiopancreatography (ERCP) with pancreatic sphincterotomy, dilatation of the MPD, and pancreatic stents placement.[2,3,5,6] The goal of endoscopic treatment is to decrease the hyperpressure of the MPD.[7] However, in some patients, the classic transpapillary retrograde approach cannot be performed owing to anatomic inability to access the ampulla, ruptured MPD, anastomotic stricture, stones that cannot be crossed by the guidewire, or tight stenosis of the MPD due to extrinsic compression by pancreatic parenchymal calcifications.[5–10] Chronic pancreatitis (CP) and postsurgical modified anatomy are the most frequent pathologies leading to ERCP failure.[11] EUS-guided drainage of the MPD (EUS-MPDD) appears to be an effective and minimally invasive therapeutic option for these patients and is an alternative to surgery.[3,5,12,13] There are 2 main types of EUS-guided MPD interventions: transparietal antegrade MPD drainage and rendezvous technique.[1,3,8,9,11] Transparietal antegrade MPD drainage consists of putting a stent in the MPD via the stomach or the duodenum with or without crossing the papilla or the anastomotic stricture. In the rendezvous technique, the guidewire is pushed

through the papilla and the stent then retrogradely inserted.[1,3,9,14] In the present study, we assessed clinical outcomes among patients who have undergone EUS-MPDD since its implementation in our tertiary-care referral center in 2016.

METHODS

Study design and patients

This was a retrospective single-center study conducted in the Department of Gastroenterology and Hepatology at the University Hospital in Lausanne, Switzerland. The study was approved by the local ethical board committee (CER-VD ID: 2022-00396). All patients who were 18 years of age or older and who underwent EUS-MPDD from April 2016 to June 2022 were identified. We did not include patients who had been treated by the rendezvous technique. Once informed consent for the study was obtained, records of the day of the endoscopic procedure (procedure protocol, anaesthesia sheet) as well as consultations carried out in our hospital before and after the procedure were analyzed via our software called Soarian, Archimède, and Endobase. Clinical information was prospectively and retrospectively obtained, including patient demographics, active alcohol consumption, cause of the MPD obstruction, CP etiology if defined (alcoholic versus nonalcoholic), presence of pain and use of painkillers before the procedure, and indication for the pancreatic duct drainage procedure. Technical data about the procedure were also recorded, including diameter of the MPD before the procedure, duration of the procedure, puncture site (stomach, duodenum), and size of stents used (cm and F). Follow-up information was analyzed, such as hospitalization status (inpatient versus outpatient), residual pain after the procedure, rate of obstructive pancreatitis recurrence after the procedure, adverse events arising from the procedure and their treatment (repeated endoscopy, surgery, interventional radiologic treatment), and procedure-related mortality. We also reported rate of stent dysfunctions during follow-up, defined as migrations or obstructions. The last available follow-up in our gastroenterology department was used to assess response to the endoscopic procedure.

Endoscopic technique

Endoscopic procedures were done with the patient under either general anesthesia or deep sedation with propofol in titration administered by another gastroenterologist. Intravenous antibiotic prophylaxis by 1 dose of amoxicillin–clavulanic acid and 1 dose of intravenous proton pump inhibitors (40 mg) was given at the beginning of the endoscopic procedure. A linear echoendoscope with carbon dioxide insufflation was used to identify the MPD. Color Doppler was used to exclude the presence of vascular structures between the GI tract and the pancreas. The site and number of strictures in MPD was taken into consideration before performing the drainage. The stenosis had to be located in the head, isthmus, or proximal part of the body of the pancreas. If the stenosis was more distal (distal part of the body or tail of the pancreas), there was insufficient margin to place the stent in the dilated MPD from the stomach or the duodenum. The MPD was punctured with a 19-gauge needle, from either the stomach or the duodenum depending on the patient's anatomy, followed by a contrast injection to provide a pancreatogram and confirm the good position into the MPD. Then a guidewire was passed through the needle into the duct. After removal of the needle over the guidewire, pathway dilation was achieved with the use of a 6F cystotome using Endo Cut I current effect 1 and, in case of hard pancreatic parenchyma, a 4-mm balloon. A pancreatic straight plastic stent was placed, with the proximal extremity into the gastric or duodenal lumen and the distal part into the MPD or through the papilla into the duodenum (Fig. 1). The length of the plastic endoprosthesis was determined at the time of procedure based on the anatomy of the patient. Four weeks later, the placement of a second stent parallel to the first one was attempted, to provide flow not only within but also between stents (Fig. 2).

End points

The primary end point of the study was clinical success of EUS-MPDS, defined as residual pain $\leq$2 on the visual analog scale (VAS, 0-10) and no recurrence of obstructive pancreatitis after successful stent placement during the follow-up period. If the indication for EUS-MPDD was painless weight loss, then clinical success was defined as weight stabilization or weight regain after the procedure.

The secondary outcomes were technical success of EUS-MPDD, defined as successful insertion of a prosthesis between the MPD and the stomach or duodenum (pancreaticogastrostomy or pancreaticoduodenostomy), adverse events and their treatment: infections, acute pancreatitis (obstructive/alcoholic), pneumoperitoneum, hemorrhage, prosthesis migration, perforation, intra-abdominal collections, pancreatic fistula, abdominal pain exacerbation, and mortality related to the procedure. The grade of adverse event was defined according to the definitions provided by the American Society for Gastrointestinal Endoscopy (ASGE) workshop.[15] We also assessed whether the endoscopic intervention was undertaken as outpatient or as inpatient.

Statistics

Data were entered into an Excel sheet (Microsoft Excel 2010; Microsoft Corp, Redmond, Wash, USA). The statistical analyses were performed by A.S. using Stata (version 16 IC; College Station, Tex, USA). QQ plots were used to analyze data distribution. Results of numeric data are presented either as mean $\pm$ SD (for normally distributed data) or as median (interquartile range [IQR]) and range (for nonparametric data). The chi-square test was used to

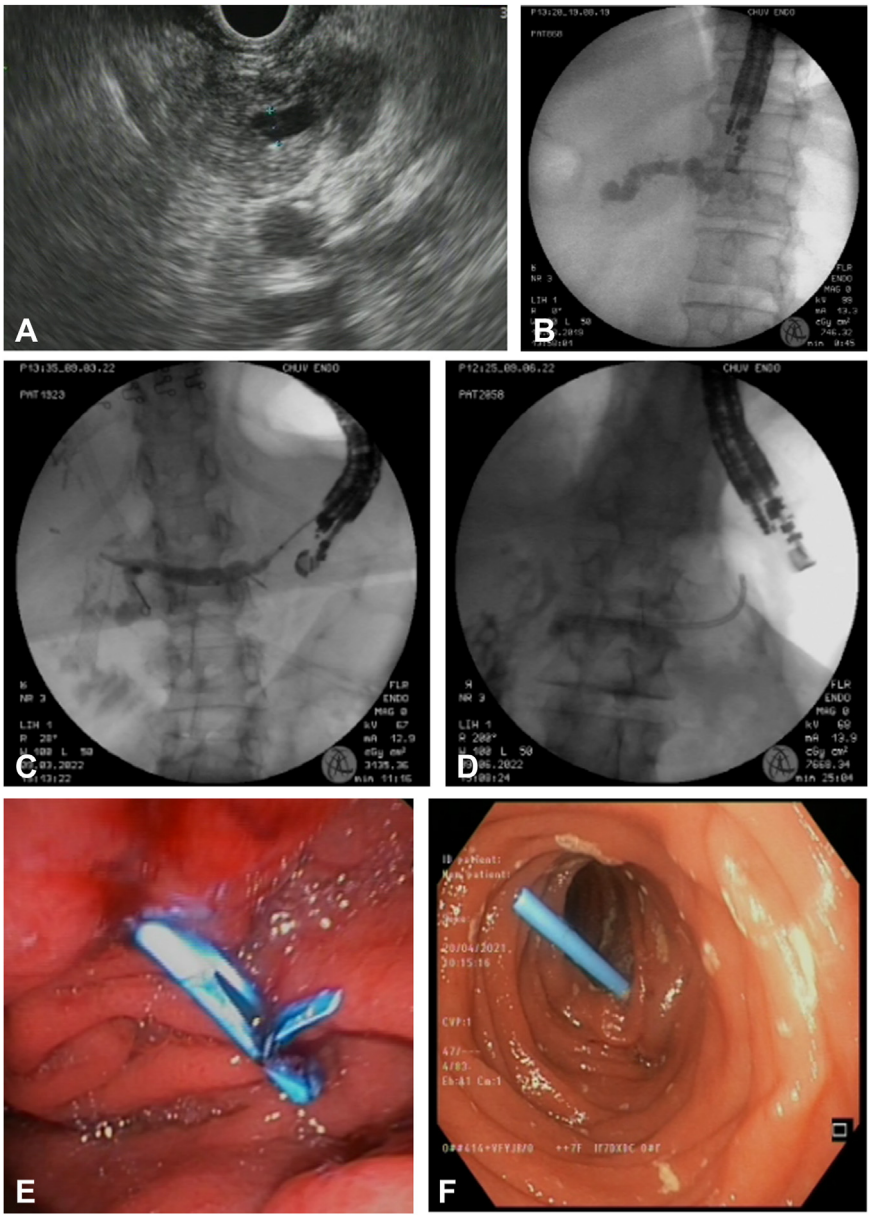

Figure 1. EUS-guided antegrade MPD drainage. **A,** EUS imaging shows a dilated main pancreatic duct. **B,** After needle access into the main pancreatic duct by EUS guidance, pancreatography confirms a dilated and irregular main pancreatic duct. **C,** A guidewire is advanced into the main pancreatic duct, then the track is dilated with the use of an electrical cautery dilator and a balloon. **D,** A single straight plastic stent is placed in the pancreatic duct. Endoscopic images show successful placement of **E,** a transgastric and **F,** a transduodenal stent.

explore associations of categoric data between 2 groups. The Wilcoxon rank sum test was used to explore associations of nonparametric numeric data between 2 groups. For the purposes of this study, a P value <.05 was considered to be statistically significant.

RESULTS

From April 2016 to June 2022, we performed 1152 pancreatic duct drainage procedures in our center, of which 4.5% were EUS-MPDD. A total of 52 patients who underwent EUS-MPDD were identified from our database. All patients provided informed consent to EUS-MPDD. Forty-six patients were included; 6 patients did not sign the general consent for the study and were excluded. The baseline characteristics of patients are summarized in Table 1. Median age was 58 years (IQR, 51-65 y; range, 40-81 y) and 69.6% were male. Median body mass index was 22.4 kg/m^2 (IQR, 19.8-25.3 kg/m^2; range, 14.7-40.1 kg/m^2). Before the procedure, 32.6% of patients were actively drinking, 56.4% had pain with VAS ≥5, and 39.1% were taking painkillers on a regular basis.

Indication for EUS-MPDD were CP in 32 patients (69.6%), with 78.1% due to alcohol abuse. Other indications included postoperative adverse events in 8 patients (7 anastomotic stricture and 1 MPD dilation after duodenal suture of an

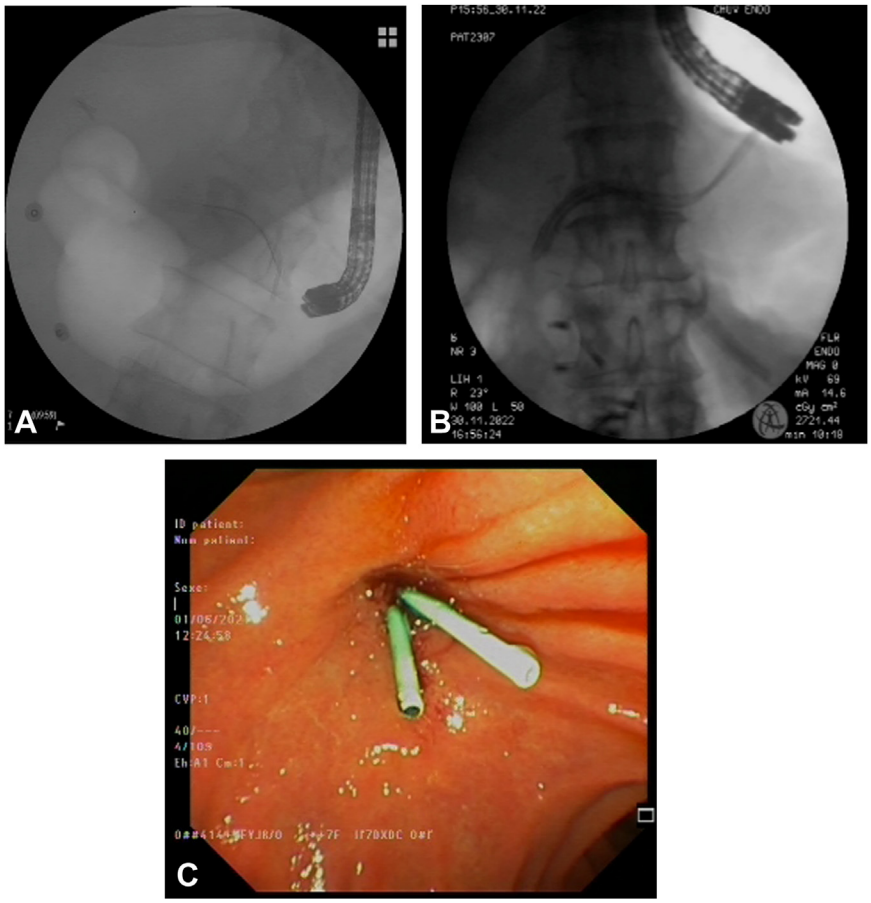

Figure 2. Placement of a second stent 4 weeks later. **A,** A guidewire is advanced into the main pancreatic duct via the old pancreaticogastrostomy or pancreaticoduodenostomy orifice with fluoroscopic guidance. **B,** A second plastic stent is placed in the pancreatic duct, parallel to the first one. **C,** Endoscopic view shows the 2 transduodenal stents side by side.

iatrogenic enteric perforation), 4 MPD ruptures, and 2 multimetastatic pancreatic cancers. Among patients with CP, 7 had both pain and recurrent pancreatitis, 10 had pain only, 10 had recurrent pancreatitis only, 3 had significant progressive painless weight loss as the only symptom before EUS-MPDD, ranging from 5 to 11 kg, 1 had a MPD stone located in the head region of the pancreas with dilation of the MPD, and 1 had acute pancreatitis with MPD rupture. Of the 2 patients with multi-metastatic pancreatic cancer, 1 presented with pancreatitis Balthazar E[16] before EUS-MPDD. In the second patient, a CT scan showed an increase in the size of an intraductal papillary mucinous neoplasm upstream of the tumor, from 26 mm to 53 mm, and a massive MPD dilation, raising fears of the occurrence of an acute pancreatitis, which could have delayed oncologic treatment.

The majority of patients with CP included in our study had a dominant MPD stricture in the head region of the pancreas (28/32 patients). Four patients had a dominant MPD stricture in the isthmus. In the 3 patients with painless weight loss, the indication for drainage was to avoid further deterioration of exocrine pancreatic function and stabilization of weight. One of the 3 patients had the distal part of the stent positioned in a transpapillary position, and in the other 2 patients it was placed in an intraductal position because the stricture of the head could not be crossed. In these 3 patients, the proximal part of the stent was placed in the stomach. Three months after the procedure, weight gain was achieved in all 3 patients ranging from 1 to 4 kg.

An EUS-guided MPD intervention was performed after failed ERCP in 28 patients. Eighteen patients did not undergo ERCP before EUS-guided drainage, 9 were postoperative patients, 5 had a large intraductal stone, 2 had a multimetastatic pancreatic head adenocarcinoma, 1 had a MPD rupture, and 1 had a MPD stenosis due to parenchymal calcifications.

General anesthesia was used for 29 patients and deep sedation using propofol in titration administered by another gastroenterologist in 17 patients. The median duration of intervention was 51 minutes (IQR, 42-70 min; range, 17-137 min). The median MPD diameter was 7 mm (IQR, 5-9 mm; range, 2-17 mm). Technical success was achieved in 43 patients (93.5%). Forty patients underwent pancreaticogastrostomy and 3 patients pancreaticoduodenostomy. Among patients who underwent pancreaticogastrostomy, the distal part of

TABLE 1. Baseline characteristics of included patients (n = 46)

Sex	
Male	32 (69.6)
Female	14 (30.4)
Age, y	58 (51-65), 40-81
Weight before intervention, kg	66 (59-76), 40-127
Height, cm	173 (166-176), 149-185
BMI, kg/m^2	22.4 (19.8-25.3), 14.7-40.1
Use of analgesics	
Yes	18 (39.1)
No	28 (60.9)
Analgesic class	
1 (paracetamol/NSAID)	5 (27.8)
2 (weak opioids: tramadol/codeine)	6 (33.3)
3 (strong opioids: morphine/fentanyl)	7 (38.9)
Alcohol consumption	
Yes	15 (32.6)
No	31 (67.4)
Abdominal pain before procedure	
Yes	26 (56.4)
No	20 (43.5)
HbA_{1c}, %	5.7 (5.4-7.9), 4.7-9.3
Fecal elastase, μg/g	104 (26-174), 15-249
Indication for pancreatic duct drainage	
Chronic calcifying pancreatitis	32
Other	14
Postoperative adverse events	8
MPD rupture	4
Pancreatic cancer	2
Etiology of chronic calcifying pancreatitis	
Alcohol	25
Other	7
Indeterminate	5
MPD stenosis after surgery	1
Drug-induced pancreatitis	1
Diameter of main pancreatic duct, mm	7 (5-9), 2-17

Values are n (%) or median (interquartile range).
MPD, Main pancreatic duct; *NSAID,* nonsteroidal antiinflammatory drug.

the stent was positioned in a transpapillary position in 6 patients. Median pancreatic stent size used was 9 cm (IQR, 8-9 cm; range, 6-17 cm) and 7F (IQR, 7F-7F; range, 5F-8.5F). Median hospitalization length was 2 days (IQR, 1-4 d; range, 1-15 d). Fifteen of 43 patients were treated as outpatients and were discharged on the same day as the procedure. At the planned repeated procedure, placement of a second side-by-side stent was accomplished in 79.1% of patients. Details regarding the main pancreatic duct drainage are presented in Table 2.

Median duration of follow-up was 10.5 months (IQR, 4-16 mo; range, 1-77 mo). Clinical success was achieved in 40 of the 43 patients who experienced technical success (93%). Three patients had no initial or sustained relief of symptoms despite technical success. After the procedure, 18.6% of patients continued to drink alcohol on a regular basis. During follow-up, 4 patients had pain, and 6 patients had pancreatitis, of which 3 were obstructive in etiology.

Adverse events occurred in 5 patients (11.6%), with 2 severe and 3 moderate adverse events according to the severity grading system of ASGE endoscopic adverse events lexicon.[15] One patient had a gastric perforation and was treated by surgery. One patient had an acute hemorrhage and was treated by radiologic embolization and surgery. One patient had increasing pain after the procedure and was treated with opioids, 1 had gastric wall hematoma successfully drained by means of lumen-apposing metal stent, and 1 had stent migration with development of an infected peripancreatic collection successfully drained with radiologic guidance. Eighteen stent dysfunctions were observed in 17 patients. Migration of stent occurred in 16 patients, 11 were treated with a new endoscopic procedure, 1 was treated with surgery, and 4 patients did not need treatment, because they had no symptom recurrence. Obstruction of stent occurred in 2 patients and was treated with a new endoscopic procedure. No patients died from the procedure. Outcomes assessed in the follow-up period are summarized in Table 3.

DISCUSSION

Endoscopic drainage by means of ERCP is the first-line treatment in patients with symptomatic obstruction of the pancreas, with the aim of decompressing the MPD.[7,17] However, the failure rate of ERCP is 3% to 10% in the literature.[2] It can rise up to 80% in case of postoperative patients with pancreatico-enteric anastomotic stenosis.[18] When retrograde approach is not feasible, EUS-MPDD is a minimally invasive technique and a good alternative to surgery.[5,12] The advantage of this technique is the possibility of different access points (stomach, duodenal, or jejunal) depending on the anatomy of the patient.[8] Nevertheless, it is one of the most difficult endoscopic techniques for other reasons: The stability of the scope in the stomach or duodenal bulb is low, leading to potential loss of position with distancing of the pancreas during the procedure; the MPD is difficult to puncture owing to an often fibrotic and hard parenchyma; the advancement of the guidewire through the needle is challenging because there is a risk of peeling; and the creation of the fistula requires manipulations with a high risk of dislocation.[19]

Compared with previous studies, the strength of our work is its large sample size. In addition, most of the available studies included patients with antegrade and rendezvous drainage in the same report.[12,20,21] We decided to

TABLE 2. Details regarding the main pancreatic duct (MPD) drainage

Type of anesthesia	
General	29 (63)
Propofol sedation (administered by another gastroenterologist)	17 (37)
Duration of intervention, min	51 (42-70), 17-137
MPD diameter, mm	7 (5-9), 2-17
Technical success	
Yes	43 (93.5)
No	3 (6.5)
Type of intervention	
Pancreaticogastrostomy	40 (93)
Pancreaticoduodenostomy	3 (7)
Stone removal from MPD	
Yes	0 (0)
No	43 (100)
Length of stent used, cm	9 (8-9), 6-17
Diameter of stent used, F	
5	3 (7)
7	39 (90.7)
8.5	1 (2.3)
No. of stents used	
1	9 (29.9)
2	34 (79.1)
Hospitalization length, d	2 (1-4), 1-15

Values are n (%) or median (interquartile range).
MPD, Main pancreatic duct.

include only patients who underwent antegrade EUS-MPDD and thus focused on one technique.

We found a technical success of 93.5% (43/46 patients). The 3 unsuccessful procedures were principally due to nondilated MPD. It is important to note that the puncture and opacification of MPD was successful in the 3 patients with technical failure, but the guidewire could not be advanced in the MPD. One of these patients was treated with surgery, and the 2 others did not need a subsequent pancreatic intervention, because they remained asymptomatic during the follow-up. The MPD puncture alone was perhaps sufficient to reduce ductal hypertension and subsequently pain. In fact, Will et al[22] suggested that fistulotomy alone can lead to clinical improvement, even without the placement of a stent.

In our study, 93% of patients who reached the outcome of technical success had an improvement of their symptoms after a median follow-up of 10.5 months. The lack of response in some patients is probably due to the fact that pain is multifactorial and only partially related to MPD hypertension.[4,23] Pancreatic ischemia, neuropathic modifications, and infiltration of immune cells within the pancreas leading to inflammation of the gland are other contributors to pain.[11] In a review of 2019 focusing on antegrade EUS-MPDD, technical success was 89% and clinical success was 87%.[11] A systematic review and meta-analysis of 16 studies and 1498 patients found an immediate pain relief of 88% but long-term clinical success of endoscopic treatment fell to 67%. Thus, the benefit of endotherapy seems to decrease over time.[7] A randomized study comparing endoscopy and surgery in patients with painful CP found similar initial pain relief in both groups but better long-term pain reduction with surgery.[24] Despite this, the recommended treatment of symptomatic MPD strictures refractory to analgesics remains endoscopic drainage,[6] which is a less invasive treatment than surgery. Of course, stopping alcohol intake is an integral part of the management of patients with CP of ethylic etiology. In 3 patients of our cohort, the indication to the EUS-MPDD was painless weight loss. All of them achieved weight gain after the procedure. However, 3 patients is too small a sample size to draw any meaningful conclusion regarding impact of pancreatic drainage on exocrine insufficiency.

Pathway dilatation is mandatory before placing a stent between the stomach/duodenum and the MPD.[1,14,25] This can be done by balloon or electrocautery dilator. The literature describes adverse events with cauterization devices due to "burn effect" around the tract, including bleeding, perforation, pancreatitis, and pancreatic juice leakage.[10,14] Fujii-Lau and Levy[12] suggest using only balloon dilating to minimize the risk of pancreatic fluid leak. Other authors observed more peripancreatic collections when using balloon dilatation compared with a diathermic catheter.[13] Because of its radial force, balloon dilatation increases the risk of perforation, leakage, and bleeding.[26] Electrocautery devices may be more efficient in case of fibrous and hard pancreatic parenchyma, as in CP.[11,27] We used electrical cautery dilators for all of our cases and observed a low bleeding rate in our patients. It is still not clear if balloon is safer than electrocautery dilator.[10] In countries where the 6F cystotome is not commercially available, balloon dilatation alone or eventually a Retriever may be used to create the fistula.

In the literature, the rate of adverse events is around 20%.[2,13] The most frequent adverse events reported are abdominal pain, acute pancreatitis, bleeding, perforation, and pancreatic juice leaks.[27,28] We observed a 11.6% adverse events rate with 2 severe and 3 moderate adverse events. Regarding the 2 severe adverse events, 1 patient had a pseudocyst drainage by 2 double-pigtail stents and a biliary stent replacement at the same time of the EUS-MPDD. He developed shock during the procedure. The CT scan showed a gastric fundus perforation, which was probably caused by the cystotome and the migration of the 5F pancreatic plastic stent to an intrapancreatic position. The perforation could have been closed endoscopically but, because of the associated intrapancreatic migration of the stent, he benefited from surgical management. In the second patient with a severe adverse event, the pancreatic parenchyma was extremely hard and we were not able to advance the cystotome through it to reach the MPD. While we were trying to drill the path with the

TABLE 3. Outcomes assessed in the follow-up period

Duration of follow-up interval, mo	**10.5 (4-16), 1-77**
Adverse events	
Yes	5 (11.6)
No	38 (88.4)
Severity of adverse events	
Mild-moderate	3 (60)
Severe	2 (40)
Type of adverse events (n = 5)	
Significant intragastric bleeding	1 (20)
Superinfected peripancreatic fluid collection	1 (20)
Pain after drainage necessitating opioid treatment	1 (20)
Gastric perforation	1 (20)
Perigastric hematoma	1 (20)
Pancreatitis during follow-up	
No	37 (86.1)
Yes	6 (13.9)
Alcoholic	3 (7)
Obstructive	3 (7)
Pain during follow-up	
No	39 (90.7)
Yes	4 (9.3)
Use of analgesics during follow-up	
No	40 (93)
Yes	3 (7)
Clinical success	
Yes	40 (93)
No	3 (7)
Alcohol consumption during follow-up	
No	35 (81.4)
Yes	8 (18.6)
Stent dysfunction during follow-up	
No	26 (60.5)
Yes	17 (39.5)
Weight at end of follow-up, kg	68 (54-75), 33-127
Death during follow-up	
Yes	0 (0)
No	43 (100)
Need for reintervention other than standard	
Yes	13 (30)
No	30 (70)
Need for surgery	
No	41 (95.4)
Yes	2 (4.6)

Values are n (%) or median (interquartile range).

cystotome, we noticed significant intragastric bleeding. The CT scan showed no active bleeding at the time it was done, but we suspected a left gastric or a pancreatic artery injury. The patient was treated with radiologic embolization followed by surgery to evacuate the hematoma. For the patients with moderate adverse events, the MPD drainage was not technically difficult. One patient had increasing pain after the procedure and lipase elevation to 2.5 times normal. He was treated with opioids, and the pain and lipase normalized after 3 days. One patient developed abdominal pain and inflammatory syndrome 3 days after the procedure. The CT scan showed a gastric wall hematoma successfully drained by lumen-apposing metal stent. Finally, 1 patient had stent migration in an intrapancreatic position with development of an infected peripancreatic collection successfully drained by radiologic guidance 2 days after the initial procedure. Fujii et al[20] found that adverse event rates decrease with operator experience. That was also the case in our series, with the 2 severe adverse events arising in 2017, at the beginning of the procedure implementation in our center.

Ten patients with unsuccessful ERCP had a sequential EUS-MPDD during the same anesthesia session. In these cases, the EUS-MPDD procedure was explained and accepted by the patients before anesthesia. Although the mean procedure time was longer (76 minutes versus 51 minutes when the EUS-MPDD was done after some time), we did not observe more adverse events in these patients (10% versus 11.6%).

In the 6 patients in whom the guidewire could be passed through the papilla, we did not opt for a rendezvous, because this technique required more manipulation, with the risk of losing the guide. We therefore preferred to insert the stent anterogradely, putting the distal part of the stent in a transpapillary position.

We used straight plastic stents only. The main problem is stent dysfunction, varying from 25%[20] to 55%[29] in the literature. We had 18 stent dysfunctions in 17 patients (39.5%), with 16 stent migrations and 2 stent obstructions. Thirteen patients had a new endoscopic procedure, 1 was treated by surgery, and 4 did not need subsequent treatment after stent migration. Among the 6 patients with the distal part of the stent placed in a transpapillary position, only 1 had a partial stent migration. This patient underwent repeated endoscopy 4 days after the initial procedure in the context of a parietal gastric hematoma, and the stent had partially migrated to the duodenal side. The transpapillary position therefore appears to reduce the stent migration rate. We decided not to count stent dysfunctions in the adverse events, because the large majority did not have major consequence to the patient's condition. In fact, migration occurred on the gastric side, except in the patient who had to be treated by surgery. In this particular case, the 5F plastic stent had migrated to an intrapancreatic position. The same patient had the gastric perforation mentioned above. In this context, we decided not to repeat the

endoscopic procedure and he was treated with surgical pancreaticoduodenectomy. The high migration rate may be due to the limited intraductal length of the stent and to the strong GI peristalsis.[30] When the procedure was first implemented in our center, we used 5F stents. However, these small stents can migrate into the MPD. We currently prefer 7F stents to be able to use a retriever in case of intracanal migration. Stent migration could perhaps be reduced with use of double-pigtail stents, as suggested Fujii et al,[20] who found that migration occurred in 23% of straight stents versus 9% of double-pigtail stents. Tyberg et al[31] used double-pigtail stents for all patients, and none suffered from stent dysfunction. However, double-pigtail stents might cause intraductal precipitation and are more difficult to position than straight plastic stents, so they are not used in our center. With single-pigtail stents, it is not possible to use a retriever in case of migration, so we do not use them, either. Stent obstruction may be related to the small diameter of the stents.[30] Hayat et al[23] suggested that placement of 2 side-by-side stents permits pancreatic drainage between the stents even in case of obstruction. We waited 4 weeks before inserting a second stent parallel to the first one, to await fistula formation and thus avoid pancreatic leakage. With this technique, we have not observed any pancreatic leaks in our patients. We were able to place a second stent 4 weeks after the initial procedure in 79.1% of patients. Oh et al[32] observed a significant pain score improvement with the use of fully covered self-expandable metal stents (FCSEMSs) in 25 patients with painful obstructive pancreatitis. One advantage of metal stents could be their tamponade effect reducing bleeding and pancreatic juice leakage risk.[10,27] In addition, there were no stent migrations or obstructions in the population treated with FCSEMSs.[32] However, the use of FCSEMSs for EUS-MPDD still lacks evidence. In our center, we do not use FCSEMSs for PD drainage owing to the risk of pancreatitis due to obstruction of secondary ducts. In addition, we think that FCSEMSs are more painful and less well tolerated than plastic stents. A study comparing different types of stents for EUS-MPDD would be interesting.

In our study, 2 patients had multi-metastatic pancreatic cancer. We usually perform celiac plexus neurolysis in pancreatic cancer patients who present with pain, but the 2 patients with multi-metastatic pancreatic cancer included in our cohort were pain free, so they would not benefit from it. Patients with tumor-induced MPD obstruction are at risk of acute pancreatitis, which if it occurs, would delay their oncologic management. In these 2 patients, drainage was intended to manage obstruction of the MPD that was causing severe acute pancreatitis or putting the patient at very high risk of acute pancreatitis. The indication for EUS-MPDD in these 2 cases was discussed and decided at a multidisciplinary meeting involving surgeons and oncologists at our institution. After drainage, these 2 patients did not develop pancreatitis and were able to receive their oncologic treatment. Uchida et al[33] suggested that EUS-MPDD can be a palliative treatment for patients with malignant strictures. However, transgastric or transduodenal drainage should be avoided in patients with resectable tumors, because of tumor cell dissemination risk. Palliative endoscopic drainage can be done by means of plastic stents or FCSEMSs. More data are needed to define the best option for stents for such patients.[2]

An international multicenter study including 7 tertiary centers and comparing EUS-MPDD with enteroscopy-assisted retrograde drainage after Whipple surgery found that EUS-MPDD was associated with significantly greater technical and clinical success.[34] According to a French retrospective single-center study, the rate of technical success, clinical success, and adverse events was not different between patients with CP and those with postoperative stenosis who underwent EUS-MPDD.[35] Some authors suggested than EUS-MPDD could be attempted as a first-line treatment in patients with pancreaticoduodenectomy owing to a high success rate in this population.[12,34] Sakai et al[36] also proposed that EUS-MPDD may be tried as a first endoscopic intervention when retrograde drainage is likely to fail. In our study, we performed EUS-MPDD as a first-line intervention in 18 patients. It included 9 postoperative cases, 5 patients with large intraductal stone, 2 patients with multi-metastatic pancreatic adenocarcinoma, 1 with MPD rupture, and 1 with MPD stenosis with parenchymal calcifications. We chose this option in patients for whom retrograde drainage was likely to be unsuccessful owing to a difficult-to-access anastomosis, a large stone, a pancreatic stenosis or fracture that could not be crossed, or massive neoplastic invasion of the papilla. In experienced hands, EUS-MPDD is a rapid and efficient procedure. Moreover, it has the advantage of being a definitive solution without need to change the stents at regular intervals. A further study comparing outcomes of anterograde versus rendezvous technique in patients with altered surgical anatomy would be interesting.

In patients with intraductal stones, we perform lithotripsy only when lithiasis can be crossed by the guidewire and a stent can be put in the MPD, owing to the risk of pancreatitis. In the patients included in the present study, the MPD stenosis or stones could not be crossed, so we opted for EUS-MPDD as a first step. If pain persists after EUS-MPDD, then lithotripsy is proposed as a second step.

Regarding retrograde drainage of MPD, European Society of Gastrointestinal Endoscopy (ESGE) guidelines recommend that the stent should be replaced, based on symptoms or signs of stent dysfunction at least every 6 months.[6] Unlike MPD retrograde drainage, there are currently no clear guidelines on whether or not EUS-MPDD stents should be replaced. Matsunami et al[37] planned stent exchange every 3 to 4 months after initial EUS-MPDD, with a long-term clinical success rate of 92%. Fujii et al[20] observed that symptom resolution persisted in most patients after stent removal, which suggests that many patients will have a durable clinical benefit even without a stent in place. In our center, we did not plan iterative stent exchange. Our protocol was to leave the EUS-MPDD stents in place indefinitely to ensure that the fistula remains open and that the drainage remains effective.

We changed stents only in patients with recurrent symptoms. This avoided additional costs and anesthetic risk for the patients. Our expertise shows that the efficacy of EUS-MPDD seems more definitive than retrograde drainage, probably because the pancreaticogastric or pancreaticoduodenal fistula remains effective over the long term even after stent migration. A study is currently underway to demonstrate the long-term benefits of this protocol. We did not perform a systematic radiologic examination after the procedure and therefore we do not know what proportion of patients still have the stent in place. Some stents may have migrated without recurrence of symptoms. One possible explanation may be that a pancreatogastric fistula could persist after stent removal.[22] However, it is not known how long these fistulous paths remains permeable.[11] A study evaluating long-term outcomes of patients who undergo EUS-MPDD is clearly needed.

The major limitation of our study is its retrospective design with inclusion bias and heterogeneity of pancreatic diseases.

CONCLUSION

EUS-MPDD is an effective and safe procedure with a high clinical success rate that allows avoiding surgery in patients with ERCP failure. It could even be used as a first-line treatment in patients in whom ERCP failure can be expected, such as postoperative patients or cases of severe MPD stenosis or large MPD stones. Nevertheless, it is a technically challenging procedure that has to be done by an experienced endoscopist trained in ERCP and therapeutic EUS. For this reason, available studies often include a small number of patients with a heterogeneous population and mixing anterograde drainage and rendezvous technique. Larger, long-term, prospective, multicenter studies focusing on anterograde drainage are mandatory to clarify the technical success, short- and long-term adverse events, the duration of fistula patency, and thus the long-term clinical success. Moreover, it may be interesting to compare straight plastic stents, double-pigtail stents, and FCSEMSs.

DISCLOSURE

This work was supported by a grant from the Swiss National Science Foundation (32003B_204751/1 to AMS). All authors disclosed no financial relationships.

Abbreviations: CP, chronic pancreatitis; EUS-MPDD, EUS-guided drainage of the main pancreatic duct; FCSEMS, fully covered self-expandable metal stent; MPD, main pancreatic duct.

REFERENCES

1. Itoi T, Kasuya K, Sofuni A, et al. Endoscopic ultrasonography–guided pancreatic duct access: techniques and literature review of pancreatography, transmural drainage and rendezvous techniques. Dig Endosc 2013;25:241-52.
2. Dawod E, Kahaleh M. Management of benign and malignant pancreatic duct strictures. Clin Endosc 2018;51:156-60.
3. Jearth V, Giri S, Sundaram S. Approach to management of pancreatic strictures: the gastroenterologist's perspective. Clin J Gastroenterol 2021;14:1587-97.
4. Sebastiano PD, di Mola FF, Büchler MW, Friess H. Pathogenesis of pain in chronic pancreatitis. Dig Dis 2004;22:267-72.
5. Widmer J, Sharaiha RZ, Kahaleh M. Endoscopic ultrasonography–guided drainage of the pancreatic duct. Gastrointest Endosc Clin N Am 2013;23:847-61.
6. Dumonceau J-M, Delhaye M, Tringali A, et al. Endoscopic treatment of chronic pancreatitis: European Society of Gastrointestinal Endoscopy (ESGE) guideline—updated August 2018. Endoscopy 2019;51:179-93.
7. Jafri M, Sachdev A, Sadiq J, et al. Efficacy of endotherapy in the treatment of pain associated with chronic pancreatitis: a systematic review and meta-analysis. JOP 2017;18:125-32.
8. Dhir V, Isayama H, Itoi T, et al. Endoscopic ultrasonography-guided biliary and pancreatic duct interventions. Dig Endosc 2017;29:472-85.
9. Shimamura Y, Mosko J, Teshima C, May GR. Endoscopic ultrasound-guided pancreatic duct intervention. Clin Endosc 2017;50:112-6.
10. Imoto A, Ogura T, Higuchi K. Endoscopic ultrasound–guided pancreatic duct drainage: techniques and literature review of transmural stenting. Clin Endosc 2020;53:525-34.
11. Krafft MR, Nasr JY. Anterograde endoscopic ultrasound-guided pancreatic duct drainage: a technical review. Dig Dis Sci 2019;64:1770-81.
12. Fujii-Lau LL, Levy MJ. Endoscopic ultrasound-guided pancreatic duct drainage. J Hepatobiliary Pancreat Sci 2015;22:51-7.
13. Giovannini M. EUS-guided pancreatic duct drainage: ready for prime time? Gastrointest Endosc 2013;78:865-7.
14. Itoi T, Yasuda I, Kurihara T, Itokawa F, Kasuya K. Technique of endoscopic ultrasonography-guided pancreatic duct intervention (with videos). J Hepatobiliary Pancreat Sci 2014;21:e4-9.
15. Cotton PB, Eisen GM, Aabakken L, et al. A lexicon for endoscopic adverse events: report of an ASGE workshop. Gastrointest Endosc 2010;71:446-54.
16. Balthazar EJ, Robinson DL, Megibow AJ, Ranson JH. Acute pancreatitis: value of CT in establishing prognosis. Radiology 1990;174:331-6.
17. Kahaleh M, Hernandez AJ, Tokar J, Adams RB, Shami VM, Yeaton P. EUS-guided pancreaticogastrostomy: analysis of its efficacy to drain inaccessible pancreatic ducts. Gastrointest Endosc 2007;65:224-30.
18. Vanbrugghe C, Campanile M, Caamaño A, Pol B. Management of delayed stenosis of pancreatico-enteric anastomosis following pancreatoduodenectomy. J Visc Surg 2019;156:30-6.
19. Devière J. EUS-guided pancreatic duct drainage: a rare indication in need of prospective evidence. Gastrointest Endosc 2017;85:178-80.
20. Fujii LL, Topazian MD, Dayyeh BKA, et al. EUS-guided pancreatic duct intervention: outcomes of a single tertiary-care referral center experience. Gastrointest Endosc 2013;78:854-64.e1.
21. Tyberg A, Bodiwala V, Kedia P, et al. EUS-guided pancreatic drainage: a steep learning curve. Endosc Ultrasound 2020;9:175-9.
22. Will U, Reichel A, Fueldner F, Meyer F. Endoscopic ultrasonography-guided drainage for patients with symptomatic obstruction and enlargement of the pancreatic duct. World J Gastroenterol 2015;21:13140-51.
23. Hayat U, Freeman ML, Trikudanathan G, Azeem N, Amateau SK, Mallery J. Endoscopic ultrasound-guided pancreatic duct intervention and pancreaticogastrostomy using a novel cross-platform technique with small-caliber devices. Endosc Int Open 2020;08:e196-202.
24. Díte P, Ruzicka M, Zboril V, Novotný I. A prospective, randomized trial comparing endoscopic and surgical therapy for chronic pancreatitis. Endoscopy 2003;35:553-8.
25. Chapman CG, Waxman I, Siddiqui UD. Endoscopic ultrasound (EUS)–guided pancreatic duct drainage: the basics of when and how to perform EUS-guided pancreatic duct interventions. Clin Endosc 2016;49:161-7.

26. Kahaleh M, Artifon EL, Perez-Miranda M, et al. Endoscopic ultrasonography guided biliary drainage: summary of consortium meeting, May 7th, 2011, Chicago. World J Gastroenterol 2013;19:1372-9.
27. Ogura T, Ohama H, Higuchi K. Endoscopic ultrasound–guided pancreatic transmural stenting and transmural intervention. Clin Endosc 2019;53:429-35.
28. Chandan S, Mohan BP, Khan SR, et al. Efficacy and safety of endoscopic ultrasound-guided pancreatic duct drainage (EUS-PDD): a systematic review and meta-analysis of 714 patients. Endosc Int Open 2020;08:e1664-72.
29. Tessier G, Bories E, Arvanitakis M, et al. EUS-guided pancreatogastrostomy and pancreatobulbostomy for the treatment of pain in patients with pancreatic ductal dilatation inaccessible for transpapillary endoscopic therapy. Gastrointest Endosc 2007;65:233-41.
30. Ergun M, Aouattah T, Gillain C, Gigot J-F, Hubert C, Deprez PH. Endoscopic ultrasound–guided transluminal drainage of pancreatic duct obstruction: long-term outcome. Endoscopy 2011;43:518-25.
31. Tyberg A, Sharaiha RZ, Kedia P, et al. EUS-guided pancreatic drainage for pancreatic strictures after failed ERCP: a multicenter international collaborative study. Gastrointest Endosc 2017;85:164-9.
32. Oh D, Park DH, Cho MK, et al. Feasibility and safety of a fully covered self-expandable metal stent with antimigration properties for EUS-guided pancreatic duct drainage: early and midterm outcomes (with video). Gastrointest Endosc 2016;83:366-73.e2.
33. Uchida D, Kato H, Saragai Y, et al. Indications for endoscopic ultrasound-guided pancreatic drainage: for benign or malignant cases? Can J Gastroenterol Hepatol 2018;2018:e8216109.
34. Chen Y-I, Levy MJ, Moreels TG, et al. An international multicenter study comparing EUS-guided pancreatic duct drainage with enteroscopy-assisted endoscopic retrograde pancreatography after Whipple surgery. Gastrointest Endosc 2017;85:170-7.
35. Rudler F, Caillol F, Ratone J-P, et al. EUS-guided drainage of the pancreatic duct for the treatment of postoperative stenosis of pancreaticodigestive anastomosis or pancreatic duct stenosis complicating chronic pancreatitis: experience at a tertiary care center. Endosc Ultrasound 2022;11:296-305.
36. Sakai T, Koshita S, Kanno Y, et al. Early and long-term clinical outcomes of endoscopic interventions for benign pancreatic duct stricture/obstruction-the possibility of additional clinical effects of endoscopic ultrasonography-guided pancreatic drainage. Pancreatology 2022;22:58-66.
37. Matsunami Y, Itoi T, Sofuni A, et al. Evaluation of a new stent for EUS-guided pancreatic duct drainage: long-term follow-up outcome. Endosc Int Open 2018;6:e505-12.

https://doi.org/10.1016/j.igie.2024.04.005

Received September 6, 2023. Accepted April 21, 2024.

Current affiliations: Department of Gastroenterology and Hepatology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland (1), Department of General Surgery, Établissements Hospitaliers du Nord Vaudois, Yverdon-les-Bains, Switzerland (2), Department of Gastroenterology and Hepatology, Institut Paoli Calmettes, Marseille, France (3).

Reprint requests: Elodie Romailler, MD, Department of Gastroenterology and Hepatology, Centre Hospitalier Universitaire Vaudois, Rue du Bugnon 44, CH-1011 Lausanne, Switzerland.