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Factors impacting treatment outcomes in the endoscopic management of walled-off pancreatic necrosis

Ji Young Bang*, C Mel Wilcox*, Jessica Trevino*, Jayapal Ramesh*, Shajan Peter*, Muhammad Hasan†, Robert H. Hawes†, and Shyam Varadarajulu†

*Division of Gastroenterology and Hepatology, University of Alabama at Birmingham, Birmingham, Alabama

†Center for Interventional Endoscopy, Florida Hospital, Orlando, Florida, USA

Abstract

Background—Treatment outcomes are suboptimal for patients undergoing endoscopic treatment of walled-off pancreatic necrosis (WOPN). The objective of this study is to identify factors that impact treatment outcomes in this patient subset.

Methods—This is a retrospective study of patients with WOPN treated endoscopically over 10 years. Patients underwent placement of stents and nasocystic catheters within the necrotic cavity. In select patients, the multiple transluminal gateway technique (MTGT) was adopted to create several openings in the stomach or duodenum to facilitate drainage of necrosis. In patients with disconnected pancreatic duct syndrome (DPDS), the transmural stents were left in place indefinitely to decrease pancreatic fluid collection (PFC) recurrence.

Results—Endoscopic treatment was successful in 53 of 76 (69.7%) patients. Treatment success was higher in patients undergoing MTGT than in those in whom conventional drainage was used (94.4% vs 62.1%, $P = 0.009$). On multivariate logistic regression analysis, only MTGT (OR 15.8, 95% CI 1.77–140.8; $P = 0.01$) and fewer endoscopic sessions being needed (OR 4.0, 95% CI 1.16–14.0; $P = 0.03$) predicted treatment success. PFC recurrence was significantly lower in patients with indwelling transmural stents than in patients in whom the stents were removed (0 vs 20.8%; $P = 0.02$).

Conclusions—Creating multiple gateways for drainage of necrotic debris improves treatment success, and not removing the transmural stents decreases PFC recurrence in patients undergoing endoscopic drainage of WOPN.

Keywords

disconnected pancreatic duct syndrome; endoscopic management; EUS-guided drainage; outcomes; walled-off pancreatic necrosis

Introduction

Walled-off pancreatic necrosis (WOPN) is characterized by a distinct rim that forms around the necrosis and adjacent pancreatic parenchyma.¹ Most WOPNs are sterile and can be managed conservatively without any intervention.^{2–4} Indications for interventions include ongoing infection despite administration of antibiotics and continued clinical deterioration despite supportive measures.⁵ Although the traditional treatment approach used to be open necrosectomy to completely remove the necrosis, this is an invasive option associated with a high risk of complications (30–94%), mortality (11–39%), and long-term pancreatic insufficiency.^{6–8}

As an alternative to open necrosectomy, minimally invasive endoscopic and radiological techniques have gained acceptance.⁵ In endoscopic drainage, the WOPN is identified by a visible luminal compression or by using endoscopic ultrasound (EUS) guidance. Following puncture, the transmural tract is dilated, and double pigtail stents and nasocystic drainage catheters are placed to drain the necrotic contents. Retrospective studies have shown a treatment success rate of 45–63% for endoscopic drainage.^{9,10} In patients with no clinical improvement despite transmural drainage, endoscopic necrosectomy or surgery can be undertaken to remove the necrotic debris. In a recent review of 10 series on endoscopic necrosectomy, the overall treatment success was 76%, mortality 5%, and procedure-related morbidity 27%.¹¹ Major limitations of endoscopic necrosectomy are that the procedure is labor intensive and requires greater technical expertise and that the procedure-related adverse events are not insignificant.^{9,12} Therefore, developing techniques that improve the treatment success of endoscopic transmural drainage is important.

Despite initial treatment success, a significant proportion of patients with WOPN develop recurrent pancreatic fluid collections (PFCs) due to disconnected pancreatic duct syndrome (DPDS).^{13,14} Therefore, techniques for minimizing long-term PFC recurrence are important treatment strategies that need development.

The objective of the present study is to identify factors that impact treatment outcomes in patients undergoing endoscopic transmural drainage of WOPN, particularly to improve treatment success and decrease PFC recurrence.

Methods

Patients

This is a retrospective study of all patients with WOPN who underwent endoscopic transmural drainage over a 10-year period at the University of Alabama at Birmingham from 2003 to 2011 and at Florida Hospital in Orlando from January to December 2012. Included in the study were (i) patients aged more than 19 years with symptomatic WOPN measuring > 6 cm in size and located adjacent to the stomach or duodenum with (ii) evidence of ongoing infection (fever, leukocytosis) despite administration of intravenous antibiotics, (iii) continued clinical deterioration despite ongoing supportive measures, and (iv) gastric outlet or biliary obstruction secondary to mass effect by the WOPN. Excluded from the study were patients with WOPN located > 1.5 cm from the gastrointestinal lumen, patients with

coagulopathy, patients who underwent only an endoscopic retrograde cholangiopancreatogram (ERCP) for pancreatic duct stent placement, and patients with follow-up of less than 90 days. Informed procedural consents were obtained from all patients. This study received approval from the Institutional Review Board of the University of Alabama at Birmingham and from Florida Hospital.

Procedural protocol

Prior to endoscopic drainage, a contrast-enhanced computed tomogram (CT) was obtained at our hospital unless a CT of suitable diagnostic quality that was performed recently at an outside institution was available for review. Intravenous ciprofloxacin (400 mg) was administered in all patients prior to the procedure and was continued for 48 h or until discharge. An ERCP was performed prior to transmural drainage to define the communication between the main pancreatic duct and the WOPN. In patients with partial duct disruption, a bridging stent was placed as long as the proximal duct could be accessed with a guidewire. ERCP was not performed in patients with DPDS diagnosed by magnetic retrograde cholangiopancreatography or if they had gastric outlet obstruction.

Standard technique (Fig. 1)

Following ERCP, in patients with a luminal compression, transmural drainage was undertaken using a standard duodenoscope. The luminal compression was punctured using a needle knife catheter, and after the fistula was dilated to 12–15 mm, two to three 10Fr double pigtail stents were deployed. A 7Fr nasocystic catheter was placed adjacent to the stents to facilitate irrigation of the necrotic cavity with 200 mL of normal saline every four hours. However, the treatment protocol evolved over time to achieve better evacuation of the necrotic material, and during the latter phase of the study, the WOPN was irrigated with 500 mL of normal saline mixed with 120 mg gentamicin every 4 h. In patients without an obvious luminal compression, transmural drainage was undertaken using a therapeutic echoendoscope. At endoscopic ultrasound (EUS), the WOPN was accessed using a 19-gauge fine needle aspiration needle. After a 0.035-inch guidewire was coiled and the transmural tract was sequentially dilated to 12–15 mm using a radial expansion balloon, two to three 7Fr double pigtail stents were deployed. Additionally, a 7Fr nasocystic catheter was deployed as described earlier.

Multiple transluminal gateway technique (Fig. 2)

Our procedural protocol evolved over time, leading to the development of a multiple transluminal gateway technique (MTGT) for drainage of WOPNs. In this technique, the caudal part of the WOPN was first accessed using EUS guidance, usually from the duodenum or the distal stomach. After dilation of the gut wall and placement of two 7Fr stents, multiple sites were created in the WOPN for placement of additional transmural stents. In general, when the WOPN was 6–12 cm in size, only one transmural tract was created for transmural drainage; for WOPNs between 12 and 15 cm in size, at least two transmural tracts were created, and three to six transmural tracts were created for WOPNs greater than 15 cm. An 18Fr nasogastric tube was then advanced over a guidewire into the gateway that drained the cranial part of the WOPN (or into the single transmural tract created for WOPNs 6–12 cm in size), which was usually at the level of the proximal

stomach. As with the standard technique, the nasogastric tube was irrigated every 4 h so as to flush out the necrotic debris through the multiple gateways in the stomach.

Postprocedure protocol

A repeat CT scan of the abdomen was obtained in all patients at 72 h to assess treatment response. If there was a decrease in the size of the necrotic collection by > 50% in association with improvement in symptoms, and there was no return of necrotic fluid on aspiration of the drainage tube, the drain was continued. If patients remained symptomatic, additional stent placement, endoscopic necrosectomy, or surgery was undertaken following interdepartmental consultation with pancreatic surgeons. A CT scan of the abdomen was obtained in all patients at 8 weeks following patient discharge from the hospital. Patients with persistent symptoms and residual necrosis on CT underwent surgery.

Stent management

At 8-week follow-up, the transpapillary pancreatic duct stents were removed if follow-up pancreatogram revealed an intact main pancreatic duct. In patients with persistent leak or strictures, stent exchange was undertaken until the leak resolved. Our practice pattern for the management of transmural stents in patients with DPDS evolved over time. While we routinely removed all transmural stents following resolution of the WOPN during the initial years, of late, we have been leaving at least two stents in place permanently to decrease the risk of PFC recurrence.¹⁵

By protocol, telephone calls were made to all patients at 6-month intervals, during which they were queried about the need for further interventions for any pancreatitis-related complaints.

Definitions

Treatment success was defined as complete resolution or decrease in size of the WOPN to 2 cm on follow-up CT at 8 weeks in association with symptom resolution.

Treatment failure was defined as persistence or worsening of symptoms in association with a residual WOPN measuring >2 cm on follow-up CT scan at 8 weeks.

PFC recurrence was defined as symptomatic peripancreatic fluid collection diagnosed on CT imaging following initial treatment success.

The *primary outcome measures* were improved treatment success and decreased rate of PFC recurrence.

Statistical analysis

Patient characteristics, features of WOPNs, and procedure details were compared according to endoscopic drainage success in order to anticipate which variables may be associated with treatment success in logistic regression. Continuous variables were summarized as means (with standard deviations) and medians (with interquartile range and range) and compared using the Wilcoxon rank sum test. Categorical variables were expressed as frequencies and

proportions and compared using the χ^2 -test or Fisher's exact test as indicated. Multiple logistic regression and reverse stepwise multivariate logistic regression analyses were then performed to identify the predictor variables associated with treatment success. Statistical significance was determined as P -value < 0.05 . Datasets were compiled using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA), and all statistical analyses were performed using Stata 10 (StataCorp LP, College Station, TX, USA).

Results

Patient and WOPN characteristics

Seventy-six patients underwent endoscopic drainage of WOPN. The median age of patients was 52.2 years, the majority were male, and alcohol was the most common etiology. Laboratory investigations revealed leukocytosis and hypoalbuminemia with a mean CT severity index¹⁶ of 7.6 (Table 1). More than 50% of WOPNs were located in the pancreatic body, and the median size (largest dimension) was 110 mm (Table 2).

Technical outcomes

At ERCP, pancreatic duct stent placement was successful in 14 (18.4%) patients. Stent placement was unsuccessful in others because of DPDS in 53, gastric outlet obstruction in four, and difficult pancreatic duct anatomy or stricture in five (Table 2). The stomach was the access point for transmural drainage in 85.5% of patients, and more than 75% of procedures were undertaken under EUS guidance.

Treatment outcomes

Overall, treatment was successful in 53 of 76 patients (69.7%). Transmural drainage was undertaken using MTGT in 18 patients and conventional technique in 58 (Table 2). The treatment success rate for MTGT was significantly better than that for conventional drainage, 94.4% versus 62.1% ($P = 0.009$) (Table 3). One of 18 patients treated by MTGT required surgery owing to worsening infection and had a successful postoperative course. Reasons for treatment failure in the 22 of 58 patients treated by conventional technique were persistence of WOPN in 16, postprocedural infection in five, and perforation in one. While two of these patients died of multiorgan failure, 20 underwent surgery, with good clinical outcomes in 18 (two patients died of postsurgical complications).

Predictors of treatment success

On multiple logistic regression analysis, only MTGT for WOPN drainage (OR 56.2, 95% CI 2.64–1194; $P = 0.01$) and fewer endoscopic interventions being needed (OR 7.85, 95% CI 1.46–42.2; $P = 0.016$) were significantly associated with treatment success when adjusted for patient demographics, serum albumin, serum white cell count, Computed Tomogram Severity Index, presence or absence of pancreatic duct stent, and location, size, etiology, and luminal effect of WOPN (Table 4). On reverse stepwise multivariate logistic regression analysis, both MTGT (OR 15.8, 95% CI, 1.77–140.8; $P = 0.013$) and just a single endoscopic intervention being needed (OR 4.03, 95% CI, 1.16–14.0; $P = 0.028$) remained significant as predictors of treatment success (Table 4).

Long-term PFC recurrence

Of the 53 patients with WOPN who had initial treatment success, transmural stents were left in permanently in 29 (54.7%; all with DPDS), and in 24 (45.3%) patients (13/24 had DPDS), the stents were removed (Table 5). At a median follow-up of 26 months, the rate of PFC recurrence was significantly less in patients in whom the stents were not removed as compared with patients in whom the stents were removed (0 vs 20.8%; $P = 0.015$). Of the five patients who had PFC recurrence, three were managed by repeat endoscopic drainage and two underwent surgery.

Other long-term outcomes

Of the 53 patients with initial endoscopic treatment success, 42 (79.2%) had DPDS. One of 11 patients without DPDS died from portal hypertension at 14-month follow-up. Of the 42 patients with DPDS, two required surgery for persistent abdominal pain at a median follow-up of 22 months. One patient underwent a total pancreatectomy with auto-islet transplantation and the other underwent a distal pancreatectomy. Seventeen of 53 patients (32.1%) still required narcotics at a median follow-up of 319 days (IQR 262–371 days).

Complications

Procedural complications were encountered in 11 of 76 patients (14.5%). Short-term procedural complications included perforation ($n = 1$), bleeding ($n = 1$), and infection ($n = 6$). While perforation was managed by surgery, bleeding was treated by coil embolization under radiological guidance. Infection was managed by surgery in three patients and by placement of additional transmural stents in two. In three patients with DPDS, the transmural stents migrated, causing small-bowel obstruction in two and lodging within the necrotic cavity in one patient. While one patient with bowel obstruction underwent surgery for stent removal, the stents migrated spontaneously with conservative measures in the other patient. The stent that migrated within the necrotic cavity could not be retrieved by endoscopy, and no further intervention was undertaken in this patient.

Discussion

Despite several improvements, necrotizing pancreatitis remains a challenging disease entity to manage. In this study, we have shown that creating multiple gateways in the gut facilitates better drainage of the necrotic debris and thereby improves short-term treatment success. In addition, not removing the transmural stents creates a conduit for secretions from the disconnected gland to drain through within the lumen of the gut, thereby decreasing PFC recurrence in the long-term.

MTGT requires the use of EUS to create multiple gateways for drainage, as described in a prior study.¹⁷ This is difficult with standard endoscopy because the technique is dependent on the presence of a luminal compression that usually disappears after the initial puncture. In contrast, when EUS is used, the partially decompressed cavity can still be accessed for creating additional gateways for drainage. With this technique, irrigation can be performed with an 18-gauge nasogastric tube through one channel while others act as conduits for rapid drainage of the necrotic debris (Fig. 3). This technique, by facilitating better drainage,

minimizes the risk of development of a superimposed infection and thereby precludes the need for a rescue endoscopic necrosectomy or surgery. This is in line with the findings of a recent randomized trial that compared surgery and the step-up approach where 35% of patients treated by percutaneous drainage alone did not require a subsequent intervention.¹⁸ We believe that aggressive irrigation in conjunction with effective drainage precludes the need for percutaneous catheter placements or a more invasive intervention in a significant proportion of patients. In this study, the mean number of interventions for treatment success per patient was 1.3, which is significantly less than the six reported for endoscopic necrosectomy in a multicenter trial.¹² We also found that the need for more than one endoscopic intervention was significantly associated with treatment failure. This is probably because of the large amount of necrotic debris and superimposed infection caused by the index instrumentation in these patients. In our opinion, performing the index procedure using the MTGT facilitates rapid drainage of necrotic debris and minimizes the chance of procedure-related infection.

Although the rate of initial treatment success following transmural drainage of WOPN appears superior, PFC recurrence in the long term is higher when the upstream gland is disconnected.^{13,14} This is because the viable upstream portion of the disconnected gland continues to secrete pancreatic juice, but without an internal conduit for drainage (Fig. 4). Although distal pancreatectomy and/or reconnection of the pancreatic duct to a Roux-en-Y limb can be effective treatment options, poor functional status, left-sided portal hypertension, ongoing inflammation, and adhesions from serial debridement oftentimes complicate this approach.¹⁹ Prolonged stent placement has been prescribed as a minimally invasive treatment strategy in these patients, as it facilitates drainage of pancreatic secretions and thereby relieves the pressure in the main pancreatic duct upstream of the rupture site.^{15,20} However, as the WOPN resolves, it causes adherence of the walls of the cavity, leading to migration of stents into the gut lumen in some patients. Despite spontaneous stent migration, this strategy appears to be effective, as scheduled removal of the stent before complete collapse of the cavity can lead to PFC recurrence, particularly when a communication exists between the cavity and the pancreatic duct. Therefore, the duration of stenting may be more important than whether the stents are still present or retrieved after an adequate stent placement period.

Although placing permanent transmural stents appears to be effective, it does have some practical limitations. The migrated double pigtail stents can cause bowel obstruction, as was evident in two of our patients. This is particularly of concern when performing drainage using the MTGT approach, where we sometimes place more than 12 stents in an individual patient. As a consequence, our current practice is to remove all but two transmural stents to facilitate drainage of secretions from the upstream duct. We have not recently encountered any cases of bowel obstruction after adopting this approach; nonetheless, more data are needed to make definitive recommendations.

Despite the technical advances detailed in this report, nearly one-third of patients with treatment success were on long-term narcotics. It is unclear if these patients were drug-dependent or had parenchymal disease-induced pain or other neuromodulatory effects contributing to their continued need for narcotics. Two of 53 patients with treatment success

eventually underwent pancreatectomy because of worsening symptoms. A EUS examination prior to surgery in these two patients revealed that the number of (sonographic) chronic pancreatitis criteria had increased from five to seven in one patient and from four to seven in the other.²¹ Endoscopic options were limited in these two patients, as they did not have any ductal dilation. This suggests that despite advances in endoscopic therapy, only surgery can provide a definitive palliation in some patients.

There are several limitations to this study. Firstly, all procedures were performed at specialized medical centers with excellent support services that may not be available at smaller institutions. Secondly, although the data collection was prospective, the retrospective nature of the study design limits our ability to investigate the effectiveness of other variables on treatment outcomes. Thirdly, the MTGT and the use of permanent transmural stents need to be validated at other centers and by other investigators. Fourthly, selection bias remains a concern. However, we believe that this may not be a major limitation, because at our institution, sicker patients are generally referred for minimally invasive endoscopy rather than being subjected to surgery as the first-line treatment approach.

In summary, what lessons can we learn from this report? One, it is clear that the MTGT facilitates better irrigation and drainage of the necrotic cavity, thereby yielding superior short-term treatment outcomes. Two, the placement of permanent transmural stents minimizes the chances of PFC recurrence, although the possibility of stent migration remains a concern. Finally, close collaboration between specialties is paramount to optimize treatment outcomes.

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Figure 1. Illustration demonstrating the standard technique for endoscopic drainage of a walled-off pancreatic necrosis.

Figure 2. Illustration demonstrating the multiple transluminal gateway technique for endoscopic drainage of a walled-off pancreatic necrosis.

Figure 3.

(a) Computed tomography of the abdomen (axial image) showing a large walled-off pancreatic necrosis (> 20 cm) containing a large amount of necrotic debris. (b) Computed tomography of the abdomen (coronal image) showing marked resolution of the walled-off pancreatic necrosis in the same patient following drainage using the multiple transluminal gateway technique.

Figure 4.

(a) Pancreatogram of a patient with a walled-off pancreatic necrosis in whom double pigtail stents were placed. (b) Magnetic retrograde cholangiopancreatography of a patient following removal of the transmural stent showing opacification of the disconnected pancreatic duct and associated peripancreatic fluid collection.

Table 1Demographic and clinical characteristics of patients who underwent endoscopic drainage of WOPN ($n = 76$)

Age (years)	Mean (SD)	52.2 (15.1)
	Median	53
	IQR	41–63
	Range	11–84
Gender, n (%)	Male	52 (68.4)
	Female	24 (31.6)
Race, n (%)	Caucasian	55 (72.4)
	African American	19 (25.0)
	Asian	1 (1.3)
	Hispanic	1 (1.3)
Type of pancreatitis, n (%)	Acute	48 (63.2)
	Chronic	28 (36.8)
Etiology of pancreatitis, n (%)	Alcohol	28 (36.8)
	Idiopathic	27 (35.5)
	Gallstones	12 (15.8)
	Hypertriglyceridemia	4 (5.3)
	Post-ERCP	2 (2.6)
	Postsurgery	2 (2.6)
	Pancreas divisum	1 (1.3)
Duration of WOPN (weeks)	Mean (SD)	8.4 (6.7)
	Median	6
	IQR	5–10
	Range	3–40
Serum white cell count ($\times 10^9/L$)	Mean (SD)	15.5 (6.6)
	Median	16.7
	IQR	9.2–18.8
	Range	5.4–40.8
Serum albumin (g/dL)	Mean (SD)	2.3 (0.7)
	Median	2.1
	IQR	1.9–2.8
	Range	1.1–4
CTSI score	Mean (SD)	7.6 (1.7)
	Median	8
	IQR	6–9.5
	Range	4–10

CTSI, Computed Tomogram Severity Index¹⁷; ERCP, endoscopic retrograde cholangiopancreatogram; IQR, interquartile range; SD, standard deviation; WOPN, walled-off pancreatic necrosis.

Table 2WOPN characteristics and technical details ($n = 76$)

Location of WOPN, n (%)	Head	13 (17.1)
	Uncinate	1 (1.3)
	Body	53 (69.7)
	Tail	9 (11.8)
Size of WOPN (long axis, mm)	Mean (SD)	115.5 (45.0)
	Median	110
	IQR	80–132
	Range	45–330
Type of endoscopic drainage, n (%)	EUS	58 (76.3)
	CTD	18 (23.7)
Route of drainage, n (%)	Transesophageal	1 (1.3)
	Transgastric	65 (85.5)
	Transduodenal	10 (13.2)
Luminal compression present, n (%)	Yes	39 (51.3)
	No	37 (48.7)
Pancreatic duct stent placed, n (%)	Yes	14 (18.4)
	No	62 (81.6)
MTGT performed, n (%)	Yes	18 (23.7)
	No	58 (76.3)
Treatment success, n (%)	Yes	53 (69.7)
	No	23 (30.3)
Number of interventions	Mean (SD)	1.4 (0.7)
	Median	1
	IQR	1–2
	Range	1–4
Duration of hospital stay (days)	Mean (SD)	10.2 (13.2)
	Median	4
	IQR	2–16
	Range	0–62
Follow-up duration (days)	Mean (SD)	310.6 (123.2)
	Median	309.5
	IQR	241.5–362.5
	Range	91–735

CTD, conventional transmural drainage; EUS, endoscopic ultrasound; IQR, interquartile range; MTGT, multiple transluminal gateway technique; SD, standard deviation; WOPN, walled-off pancreatic necrosis.

Table 3

Comparison of patient demographics, WOPN characteristics, and technical details in patients undergoing endoscopic drainage of WOPN

		Treatment success		P-value
		Yes (n = 53)	No (n = 23)	
Age (years)	Mean (SD)	53.0 (15.8)	50.4 (13.5)	
	Median	53	52	0.487
	IQR	41–64	38–62	
	Range	11–84	27–73	
Gender, n (%)	Male	36 (69.2)	16 (30.8)	0.888
	Female	17 (70.8)	7 (29.2)	
Race, n (%)	Caucasian	38 (69.1)	17 (30.9)	0.843
	Non-Caucasian	15 (71.4)	6 (28.6)	
Type of pancreatitis, n (%)	Acute	36 (75.0)	12 (25.0)	0.191
	Chronic	17 (60.7)	11 (39.3)	
Etiology of pancreatitis, n (%)	Alcohol	19 (67.9)	9 (32.1)	0.785
	Other	34 (70.8)	14 (29.2)	
Duration of WOPN (weeks)	Mean (SD)	8.5 (7.4)	8.0 (4.8)	
	Median	5	7	0.507
	IQR	5–10	5–10	
	Range	3–40	3–24	
Serum white cell count ($\times 10^9/L$)	Mean (SD)	15.8 (6.6)	14.9 (6.5)	
	Median	16.7	16.7	0.623
	IQR	10–18.7	7.9–18.9	
	Range	5.4–40.8	6.5–29.9	
Serum albumin (g/dL)	Mean (SD)	2.3 (0.6)	2.3 (0.8)	
	Median	2.1	2.1	0.923
	IQR	1.9–2.7	1.8–2.9	
	Range	1.1–4.0	1.1–3.8	
CTSI score	Mean (SD)	7.4 (1.8)	8.1 (1.5)	
	Median	7	8	0.108
	IQR	6–9	6–10	
	Range	4–10	6–10	
Location of WOPN, n (%)	Head/uncinate	9 (64.3)	5 (35.7)	0.749
	Body/tail	44 (71.0)	18 (29.0)	
Size of WOPN (long axis, mm)	Mean (SD)	117.3 (49.0)	111.2 (34.8)	
	Median	110	110	0.794
	IQR	80–136	90–120	
	Range	45–330	59–200	
Type of endoscopic drainage, n (%)	EUS	41 (70.7)	17 (29.3)	0.746
	CTD	12 (66.7)	6 (33.3)	
Route of drainage, n (%)	Transesophageal/gastric	45 (68.2)	21 (31.8)	0.448

		Treatment success		P-value
		Yes (n = 53)	No (n = 23)	
	Transduodenal	8 (80.0)	2 (20.0)	
Luminal compression present, n (%)	Yes	27 (69.2)	12 (30.8)	0.921
	No	26 (70.3)	11 (29.7)	
Pancreatic duct stent placed, n (%)	Yes	12 (85.7)	2 (14.3)	0.205
	No	41 (66.1)	21 (33.9)	
MTGT performed, n (%)	Yes	17 (94.4)	1 (5.6)	0.009
	No	36 (62.1)	22 (37.9)	
Number of interventions	Mean (SD)	1.3 (0.7)	1.5 (0.7)	0.110
	Median	1	1	
	IQR	1–1	1–2	
	Range	1–4	1–3	
Duration of hospital stay (days)	Mean (SD)	9.1 (13.5)	12.7 (12.5)	0.074
	Median	3	9	
	IQR	2–9	3–20	
	Range	0–62	0–45	
Follow-up duration (days)	Mean (SD)	328.8 (123.6)	268.6 (114.2)	0.068
	Median	319	210	
	IQR	262–371	170–350	
	Range	91–735	151–530	

CTD, conventional transmural drainage; EUS, endoscopic ultrasound; IQR, interquartile range; MTGT, multiple transluminal gateway technique; SD, standard deviation; WOPN, walled-off pancreatic necrosis.

Table 4

Multiple logistic regression and reverse stepwise multivariate logistic regression analysis examining factors associated with treatment success

Multiple logistic regression	OR	95% CI	P-value
Age (< 50 years vs ≥ 50 years)	0.73	0.19–2.85	0.648
Gender (female vs male)	0.42	0.10–1.84	0.252
Race (Caucasian vs non-Caucasian)	0.71	0.13–3.88	0.697
Size of WOPN (< 100 mm vs ≥ 100 mm)	0.69	0.13–3.75	0.671
Duration of WOPN (< 4 weeks vs ≥ 4 weeks)	0.52	0.08–3.37	0.492
Etiology of WOPN (non-alcohol vs alcohol)	1.43	0.33–6.13	0.630
Single WOPN vs multiple WOPNs	0.31	0.04–2.58	0.278
Location of WOPN (body/tail vs head/uncinate)	1.70	0.31–9.17	0.538
Serum white cell count (< $12 \times 10^9/L$ vs $\geq 12 \times 10^9/L$)	0.72	0.18–2.90	0.640
Serum albumin (> 2.5 g/dL vs ≤ 2.5 g/dL)	1.13	0.26–4.80	0.872
Luminal compression (present vs not present at endoscopy)	1.12	0.25–4.93	0.879
CTSI score (< 7 vs ≥ 7)	3.49	0.82–14.9	0.091
Number of interventions performed (1 vs > 1)	7.85	1.46–42.2	0.016
Pancreatic duct stent (placed vs not placed)	2.56	0.36–18.0	0.345
MTGT (performed vs not performed)	56.2	2.64–1194	0.010
Reverse stepwise multivariate logistic regression	OR	95% CI	P-value
Number of interventions performed (1 vs > 1)	4.03	1.16–14.0	0.028
MTGT (performed vs not performed)	15.8	1.77–140.8	0.013

CI, confidence interval; CTSI, Computed Tomogram Severity Index¹⁷; MTGT, multiple transluminal gateway technique; OR, odds ratio; WOPN, walled-off pancreatic necrosis.

Table 5

Pancreatic fluid collection recurrence in patients who underwent successful endoscopic drainage of WOPN according to placement of permanent transmural stents ($n = 53$)

		WOPN recurrence		<i>P</i> -value
		Yes ($n = 5$)	No ($n = 48$)	
Permanent transmural stent placed, n (%)	Yes	0	29 (100)	0.015
	No	5 (20.8)	19 (79.2)	