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Clinical utility of the forward-viewing echoendoscope in patients after pancreatoduodenectomy: A prospective study

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ABSTRACT

Background and Objectives: Endoscopic treatment of obstructive jaundice and pancreatitis due to hepaticojejunostomy (H-J), pancreatojejunostomy (P-J) strictures, and tumor recurrence after pancreatoduodenectomy (PD) is technically challenging. Treatment of P-J strictures results in poor outcomes. Although conventional EUS that has an oblique view is not suitable for such patients, forward-viewing EUS (FV-EUS) may become a useful option. This study aimed to evaluate the feasibility and efficacy of FV-EUS in patients who have undergone PD.

Methods: Patients with PD who were scheduled to undergo diagnosis and treatment using FV-EUS for H-J or P-J lesions were enrolled in this single-center prospective study. After observation of the P-J and H-J using FV-EUS according to a predetermined protocol, treatment using FV-EUS was performed as needed.

Results: A total of 30 patients were enrolled, and FV-EUS was used to observe P-J and H-J in 24 and 28 patients, respectively. The detection rates of P-J and H-J by endoscopy were 50% (12/24) and 96.4% (27/28), respectively, and by EUS were 70.8% (17/24) and 100% (28/28), respectively. Of these, P-J and H-J were found by endoscopy only after EUS observation in 3 and 1 patient, respectively. The success rates of endoscopic treatment using FV-EUS were 66.7% (2/3), 95.2% (20/21), and 25% (1/4) for benign P-J strictures, benign H-J strictures, and tumor recurrence, respectively.

Conclusions: Endoscopic treatment using FV-EUS is feasible and effective for patients after PD. Moreover, FV-EUS increases the P-J lesion detection rate by adding EUS observation.

Keywords: EUS; Pancreatoduodenectomy; Hepaticojejunostomy; Pancreatojejunostomy; Drainage

INTRODUCTION

Pancreatoduodenectomy (PD) is a radical surgery for neoplasms arising from the pancreatic head, including pancreatic, bile duct, duodenal, intraductal papillary mucinous, and neuroendocrine neoplasms. The representative disease is pancreatic cancer, and its incidence has risen in the last 30 years.[1] Hepaticojejunostomy (H-J) and pancreatojejunostomy (P-J) strictures post-PD can cause cholangitis and pancreatitis and occur in 8.2% and 4.6% of patients 5 years after PD, respectively.[2,3] Furthermore, tumor recurrence near H-J and P-J can also cause cholangitis and pancreatitis. Endoscopic diagnosis and treatment of H-J and P-J lesions are performed after endoscopic observation of the lesion. A colonoscope is used sometimes for this purpose; however, balloon enteroscopy is used if colonoscopy fails. Furthermore, the success of the procedure also depends on the available device and the experience level of the operator. The length of the endoscope used depends on the length of the afferent limb. One disadvantage of endoscopy is that only lesions inside the gastrointestinal tract can be observed. Thus, in cases of tumor recurrence, it is impossible to diagnose and perform a biopsy if the tumor does not exist in the gastrointestinal tract. Furthermore, a retrospective study revealed that the overall success rate of endoscopic treatment was approximately 50% (84% and 18% for the H-J and P-J strictures, respectively).[4] Therefore, improvement in endoscopic diagnosis and treatment for H-J and P-J lesions is essential.

Convex curved linear array echoendoscopes (CLA-EUS) are widely used for the diagnosis and treatment of pancreatobiliary diseases. However, because of the oblique view of the echoendoscope, it is occasionally difficult to position the device optimally into the targeted lesion, and it can be challenging to use in cases of surgically altered

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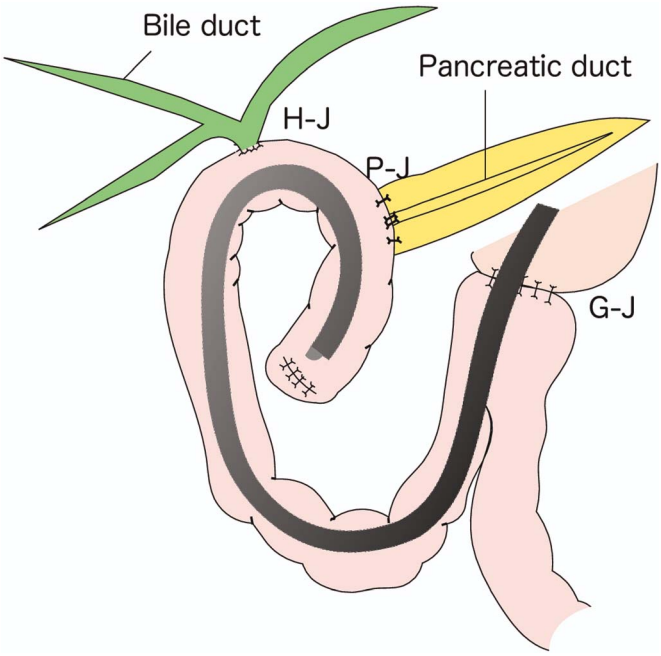

Figure 1. Schema of pancreatoduodenectomy with modified Child reconstruction. G-J: Gastrojejunostomy; H-J: Hepaticojejunostomy; P-J: Pancreatojejunostomy.

anatomy. To overcome this technical hurdle, a forward-viewing linear echoendoscope (FV-EUS) has been developed and used for fine-needle aspiration (FNA), celiac plexus neurolysis, and drainage of pseudocysts and the bile and pancreatic ducts, in cases of normal anatomy.[5–10] A retrospective study evaluated FV-EUS usage in patients after Billroth II and Roux-en-Y reconstruction and found that FV-EUS was effective in reaching the periampullary area and performing FNA in patients with previous Billroth II.[11] Although there have been no studies evaluating the utility of FV-EUS in patients post-PD, FV-EUS has the potential to overcome the difficulty of conventional diagnosis and treatment of H-J and P-J lesions after PD. Therefore, this prospective study aimed to evaluate the utility of FV-EUS for H-J and P-J lesions after PD.

PATIENTS AND METHODS

Study design

This prospective study was conducted at our hospital, where more than 100 PDs and 500 endoscopic retrograde cholangiopancreatography procedures are performed annually. The study protocol was approved by the institutional review board of the institution, and written informed consent was obtained from all participants. The study conforms to the ethical principles of medical research involving human subjects, as described by the Declaration of Helsinki. The trial was registered with the University Hospital Medical Information Network Trials Registry (UMIN000035099).

Patients

Patients who met the following criteria were considered eligible for this study: (1) surgical history of PD, hepatopancreatoduodenectomy (HPD), or total pancreatectomy; (2) modified Child method used as a reconstruction method in pancreatobiliary surgery; and (3) suspected of having P-J or H-J lesions and scheduled to undergo therapeutic endoscopic treatment. Patients were excluded if they met any of the following criteria: (1) previous gastrectomy or esophagectomy, (2) pregnant or breastfeeding, (3) Eastern Cooperative Oncology Group performance status of 4, and (4) age <20 years.

Pancreatoduodenectomy

The standard procedure for PD at our hospital is subtotal stomach-preserving PD, and the reconstruction was performed using a modified Child method via end-to-side P-J and end-to-side H-J without Braun anastomosis (Figure 1).[12] Although the dividing level of the hepatic duct varied among patients, those with multiple biliary orifices at the stump underwent a single H-J after side-to-side connection of the hepatic duct.[12] Before the initiation of this study, standard colonoscopy was routinely performed in patients with suspected H-J or P-J lesions post-PD in our hospital.

Study protocol

Endoscopic treatment was performed using an FV-EUS (TGF-UC260J; Olympus Medical Systems, Tokyo, Japan), with patients in the prone position under conscious sedation (Figure 2). To facilitate the insertion of FV-EUS into the afferent limb, we attached a cap device (MAJ-2187; Olympus Medical Systems) to the scope tip. All procedures were conducted or supervised by an expert endoscopist (H.I.), who had performed more than 6000 endoscopic retrograde cholangiopancreatography procedures, 3000 EUS-FNAs, and 500 EUS-guided treatments. Regardless of the site of the targeted H-J or P-J lesion, FV-EUS was inserted into the blind end of the afferent limb, and its position was confirmed by endoscopic and fluoroscopic findings (Figure 1). Thereafter, endoscopic diagnosis and treatment of the P-J and H-J lesions were performed in the following order (Figure 3): (*a*) endoscopic observation of the P-J lesion;

Figure 2. The tip of a cap-fitted forward-viewing echoendoscope.

(*b*) EUS observation of the P-J lesion; (*c*) second endoscopic observation of the P-J lesion in cases where the P-J lesion was not found by endoscopic observation, but by EUS observation; (*d*) endoscopic observation of the H-J lesion; (*e*) EUS observation of the H-J lesion; and (*f*) second endoscopic observation of the H-J lesion in cases where the H-J lesion was not found by endoscopic observation, but by EUS observation. When P-J and H-J lesions were not detected, they were searched for at least 5 minutes. Subsequently, EUS-FNA and endoscopic treatment using FV-EUS were performed according to the objectives determined for each participant at the time of enrollment. For benign H-J or P-J strictures, guidewire insertion through the stricture and balloon dilation of the stricture was followed by stone removal using a balloon and/or basket catheter, if necessary. In case of biliary obstruction due to tumor recurrence, stents were inserted via the H-J, although the type and combination of stents used in each case were determined according to the obstruction pattern of the bile duct. If H-J and P-J lesions were not detected, but a targeted dilated duct was found, EUS-guided transmural duct drainage was considered and performed as follows: (1) the dilated duct was punctured with a 19-gauge needle under EUS observation; (2) a 0.025-inch guidewire was inserted into the duct under fluoroscopic imaging; (3) the fistula was dilated using a 4-to 8-mm balloon catheter; and (4) a stent, which was chosen according to the clinical condition of the patient, was placed through the fistula. All endoscopic procedures were performed on an inpatient basis. We evaluated the symptoms, laboratory data, and/or abdominal radiographs the next day. When no adverse events (AEs) were observed, patients were allowed to start oral intake of food.

Outcome parameters

The outcome parameters included the following: (1) the detection rate of H-J and P-J by endoscopic observation, (2) the detection rate of H-J and P-J by EUS observation, (3) the success rate of EUS-FNA, (4) the success rate of endoscopic treatment using FV-EUS, and (5) early AEs. The success of FV-EUS in detecting H-J or P-J was judged by endoscopic or EUS observation. When these could not be visualized, the arrival of FV-EUS at the H-J or P-J site was assessed based on fluoroscopic findings. The detection rate of H-J or P-J was the number of cases in which H-J or P-J was observed by endoscopy or EUS, divided by the number of cases in which FV-EUS reached the site of H-J or P-J. Success of EUS-FNA was defined as obtaining of a sample appropriate for pathological diagnosis. Success of endoscopic treatment using FV-EUS was defined as intended endoscopic treatment of the H-J or P-J lesion was accomplished from the jejunum. When endoscopic treatment was not achieved, and the use of other endoscopes (CLA-EUS) or of percutaneous drainage was required, this was defined as failure. Early AEs were defined based on the American Society for Gastrointestinal Endoscopy workshop.[13] We evaluated early AEs until 3 days after endoscopic treatment using FV-EUS. We did not perform a sample size calculation because this was a pilot study; however, we arbitrarily set 30 patients as the target sample size.

RESULTS

Thirty patients were enrolled in this study between December 2018 and January 2021. Patient characteristics are shown in Table 1. Pancreatoduodenectomy, left HPD, and total pancreatectomy were performed in 28, 1, and 1 patient, respectively. Twenty-seven H-J and 3 P-J lesions were diagnosed and treated. All patients with suspected tumors near the H-J (n = 4) and suspected benign P-J strictures (n = 3) required biliary or pancreatic duct stenting because of obstructive jaundice or recurrent pancreatitis, respectively. Dilation of the H-J with or without stone removal was planned for patients with suspected benign H-J strictures (n = 23).

Flow diagrams are illustrated in Figure 4, and the deepest sites where FV-EUS was performed are shown in Table 2. Arrival at the blind end of the afferent limb was achieved in 24 patients. In 4 patients, the FV-EUS did not advance beyond H-J. In 3 of these patients, this was because of acute angulation of the afferent limb and tumor recurrence near H-J after total pancreatectomy in the other patient. In 2 patients who were suspected of recurrence of

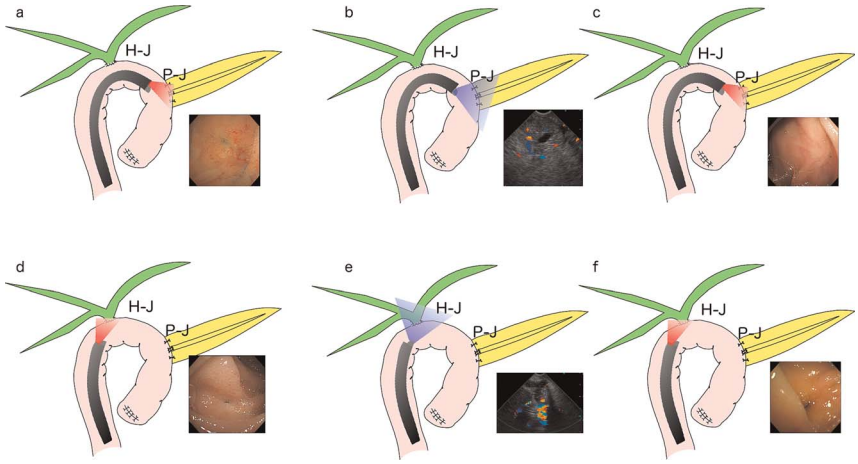

Figure 3. Protocol for observing the pancreatojejunostomy and hepaticojejunostomy. A, Endoscopic observation of the P-J. B, EUS observation of the P-J. C, Second endoscopic observation of the P-J. D, Endoscopic observation of the H-J. E, EUS observation of the H-J. F, Second endoscopic observation of the H-J. After FV-EUS reached the blind end of the afferent limb, the P-J and H-J lesions were observed in the following order: (A) endoscopic and (B) EUS observation of the P-J lesion, (C) second endoscopic observation of the P-J lesion only if first found during EUS, (D) first endoscopic and (E) EUS observation of the H-J lesion, and (D) second endoscopic observation of the H-J lesion only when the H-J was not found in the first endoscopic observation. EUS: FV-EUS: Forward-viewing EUS; H-J: Hepaticojejunostomy; P-J: Pancreatojejunostomy.

Table 1

Patient characteristics.

Gender (male), *n* (%)		23 (76.7)
Age, median (IQR), y		73 (65–77)
Primary disease, *n* (%)	Pancreatic cancer	10 (33.3)
	IPMN	7 (23.3)
	Biliary cancer	6 (20.0)
	PNEN	4 (13.3)
	Others	3 (10.0)
Operation, *n* (%)	Pancreatoduodenectomy	28 (93.3)
	Left HPD	1 (3.3)
	Total pancreatectomy	1 (3.3)
Period between operation and study enrollment, median (IQR), mo		34.9 (12.3–66.1)
Maximum pancreatic duct diameter, median (IQR), mm		2 (1–4)
Pre-endoscopic procedural diagnosis, *n* (%)		
Suspected benign H-J stricture		23 (76.7)
Suspected tumor recurrence near the H-J		4* (13.3)
Suspected benign P-J stricture		3 (10.0)
The objective of the procedure, *n*		
EUS-FNA		4
The dilation of the H-J with/without stone removal		23
Biliary stenting		4
Pancreatic duct stenting		3

H-J: Hepaticojejunostomy; HPD: Hepatopancreatoduodenectomy; IPMN: Intraductal papillary mucinous neoplasm; IQR: Interquartile range; P-J: Pancreatojejunostomy; PNEN: Pancreatic neuroendocrine neoplasm.

*A patient had recurrent tumor near both H-J and P-J.

malignant tumor near H-J, stenosis of the afferent limb due to the tumor hampered the arrival of FV-EUS at the H-J site. In 1 of these 2 patients, EUS-FNA was performed using FV-EUS with a 22-gauge Franseen needle (Acquire; Boston Scientific, Marlborough, MA) with 2 needle passes, and EUS-guided hepaticogastrostomy (EUS-HGS) was performed using CLA-EUS later (Table 3). In the remaining patient after left HPD, EUS-FNA was not performed, because the tumor was not found, and percutaneous biliary drainage was performed later (Table 3). Therefore, P-J and H-J lesions were evaluated in 24 and 28 patients, respectively.

The detection of P-J and H-J lesions by FV-EUS is shown in Table 2. Pancreatojejunostomy was initially found by endoscopic observation in 9 patients but was detected by EUS observation in 17 patients. After EUS observation, endoscopic observation succeeded in finding P-J in 3 more patients whose P-J was not observed before EUS observation. In summary, P-J detection rates were 50.0% (12/24) and 70.8% (17/24) in endoscopic and EUS observations, respectively (Supplementary Figure 1, http://links.lww.com/ENUS/A341). Hepaticojejunostomy was first found by endoscopic observation in 26 patients but was detected by EUS observation in 28 patients. After EUS observation, endoscopic observation succeeded in finding H-J in 1 patient whose H-J could not be found before EUS observation. Hepaticojejunostomy detection rates were 96.4% (27/28) and 100% (28/28) by endoscopic and EUS observations, respectively (Supplementary Figure 1, http://links.lww.com/ENUS/A341). In 1 patient with intact H-J, a low echoic mass in the liver near the H-J site was observed on EUS, and this was diagnosed with biliary obstruction due to tumor recurrence in the liver (Figure 4 and Supplementary Figure 2, http://links.lww.com/ENUS/A342). Furthermore, in another patient where H-J was not detected by endoscopic observation, it was later diagnosed as H-J involving a recurrent tumor in the liver because a low echoic mass and dilated bile duct were found by EUS. In both patients, EUS-FNA was performed using a 22-gauge Franseen needle (Acquire; Boston Scientific) with 2 needle passes.

In total, EUS-FNA was performed in 3 of 4 patients who were scheduled to undergo EUS-FNA at registration (Figure 4). An appropriate sample for pathological evaluation was obtained in all 3 patients who were pathologically diagnosed with adenocarcinoma. Thus, the success rate of EUS-FNA was 75%.

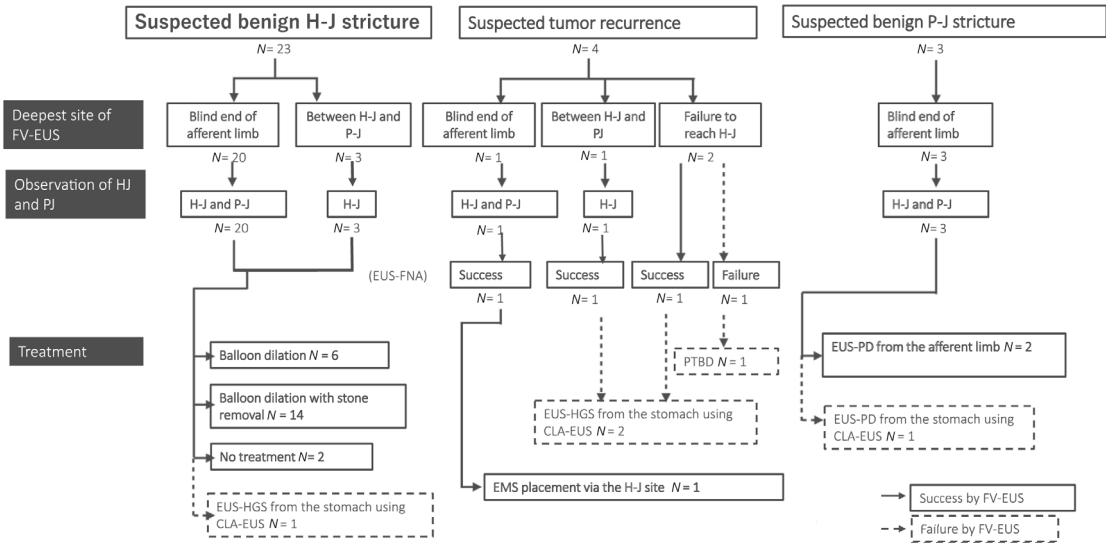

Figure 4. Flow diagram of the patients scheduled to undergo therapeutic endoscopic treatment. Solid and dotted lines indicate the success and failure of the procedure by FV-EUS, respectively. CLA-EUS: Curved linear array–EUS; EUS-HGS: EUS–guided hepaticogastrostomy; EUS-PD: EUS–guided pancreatic duct drainage; FV-EUS: Forward-viewing EUS; H-J: Hepaticojejunostomy; P-J: Pancreatojejunostomy; PTBD: Percutaneous transhepatic biliary drainage.

Endoscopic treatment using FV-EUS is shown in Table 3 and Figure 4. In 3 patients with suspected P-J stricture, the P-J lesion was detected by endoscopic observation before EUS, after EUS, and only by EUS in each patient. In 2 patients where P-J was visualized by endoscopic observation, PD cannulation through P-J was attempted but failed because of severe P-J stricture. Therefore, EUS-guided pancreatic duct drainage (EUS-PD) was conducted from the afferent limb near P-J, and a plastic stent was successfully placed in 2 patients (Supplementary Figure 3, http://links.lww.com/ENUS/A343). In the remaining patient, EUS-PD was done from the stomach because fluid collection near the pancreatic stump hindered the puncturing of the pancreatic duct from the afferent limb. As for suspected benign H-J strictures, balloon dilation of the H-J stricture with or without stone removal was accomplished in 20 patients, and 1 patient required EUS-HGS because of severe H-J stricture (Supplementary Figure 2, http://links.lww.com/ENUS/A342). In 2 patients, no endoscopic treatment was required because there was no H-J stricture. In 1 patient with tumor recurrence, biliary cannulation was achieved from an intact H-J, and 2 metallic stents were inserted into the right and left hepatic ducts using a partial stent-in-stent technique (Supplementary Figure 2. http://links.lww.com/ENUS/A342). In the remaining patient, an appropriately dilated bile duct for puncture was not visualized from the afferent limb by FV-EUS; therefore, EUS-HGS was performed later. In summary, the success rates of endoscopic treatment using FV-EUS were 66.6% (2/3), 95.2% (20/21), and 25% (1/4) for benign P-J lesions, benign H-J lesions, and obstructive jaundice due to tumor recurrence near H-J, respectively. No AE was encountered after the use of FV-EUS in any of the enrolled patients.

Table 2

Detection of pancreatojejunostomy and hepaticojejunostomy lesions using FV-EUS.

Location where FV-EUS reached			
The end of the afferent limb, *n*			24
The location between the H-J and P-J, *n*			4
Tumor between the H-J and the gastrojejunostomy, *n*			2
Detection and finding of pancreatojejunostomy, *n*			24
Endoscopy	Detection	Possible, *n* (%)	12 (50.0)
		Before EUS observation, *n* (%)	9 (37.5)
		After EUS observation, *n* (%)	3 (12.5)
		Impossible, *n* (%)	12 (50.0)
	Finding	No tumor	11
		Tumor	1
EUS	Detection	Possible, *n* (%)	17 (70.8)
		Impossible, *n* (%)	7 (29.2)
	Finding	No tumor	15
		P-J involved by a low echoic mass	1
		Fluid collection and PD dilation	1
Detection and finding of hepaticojejunostomy, *n*			28
Endoscopy	Detection	Possible, *n* (%)	27 (96.4)
		Before EUS observation, *n* (%)	26 (92.9)
		After EUS observation, *n* (%)	1 (3.6)
		Impossible, *n* (%)	1 (3.6)
	Finding	No tumor	26
		Tumor	1
EUS	Detection	Possible, *n* (%)	28 (100)
		Impossible, *n* (%)	0 (0)
	Finding	No tumor	26
		A low echoic mass near intact H-J	1
		H-J involved by a low echoic mass	1

FV-EUS: Forward-viewing EUS; H-J: Hepaticojejunostomy; P-J: Pancreatojejunostomy.

Table 3

EUS–guided fine-needle aspiration and treatment for patients.

Pancreatojejunostomy, *n*	3
Benign P-J stricture, *n*	3
EUS-guided pancreatojejunostomy from the afferent limb, *n*	2
EUS-guided pancreatogastrostomy from the stomach, *n*	1
Hepaticojejunostomy, *n*	27
Benign hepaticojejunostomy stricture, *n*	23
Only balloon dilation of the H-J site, *n*	6
Balloon dilation of the H-J site with stone removal, *n*	14
EUS-guided hepaticogastrostomy using a CLA-EUS scope, *n*	1
No endoscopic treatment because of no H-J stricture, *n*	2
Tumor recurrence near the H-J site, *n*	4
EUS-FNA followed by EMS placement via the H-J site, *n*	1
EUS-FNA using an FV-EUS and EUS-guided hepaticogastrostomy using a CLA-EUS scope, *n*	2
PTBD, *n*	1*

CLA-EUS: Curved linear echoendoscope; EMS: Expandable metallic stent; H-J: Hepaticojejunostomy; P-J: Pancreatojejunostomy; PTBD: Percutaneous transhepatic biliary drainage.

*A patient after left hepatopancreatoduodenectomy.

DISCUSSION

We evaluated the utility of FV-EUS for H-J or P-J lesions after PD in a single-center prospective study. We found that the detection rate of H-J and P-J increased with the addition of EUS observation, compared with endoscopic observation alone. In particular, the benefit of adding an EUS observation was greater while finding the P-J lesion. In addition, subsequent EUS-FNA and endoscopic treatments using FV-EUS were successfully performed when the target lesion was found via EUS. This is the first study to evaluate the utility of FV-EUS in patients after PD.

The treatment of H-J or P-J strictures is ideally performed by endoscopy as a first-line treatment option.[4,14–17] The success rates of treating H-J and P-J lesions post-PD using standard colonoscopy or balloon enteroscopy are 82.3% to 100% and 8% to 20%, respectively.[14–16] Thus, there is a need to improve the success rate for treating P-J lesions. An international multicenter retrospective study reported that the reasons for P-J lesion treatment failure were high-grade stricture, inability to identify, and inability to reach P-J in 42.9%, 35.7%, and 21.4% of patients, respectively.[14] Therefore, improving the PJ detection rate might increase the success rate of the treatment. In our study, the PJ detection rates by endoscopic and EUS observation were 37.5% and 70.8%, respectively. Furthermore, in 3 patients where P-J was not found in the first endoscopic observation, it was later identified by EUS observation, and the P-J detection rate by endoscopic observation increased up to 50%. This indicates that using FV-EUS may enhance the possibility of P-J treatment.

An international multicenter retrospective study showed that the technical and clinical success rates of EUS-PD from the stomach were 89% and 81%, respectively.[18] The rates were slightly lower than those of other EUS-guided treatments, such as biliary drainage, pseudocyst drainage, and celiac plexus neurolysis; therefore, EUS-PD is considered to be a challenging procedure, even for an expert.[19] Furthermore, the rate of major AEs, such as pancreatitis, pancreatic fluid collection, perforation, and main pancreatic duct leak, is 15% for this procedure.[18] However, using EUS-PD from

the afferent limb, main pancreatic duct leak might occur less frequently because of the adhesion of the pancreatic stump and the afferent limb. In addition, the technique is easier because the directions of the endoscope and pancreatic duct are almost parallel. Moreover, the most dilated site of the pancreatic duct, namely, the site close to P-J, becomes the targeted site for puncturing in EUS-PD, which would make the procedure more accessible. Therefore, EUS-PD from the afferent limb might be more suitable than EUS-PD from the stomach in patients with less pancreatic duct dilation and in patients where the stomach and remnant pancreas are not in proximity. However, one of the biggest concerns related to this procedure is the obstruction of the fistula after stent removal. In most patients with benign P-J strictures after EUS-PD, stent removal is desirable. However, it is unclear whether the fistula that is newly created by EUS-PD is maintained for a long time after stent removal. Although a few case reports on this procedure have been published, it is necessary to accumulate more data to investigate the efficacy of the treatment.[20,21]

While performing EUS-guided biliary drainage for patients with recurrent tumors after PD, EUS-HGS is ideal unless the right and left intrahepatic bile ducts are divided. When they are divided, the bridging method, where a stent is placed from the right to the left bile duct, would be an option for drainage of the right hepatic bile duct.[22,23] However, this technique involves the insertion of a guidewire through the hilar biliary stricture with an acute angle, which can be difficult. In such cases, EUS-guided right hepatic bile duct drainage from the afferent limb using FV-EUS could be an alternative. Although it was not applied to the participants in our study, a few case reports have been reported in the literature.[24,25] Therefore, when the right hepatic bile duct is visualized on EUS, this procedure would be a good option.

In our study, diagnosis of the lesion, EUS-FNA, and endoscopic treatment were successfully performed if FV-EUS was able to reach the target P-J or H-J lesion. However, an important question is whether FV-EUS should always be used for patients post-PD. In patients with benign H-J strictures, standard colonoscopy or balloon enteroscopy treatment has been reported to succeed in >80% of patients.[15–17] Therefore, considering that the endoscopic capabilities of FV-EUS, such as length, field of view, and bending range, are inferior to colonoscopy or balloon enteroscopy, the use of FV-EUS would not be suitable as a first-line treatment in these patients. When H-J is not found, FV-EUS could be an alternative to these endoscopic techniques. However, for P-J lesions, the success rate of treatment using these endoscopic techniques was <20%, and FV-EUS can be a good option in this perspective as the first-line treatment if it can reach the target lesion.[14] However, even if the FV-EUS endoscopic capabilities and ease of manipulation were improved, some additional improvements would still be required. A wider ultrasound field of view would facilitate EUS observation and interventions such as FNA and drainage. In addition, FV-EUS lacks an elevator to raise and lower accessories passed through the working channel, and adding such functionality may lead to easier manipulation of the FNA needle. With these modifications, FV-EUS might be chosen as a first option for patients with surgically altered anatomy.

Our study has several limitations. First, only a few patients requiring pancreatic duct drainage were included in the study. A major concern regarding EUS-PD is the low number of patients for whom this procedure is indicated. Even in large referral centers, the number of cases is too low to validate this procedure and effectively compare it with other therapeutic modalities.[19] Therefore, a multicenter, large-scale retrospective cohort study is warranted to evaluate EUS-PD from the afferent limb. Second, H-J or P-J was first observed during endoscopic observation before EUS. If this order was reversed, the results would be different. However, it is unrealistic to find H-J or P-J lesions by EUS at first observation; therefore, our results are in line with actual clinical setup. Third, it would be difficult to apply FV-EUS to all patients post-PD with Child's reconstruction because the length of the afferent limb varies according to the surgeon. In a retrospective study to evaluate the performance of FV-EUS, the arrival of FV-EUS to the duodenum was successful in 25% of the patients (3/12) after Roux-en-Y.[11] In general, it has longer afferent limb. Therefore, if FV-EUS with a longer length is developed, the number of patients benefiting from this would increase. We speculate that our study findings may encourage the application of FV-EUS in clinical practice.

In conclusion, in post-PD patients with Child's reconstruction, the diagnosis and treatment of H-J and P-J lesions using FV-EUS were feasible and effective. In the P-J group, the detection rate increased with the addition of EUS observation compared with only endoscopic observation, and the use of FV-EUS might make the treatment through the P-J easier. In addition, when P-J was not found, FV-EUS had the advantage of seamlessly performing EUS-PD from the afferent limb.

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Conflicts of interest

The authors declare that they have no financial conflict of interest with regard to the content of this report.

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Author contributions

Hirotoshi Ishiwatari, Junichi Kaneko, and Junya Sato did the concept and design. Hirotoshi Ishiwatari analyzed and interpreted the data. Hirotoshi Ishiwatari drafted the article. Junichi Kaneko, Junya Sato, Tatsunori Satoh, Kazuma Ishikawa, Fumitaka Niiya, Hiroyuki Matsubayashi, Tatsunori Minamide, Yuki Maeda,Youichi Yamamoto, Yoshihiro Kishida, MasaoYoshida, Sayo Ito, Noboru Kawata, Kenichiro Imai, Kinichi Hotta, Taisuke Imamura, Teiichi Sugiura, Katsuhiko Uesaka, and Hiroyuki Ono critically revised the article for important intellectual content.
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References

1. GBD 2017 Pancreatic Cancer Collaborators. The global, regional, and national burden of pancreatic cancer and its attributable risk factors in 195 countries and territories, 1990–2017: a systematic analysis for the global burden of disease study 2017. *Lancet Gastroenterol Hepatol* 2019; 4:934–947. doi:10.1016/S2468-1253(19)30347-4.

2. Reid-Lombardo KM, Ramos-De la Medina A, Thomsen K, et al. Long-term anastomotic complications after pancreaticoduodenectomy for benign diseases. *J Gastrointest Surg* 2007;11:1704–1711. doi:10.1007/s11605-007-0369-7.
3. House MG, Cameron JL, Schulick RD, et al. Incidence and outcome of biliary strictures after pancreaticoduodenectomy. *Ann Surg* 2006;243: 571–576; discussion 576. doi:10.1097/01.sla.0000216285.07069.fc.
4. Chahal P, Baron TH, Topazian MD, et al. Endoscopic retrograde cholangiopancreatography in post-Whipple patients. *Endoscopy* 2006; 38:1241–1245. doi:10.1055/s-2006-945003.
5. Fusaroli P, Ceroni L, Caletti G. Forward-view endoscopic ultrasound: a systematic review of diagnostic and therapeutic applications. *Endosc Ultrasound* 2013;2:64–70. doi:10.4103/2303-9027.117689.
6. Iwashita T, Nakai Y, Lee JG, et al. Newly-developed, forward-viewing echoendoscope: a comparative pilot study to the standard echoendoscope in the imaging of abdominal organs and feasibility of endoscopic ultrasound–guided interventions. *J Gastroenterol Hepatol* 2012;27:362–367. doi:10. 1111/j.1440-1746.2011.06923.x.
7. Matsuzaki I, Miyahara R, Hirooka Y, et al. Forward-viewing versus oblique-viewing echoendoscopes in the diagnosis of upper GI subepithelial lesions with EUS-guided FNA: a prospective, randomized, crossover study. *Gastrointest Endosc* 2015;82:287–295. doi:10.1016/j.gie.2014.12.051.
8. Voermans RP, Eisendrath P, Bruno MJ, et al. Initial evaluation of a novel prototype forward-viewing US endoscope in transmural drainage of pancreatic pseudocysts (with videos). *Gastrointest Endosc* 2007;66:1013–1017. doi: 10.1016/j.gie.2007.02.057.
9. Trevino JM, Varadarajulu S. Initial experience with the prototype forward-viewing echoendoscope for therapeutic interventions other than pancreatic pseudocyst drainage (with videos). *Gastrointest Endosc* 2009;69:361–365. doi:10.1016/j.gie.2008.09.021.
10. Hara K, Yamao K, Hijioka S, et al. Prospective clinical study of endoscopic ultrasound–guided choledochoduodenostomy with direct metallic stent placement using a forward-viewing echoendoscope. *Endoscopy* 2013;45: 392–396. doi:10.1055/s-0032-1326076.
11. Fusaroli P, Serrani M, Lisotti A, et al. Performance of the forward-view echoendoscope for pancreaticobiliary examination in patients with status post-upper gastrointestinal surgery. *Endosc Ultrasound* 2015;4:336–341. doi:10.4103/2303-9027.170427.
12. Ito T, Sugiura T, Okamura Y, et al. Late benign biliary complications after pancreatoduodenectomy. *Surgery* 2018;163:1295–1300. doi:10.1016/j. surg.2018.02.015.
13. Cotton PB, Eisen GM, Aabakken L, et al. A lexicon for endoscopic adverse events: report of an ASGE workshop. *Gastrointest Endosc* 2010;71:446–454. doi:10.1016/j.gie.2009.10.027.
14. Chen YI, 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;85:170–177. doi:10.1016/j.gie.2016.07.031.
15. Sakakihara I, Kato H, Muro S, et al. Double-balloon enteroscopy for choledochojejunal anastomotic stenosis after hepato-biliary-pancreatic operation. *Dig Endosc* 2015;27:146–154. doi:10.1111/den.12332.
16. Mizukawa S, Tsutsumi K, Kato H, et al. Endoscopic balloon dilatation for benign hepaticojejunostomy anastomotic stricture using short double-balloon enteroscopy in patients with a prior Whipple's procedure: a retrospective study. *BMC Gastroenterol* 2018;18:14. doi:10.1186/s12876-018-0742-x.
17. Park BK, Jeon TJ, Jayaraman V, et al. Endoscopic retrograde cholangiopancreatography in patients with previous pancreaticoduodenectomy: a single-center experience. *Dig Dis Sci* 2016;61:293–302. doi:10.1007/s10620-015-3861-z.
18. 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;85:164–169. doi:10.1016/j.gie.2016.07.030.
19. Devière J. EUS-guided pancreatic duct drainage: a rare indication in need of prospective evidence. *Gastrointest Endosc* 2017;85:178–180. doi:10.1016/ j.gie.2016.08.041.
20. Hodo Y, Shirota Y, Suda T, et al. Successful EUS-guided retrograde pancreatic duct stent placement for refractory pancreaticojejunostomy stricture after pancreaticoduodenectomy with a forward-viewing echoendoscope. *VideoGIE* 2018;3:196–198. doi:10.1016/j.vgie.2018.03.009.
21. Nakaji S, Hirata N, Shiratori T, et al. Endoscopic ultrasound–guided pancreaticojejunostomy with a forward-viewing echoendoscope as a treatment for stenotic pancreaticojejunal anastomosis. *Endoscopy* 2015;47(Suppl 1 UCTN):E41–E42. doi:10.1055/s-0034-1391245.
22. Ogura T, Sano T, Onda S, et al. Endoscopic ultrasound–guided biliary drainage for right hepatic bile duct obstruction: novel technical tips. *Endoscopy* 2015;47:72–75. doi:10.1055/s-0034-1378111.
23. Ishiwatari H, Satoh T, Sato J, et al. Double-guidewire technique facilitates endoscopic ultrasound–guided biliary drainage for hilar biliary obstruction. *Endoscopy* 2019;51:E321–E322. doi:10.1055/a-0915-1917.
24. Ishiwatari H, Sato J, Kaneko J. Hepaticojejunostomy for the right hepatic bile duct using a forward-viewing echoendoscope in a patient after pancreatoduodenectomy. *Dig Endosc* 2019;31:e82–e83. doi:10.1111/den. 13390.
25. Ishikawa K, Ishiwatari H, Niiya F, et al. Combined ERCP and endoscopic ultrasound–guided antegrade stenting for hilar biliary obstruction in a patient after pancreatoduodenectomy. *Endoscopy* 2022;54:E888–E889. doi:10.1055/a-1858-4702.