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Conversion to pancreaticogastrostomy for salvage of disrupted pancreaticojejunostomy following pancreaticoduodenectomy

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Purpose: This study aimed to report on a pancreas-preserving strategy consisting of the conversion to pancreaticogastrostomy (PG) for the salvage of disrupted pancreaticojejunostomy (PJ) following pancreaticoduodenectomy (PD).
Methods: This single-center retrospective study included 188 patients who underwent PD between March 2000 and June 2021. Conversion to PG was performed by placing the pancreatic stump with an internal stent in the stomach through the posterior gastrostomy and suturing the wound in 2 layers through the anterior gastrostomy.
Results: A total of 181 patients underwent PJ, while 7 underwent PG. Of all patients, 6 had International Study Group on Pancreatic Fistula grade C postoperative pancreatic fistulae (POPF; 3.3%) and 23 had grade B POPF (12.7%). Two of the 6 grade C patients underwent completion pancreatectomy and died of liver failure after common hepatic artery embolization due to pseudoaneurysm. Conversion to PG was performed in 4, all of whom survived and experienced no long-term pancreatic fistulae, remnant pancreatic atrophy, or newly developed diabetes after a median follow-up period of 11.5 months.
Conclusion: Conversion to PG for the salvage of disrupted PJ following PD is safe and effective in selected patients that can lower mortality rates while maintaining pancreatic function.
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Key Words: Pancreatic fistula, Pancreaticoduodenectomy, Pancreaticogastrostomy, Pancreaticojejunostomy

INTRODUCTION

Pancreaticoduodenectomy (PD) is among the most complicated and technically challenging surgical procedures for benign and malignant periampullary lesions [1]. Historically, PD maintained a perioperative mortality rate of 25% and morbidity rate of >50% until the 1970s [2]. As surgical techniques and perioperative management have increased and advanced, surgical mortality rates have declined dramatically. Perioperative mortality has become a rare event after PD, occurring in <2% of cases at high-volume centers [3,4]. Despite a significant reduction in mortality rates, clinically relevant postoperative pancreatic fistulae (POPF) remains a common serious complication occurring in up to 15% of cases [3,5]. POPF is defined and graded according to the International Study Group on Pancreatic Fistula (ISGPF) classification [6]. Grade C POPF in particular involves a more serious systemic condition characterized by POPF-related organ failure, possibly requiring reoperation. Despite several recently published studies [7,8], managing grade C POPF cases remains a clinical challenge.

Even among patients with grade C POPF, disrupted pancreaticojejunostomy (PJ) after PD requires urgent salvage reoperation.

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Traditionally, several options have been implemented as surgical methods for disrupted PJ: debridement and drainage, revision of the initial PJ, completion pancreatectomy, external drainage using pancreatic duct stenting, and conversion to alternative pancreaticoenteric anastomosis [9-12]. However, each of these surgical methods has advantages and disadvantages, and controversy persists regarding the optimal surgical treatment for disrupted PJ following PD.

This study aimed to report the results of a pancreas-preserving strategy, the conversion to pancreaticogastrostomy (PG), to salvage disrupted PJ following PD.

METHODS

This study was approved by the Institutional Review Board of Konyang University Hospital, which waived the requirement for informed consent owing to its retrospective study design (No. 2022-01-018).

Patients and data collection

Between March 2000 and June 2021, all consecutive patients who underwent PD for periampullary tumors, pancreatitis, or traumatic pancreatic injury at Konyang University Hospital were evaluated. Of the 188 patients, 181 underwent PJ and 7 underwent PG. Patients treated with PG were excluded from the study.

Each patient's general preoperative condition was evaluated using the American Society of Anesthesiologists physical status (ASA PS) classification [13]. Operation time was calculated as the time from skin incision to skin closure. Blood loss estimates were obtained from the surgical records. The pancreatic texture and size of the main pancreatic duct were analyzed based on surgical records written by the operator. The definition and grading of POPF was based on the 2016 ISGPF classification [6]. The definitions of delayed gastric emptying and postpancreatectomy hemorrhage were based on the ISGPS [14,15]. Marginal ulcers were defined as ulcerations at or around the duodenojejunostomy or gastrojejunostomy site after PD [16]. A pseudoaneurysm was diagnosed using contrast-enhanced CT. On contrast-enhanced CT scan images, pseudoaneurysm was defined as a hyperattenuating contrast-enhanced smooth-walled sac, often round or oval with a possible neck adjacent to an artery, less apparent on delayed images [17]. Long-term complications, such as pancreatic fistulae, pancreatic atrophy, and newly diagnosed diabetes, were assessed through imaging studies and patient conditions during the follow-up period.

Diagnosis and management of disrupted pancreaticojejunostomy

The surgical procedure of PD and routine postoperative management following PD in our institution has developed over time. In recent years, 2 or 3 drains were placed after PD and all patients resumed water intake on postoperative day (POD) 1, and a solid diet was resumed gradually from POD 3. Prophylactic antibiotics and somatostatin have been routinely used for 3 days after surgery. Contrast-enhanced CT was routinely performed between POD 5 and POD 7.

After the index surgery, drain fluid amylase was routinely measured on POD 1, 3, and 5, and the drains were removed on POD 3–5 if there was no evidence of POPF. The diagnosis of disrupted PJ was based on the symptoms in patients presenting with sepsis and bleeding, elevated drain fluid amylase levels, and radiographic findings on contrast-enhanced CT. Fig. 1 shows a disrupted PJ with peripancreatic fluid collection and an associated "interval" (arrows) between the jejunum and the remnant pancreas margin.

For patients with evidence of POPF and stable hemodynamic status but without evidence of PJ dehiscence, conservative treatment was initially adopted, including total parenteral nutrition, intravenous antibiotics, and percutaneous drainage of infected intraabdominal fluid. Interventional angiography and upper gastrointestinal endoscopy were performed in patients with intraabdominal or gastrointestinal hemorrhage.

Urgent salvage relaparotomy was indicated as follows: active bleeding after radiologic or endoscopic intervention failure; deteriorating general condition due to sepsis despite maximal conservative care; and suspected panperitonitis. Initial relaparotomy and total pancreatectomy were performed rather than conversion to PG when the necrosis of the pancreatic parenchyma was too extensive or the main pancreatic duct could not be identified.

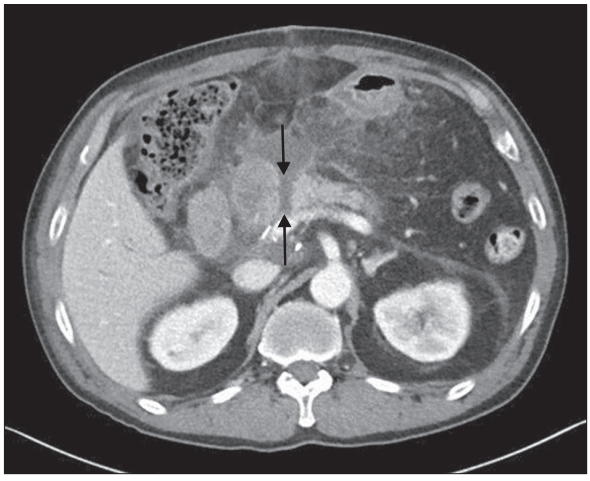

Fig. 1. Axial computed tomography image taken after the index operation. Disrupted pancreaticojejunostomy with peripancreatic fluid collection and an associated "gap" (arrows) between the jejunum and the remnant pancreas margin is visible.

Surgical technique of conversion to pancreaticogastrostomy

Upon relaparotomy, the disrupted PJ was first checked and the jejunum of the afferent loop was transected before choledochojejunostomy (CJ). The remnant pancreatic parenchyma was checked and the pancreatic stump mobilized 3 cm from the splenic vessels and adjacent structures. Two traction sutures were applied to the upper and lower borders of the remnant pancreas close to the cut surface. An infant feeding tube or silastic T-tube was inserted into the main pancreatic duct, and an anchoring suture was applied to the pancreatic parenchyma with 4-0 PDS II sutures (Ethicon Inc., Somerville, NJ, USA).

The stomach was fully mobilized distally to allow the pancreatic stump to be brought to the posterior surface of the antrum of the stomach. An anterior gastrostomy incision was made in the antrum of the stomach and a posterior gastrostomy incision was made through the anterior gastrostomy. The pancreatic stump with an internal stent was brought to the stomach lumen through the posterior gastrostomy using 2 traction sutures (Fig. 2A). Subsequently, a continuous suture between the pancreatic parenchyma and posterior wall of the stomach was applied in 2 layers (seromuscular and mucosa) through the anterior gastrostomy with 4-0 or 5-0 PDS II sutures (Ethicon Inc.) (Fig. 2B). The anterior gastrostomy was then closed in 2 layer with continuous sutures. After conversion to PG, a closed suction drain was placed around the PG.

After conversion to PG, contrast-enhanced CT revealed a pancreatic stump with an internal stent protruding into the stomach lumen (Fig. 3).

RESULTS

Study population

A total of 181 patients underwent PD with PJ; their characteristics and surgical outcomes are listed in Table 1. The mean age was 65.2 years; 109 (60.2%) were male and 72 (39.8%) were female. The mean body mass index was 23.2 kg/m^2, and 40 patients (22.1%) had an ASA PS classification of ≥III. Forty-

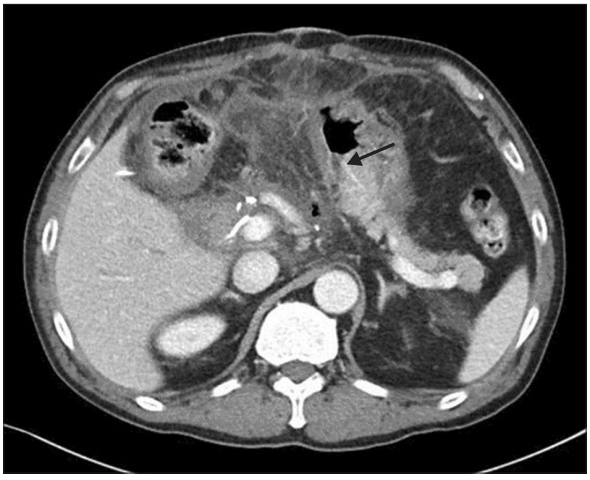

Fig. 3. Axial computed tomography image taken after the pancreaticogastrostomy. The pancreatic stump with internal stent (arrow) is visibly protruding into the stomach lumen after conversion to pancreaticogastrostomy.

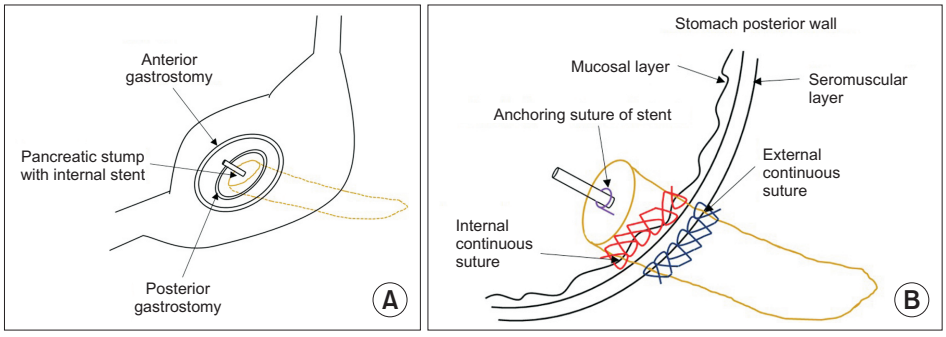

Fig. 2. Schematic drawing of the pancreaticogastrostomy technique. (A) The pancreatic stump with an internal stent was placed in the stomach through the posterior gastrostomy. (B) A continuous suture was placed between the remnant pancreas and the posterior wall of the stomach in 2 layers through the anterior gastrostomy.

Table 1. Characteristics and surgical outcomes of the study population

Variable	All patients	CR-POPF (–)	CR-POPF (+)	P-value
No. of patients	181	152	29	
Age (yr)	65.2 ± 10.2	64.8 ± 10.4	67.3 ± 9.2	0.182
Female sex	72 (39.8)	63 (41.4)	9 (31.0)	0.294
Body mass index (kg/m^2)	23.2 ± 3.5	23.0 ± 3.7	24.3 ± 2.6	0.079
ASA PS classification ≥ III	40 (22.1)	34 (22.4)	6 (20.7)	0.842
Previous abdominal surgery	43 (23.8)	34 (22.4)	9 (31.0)	0.315
Preoperative biliary drainage	124 (68.5)	109 (71.7)	15 (51.7)	0.034

Table 1. Continued

Variable	All patients	CR-POPF (–)	CR-POPF (+)	P-value
Primary site				0.543
Pancreas	61 (33.7)	55 (36.2)	6 (20.7)	
Bile duct	59 (32.6)	47 (30.9)	12 (41.4)	
Ampulla of Vater	47 (26.0)	38 (25.0)	9 (31.0)	
Duodenum	13 (7.2)	11 (7.2)	2 (6.9)	
Traumatic pancreas injury	1 (0.5)	1 (0.7)	0 (0)	
Surgical method				0.188
Open	156 (86.2)	134 (88.2)	22 (75.9)	
Laparoscopic	18 (9.9)	13 (8.6)	5 (17.2)	
Robotic	5 (2.8)	3 (2.0)	2 (6.9)	
Open conversion	2 (1.1)	2 (1.3)	0 (0)	
Neoadjuvant therapy	0 (0)	0 (0)	0 (0)	-
Level of stomach resection				0.097
Pylorus preservation	149 (82.3)	122 (80.3)	27 (93.1)	
Pylorus resection	32 (17.7)	30 (19.7)	2 (6.9)	
Additional vessel/organ resection				0.754
Portal vein/superior mesenteric vein	16 (8.8)	14 (9.2)	2 (6.9)	
Colon	3 (1.7)	3 (2.0)	0 (0)	
Operation time (min)	452.3 ± 117.8	447.8 ± 120.0	476.2 ± 103.6	0.194
Estimated blood loss (mL)	336.5 ± 382.0	327.9 ± 351.1	381.4 ± 520.5	0.599
Transfusion				
Intraoperative	38 (21.0)	32 (21.1)	6 (20.7)	0.965
Postoperative	47 (26.0)	39 (25.7)	8 (27.6)	0.828
Pancreas texture				0.006
Soft	40 (22.1)	28 (18.4)	12 (41.4)	
Firm	141 (77.9)	124 (81.6)	17 (58.6)	
Main pancreatic duct size (mm)	3.3 ± 2.0	3.2 ± 1.9	3.6 ± 2.3	0.501
Pancreatic duct stenting	175 (96.7)	146 (96.1)	29 (100.0)	0.277
Method of pancreaticojejunostomy				0.748
Duct-to-mucosa	178 (98.3)	149 (98.0)	29 (100.0)	
Dunkin style	2 (1.1)	2 (1.3)	0 (0)	
Modified Blumgart style	1 (0.6)	1 (0.7)	0 (0)	
Drain fluid amylase level (U/L)				
At POD 1, ≥5,000[a]	12/130 (9.2)	7/104 (6.7)	5/26 (19.2)	0.049
At POD 3, ≥350[b]	44/159 (27.7)	31/132 (23.5)	13/27 (48.1)	0.009
POPF				-
Biochemical leak	14 (7.7)	14 (9.2)	0 (0)	
Grade B	23 (12.7)	0 (0)	23 (79.3)	
Grade C	6 (3.3)	0 (0)	6 (20.7)	
Delayed gastric emptying	13 (7.2)	13 (8.6)	0 (0)	0.102
Postpancreatectomy hemorrhage	5 (2.8)	4 (2.6)	1 (3.4)	0.806
Marginal ulcer	6 (3.3)	6 (3.9)	0 (0)	0.277
Pseudoaneurysm	8 (4.4)	0 (0)	8 (27.6)	<0.001
Postoperative complication				<0.001
CD grade I–II	34 (18.8)	28 (18.5)	6 (20.7)	
CD grade III–V	39 (21.5)	16 (10.5)	23 (79.3)	
Mortality	6 (3.3)	3 (2.0)	3 (10.3)	0.021

Values are presented as number only, mean ± standard deviation, or number (%).
POPF, postoperative pancreatic fistula; CR-POPF, clinically relevant POPF; ASA PS, American Society of Anesthesiologists physical status; POD, postoperative day; CD, Clavien-Dindo classification.
[a]One hundred thirty patients had drain fluid amylase levels at POD 1 available for analysis. Excluded from 51 patients with missing values.
[b]One hundred fifty-nine patients had drain fluid amylase levels at POD 3 available for analysis. Excluded from 22 patients with missing values.

three patients (23.8%) had a history of abdominal surgery. Preoperative biliary drainage was performed in 124 patients (68.5%). The primary lesions were in the pancreas in 61 (33.7%), bile duct in 59 (32.6%), ampulla in 47 (26.0%), duodenum in 13 (7.2%), and traumatic pancreatic injury in 1 (0.6%). A total of 156 (86.2%), 18 (9.9%), and 5 (2.8%) patients underwent open, laparoscopic, and robotic PD, respectively. Open conversion from minimally invasive PD was performed in 2 (1.1%). None of the patients received neoadjuvant chemotherapy.

A total of 149 patients (82.3%) underwent pylorus-preserving

Table 2. Characteristics and surgical outcomes of the patients with clinically relevant POPF

Variable	Grade B POPF	Grade C POPF	P-value
No. of patients	23	6	
Age (yr)	65.7 ± 8.9	73.7 ± 7.7	0.057
Female sex	7 (30.4)	2 (33.3)	0.891
Body mass index (kg/m^2)	24.3 ± 2.8	24.2 ± 2.1	0.956
ASA PS classification ≥ III	5 (21.7)	1 (16.7)	0.785
Previous abdominal surgery	7 (30.4)	2 (33.3)	0.891
Preoperative biliary drainage	13 (56.5)	2 (33.3)	0.311
Primary site			0.202
Pancreas	4 (17.4)	2 (33.3)	
Bile duct	8 (34.8)	4 (66.7)	
Ampulla of Vater	9 (39.1)	0 (0)	
Duodenum	2 (8.7)	0 (0)	
Surgical method			0.240
Open	19 (82.6)	3 (50.0)	
Laparoscopic	3 (13.0)	2 (33.3)	
Robotic	1 (4.3)	1 (16.7)	
Level of stomach resection			0.454
Pylorus preservation	21 (91.3)	6 (100)	
Pylorus resection	2 (8.7)	0 (0)	
Additional vessel/organ resection			0.754
Portal vein/superior mesenteric vein	2 (8.7)	0 (0)	0.454
Operation time (min)	463.0 ± 108.3	526.7 ± 67.8	0.099
Estimated blood loss (mL)	431.7 ± 569.0	188.3 ± 190.3	0.099
Transfusion			
Intraoperative	5.0 ± 21.7	1.0 ± 16.7	0.785
Postoperative	4 (17.4)	4 (66.7)	0.016
Pancreas texture			0.019
Soft	7 (30.4)	5 (83.3)	
Firm	16 (69.6)	1 (16.7)	
Main pancreatic duct size (mm)	3.4 ± 2.1	4.3 ± 2.9	0.469
Pancreatic duct stenting	23 (100)	6 (100)	-
Method of pancreaticojejunostomy			-
Duct-to-mucosa	23 (100)	6 (100)	
Drain fluid amylase level (U/L)			
At POD 1, ≥5,000[a]	3/20 (15.0)	2/6 (33.3)	0.318
At POD 3, ≥350[b]	10/21 (47.6)	3/6 (50.0)	0.918
Delayed gastric emptying	0 (0)	0 (0)	-
Postpancreatectomy hemorrhage	1 (4.3)	0 (0)	0.603
Marginal ulcer	0 (0)	0 (0)	-
Pseudoaneurysm	4 (17.4)	4 (66.7)	0.016
Postoperative complication			0.007
CD grade I–II	6 (26.1)	0 (0)	
CD grade III–V	17 (73.9)	6 (100)	
Mortality	1 (4.3)	2 (33.3)	0.038

Values are presented as number only, mean ± standard deviation, or number (%).
POPF, postoperative pancreatic fistula; ASA PS, American Society of Anesthesiologists physical status; POD, postoperative day; CD, Clavien-Dindo classification.
[a]Twenty six patients had drain fluid amylase levels at POD 1 available for analysis. Excluded from three patients with missing values.
[b]Twenty seven patients had drain fluid amylase levels at POD 1 available for analysis. Excluded from two patients with missing values.

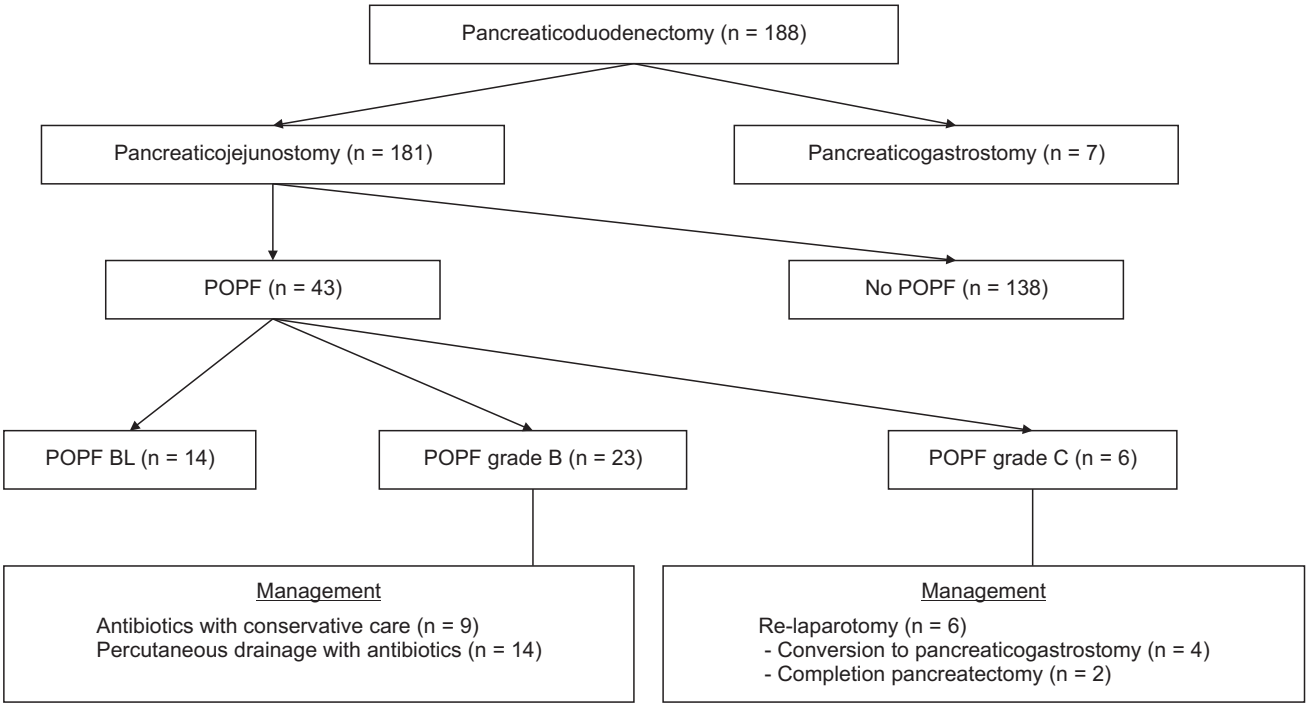

Fig. 4. Incidence and management of postoperative pancreatic fistulae (POPF) in the study population according to International Study Group on Pancreatic Fistula grade. BL, biochemical leak.

PD, while 32 (17.7%) underwent pylorus resection of the PD. Concomitant portal vein/superior mesenteric vein resection was performed in 16 patients (8.8%). The mean operation time was 452.3 minutes, and the mean estimated blood loss was 336.5 mL. Intra- and postoperative transfusions were performed in 38 (21.0%) and 47 patients (26.0%), respectively. The texture of the pancreas was soft in 40 patients (22.1%), and a pancreatic duct internal stent was inserted in 175 patients (96.7%). PJ was performed duct-to-mucosa in 178 patients (98.3%), Dunkin style in 2 (1.1%), and modified Blumgart style in 1 (0.6%). Clinically relevant POPF, delayed gastric emptying, a marginal ulcer, and a pseudoaneurysm occurred in 29 (16.0%), 13 (7.2%), 6 (3.3%), and 8 patients (4.4%), respectively. The in-hospital mortality rate was 3.3%.

We divided the study population into 2 groups based on with or without a clinically relevant POPF. Patients with clinically relevant POPF had a significantly higher rate of soft pancreas than patients without clinically relevant POPF (18.4% *vs.* 41.4%, P = 0.006). Drain fluid amylase level at POD 1 ≥ 5,000 U/L (6.7% *vs.* 19.2%, P = 0.049) and drain fluid amylase level at POD 3 ≥ 350 U/L (23.5% *vs.* 48.1%, P = 0.009) were also significantly higher in patients with clinically relevant POPF. There were no significant differences in patients' characteristics between the 2 groups.

Characteristics and surgical outcomes of the patients with clinically relevant POPF are listed in Table 2. There was no significant differences in patients' characteristics between 2 groups except pancreas texture (soft, 30.4% *vs.* 83.3%; P = 0.019). In surgical outcomes, postoperative transfusion (17.4% *vs.* 66.7%, P = 0.016), pseudoaneurysm (17.4% *vs.* 66.7%, P = 0.016), and mortality (4.3% *vs.* 33.3%, P = 0.038) were significantly higher in patients with grade C POPF than those with grade B POPF.

Fig. 4 shows the incidence and management of POPF according to the ISGPF grading system in the study population. Of the 181 patients, 14 (7.7%) had biochemical leaks, 23 (12.7%) had grade B POPF, and 6 (3.3%) had grade C POPF. Of the 23 patients with grade B POPF, 9 received antibiotics and conservative treatment, while 14 received percutaneous drainage and antibiotic treatment. Overall, 6 patients with grade C POPF underwent reoperation, 4 underwent conversion to PG, and 2 underwent completion pancreatectomy.

Patients with grade C postoperative pancreatic fistulae

The characteristics of the 6 patients who underwent conversion to PG (n = 4) or completion pancreatectomy (n = 2) for grade C POPF are listed in Table 3. Those 4 patients who underwent conversion to PG included 2 with cholangiocarcinoma, 1 with pancreatic ductal adenocarcinoma, and 1 with intraductal papillary mucinous neoplasm of the pancreas. The index surgery involved pylorus-preserving PD, including 2 using laparoscopic surgery, 1 using robotic surgery, and 1 using open surgery. Three patients had a soft pancreas. The median main pancreatic duct size, operation time of the

Table 3. Patients managed with conversion to pancreaticogastrostomy (G) or completion pancreatectomy (C) for grade C postoperative pancreatic fistulae

Variable	Patient G-1	Patient G-2	Patient G-3	Patient G-4	Patient C-1	Patient C-2
Sex	Male	Female	Male	Male	Female	Male
Age (yr)	66	79	65	85	72	75
ASA PS classification	II	II	II	II	II	III
Diagnosis	Intraductal papillary mucinous neoplasm	Pancreatic ductal adenocarcinoma	Cholangiocarcinoma	Cholangiocarcinoma	Cholangiocarcinoma	Cholangiocarcinoma
Surgical method	Laparoscopic	Laparoscopic	Robotic	Open	Open	Open
Pancreas texture	Soft	Firm	Soft	Soft	Soft	Soft
Pancreatic duct size (mm)	10	5	3	4	2	3
Operation time, index operation (min)	590	515	625	460	460	510
Estimated blood loss, index operation (mL)	50	50	200	80	550	200
Drain fluid amylase (U/L)						
POD 1	190.3	10,238.7	15,536.8	4,571.4	225.1	12,442.6
POD 3	50.8	2,381.0	2,528.8	241.0	82.5	1,931.8
Symptom	Sepsis	Bleeding	Peritonitis	Peritonitis	Bleeding	Sepsis
Reoperation timing	POD 7	POD 3	POD 21	POD 16	POD 7	POD 8
Operation time, reoperation (min)	325	250	240	390	275	235
Combined leakage						
CJ	No	Yes	No	No	Yes	No
DJ/GJ	Yes	No	No	Yes	No	Yes
Length of hospital stay after reoperation (day)	14	17	33	42	7	2
Pseudoaneurysm/treatment	No/(–)	No/(–)	Yes/stent insertion	Yes/stent insertion	Yes/embolization	Yes/embolization
ICU admission after reoperation	Yes	No	Yes	Yes	Yes	Yes
Mortality	No	No	No	No	Yes	Yes
Long-term complication						
Pancreatic fistulae	(–)	(–)	(–)	(–)	NC	NC
Pancreatic atrophy	(–)	(–)	(–)	(–)	NC	NC
Diabetes mellitus	(–)	(–)	Preoperative	(–)	NC	NC

ASA PS, American Society of Anesthesiologists physical status; POD, postoperative day; CJ, choledochojejunostomy; DJ, duodenojejunostomy; GJ, gastrojejunostomy; ICU, intensive care unit.

index surgery, and estimated blood loss of the index surgery were 4.5 mm (range, 3–10 mm), 487.5 minutes (range, 460–625 minutes), and 65 mL (range, 50–200 mL), respectively. Drain fluid amylase levels on POD 1 and 3 were very high in 2 patients. The reoperation timing varied from POD 3 to POD 21. Combined leakage of the CJ or duodenojejunostomy occurred in 3 patients. The median reoperation time and length of hospital stay after reoperation were 287.5 minutes (range, 240–390 minutes) and 25 days (range, 17–42 days), respectively. Pseudoaneurysms occurred in 2 patients, both of whom were treated with angiographic stent insertion. All 4 patients survived and experienced no long-term pancreatic fistulae, remnant pancreatic atrophy, or newly developed diabetes after a median follow-up period of 11.5 months.

Two of the 6 grade C patients underwent completion pancreatectomy. Both patients had cholangiocarcinoma and open surgeries were performed. The reoperation timings were POD 7 and POD 8. All 2 patients died of liver failure after common hepatic artery embolization due to pseudoaneurysm.

DISCUSSION

Grade C POPF with PJ dehiscence is rare; however, it is a life-threatening problem following PD. Disrupted PJ mostly requires surgical treatment, the most technically challenging procedure. Patients with PJ dehiscence may have severe inflammation and fibrosis around the PJ site and severe adhesions between the splenic vessels and remnant pancreas. In addition, the remnant pancreas is often necrotized, friable, and difficult to grasp, and the persistent oozing of blood often obscures the surgical field. All of these factors may interfere with safe surgical intervention regardless of the surgical procedure. A patient's general condition is also very unstable due to sepsis and organ failure associated with POPF. Therefore, it is important to determine the optimal surgical procedure by considering the patient's general condition and the local surgical field to rescue the patient's life.

There are several options for surgical intervention to resolve PJ anastomotic disruptions. Surgical drainage is the simplest procedure; however, it is not recommended for severe POPF cases with disrupted PJ because it carries a high reoperation rate (30%) and mortality rate (48%–55%) [8,18]. Therefore, our institution did not consider surgical drainage when performing reoperation to rescue grade C POPF with a disrupted PJ.

Completion pancreatectomy is the most definitive surgical treatment for severe POPF with a disrupted PJ. Complete pancreatectomy can achieve sterilization of the infectious source, prevent recurrent bleeding, and reduce the need for reoperation [11,19]. However, complete pancreatectomy has a significant side effect of complete endocrine and exocrine insufficiency, and the mortality rate is still reportedly high (21%–50%) [18,20]. In the present study, although few patients were included, 2 patients who underwent completion pancreatectomy experienced in-hospital mortality (100%). A recently published meta-analysis reported that a pancreas-preserving procedure seems preferable to completion pancreatectomy in patients in whom relaparotomy is deemed necessary for POPF after PD [21]. Emergency completion pancreatectomy is also a technically difficult procedure because of active bleeding, severe adhesions around the splenic vessels, and necrotized friable remnant pancreas and adjacent organs. Therefore, rather than performing completion pancreatectomy in all patients at the time of salvage reoperation for disrupted PJ, we should consider performing a pancreas-preserving procedure to reduce mortality rates and maintain pancreatic function according to the intraoperative findings.

Pancreas-preserving procedures, such as wirsungostomy and conversion to PG, are treatment options for severe POPF with disrupted PJ. These procedures appear to have favorable outcomes in terms of the long-term maintenance of pancreatic function [22]. Recently published studies on external wirsungostomy reported a 0% mortality rate and a high rate of maintenance of long-term endocrine function (66%–100%) [10,23]. However, since wirsungostomy requires reintervention about 3 months after the salvage operation, in the case of patients with malignancy, it may interfere with adjuvant therapy and adversely affect tumor recurrence or progression. On the other hand, the conversion to PG introduced in our study has the advantage of reintervention not necessarily being required after salvage operations. In the present study, none of the 4 patients who underwent conversion to PG required reintervention. The patients survived and did not experience long-term pancreatic insufficiency.

There have been 2 previously published studies on PG as a salvage procedure for POPF [12,24]. Bachellier et al. [12] reported that 4 patients underwent conversion to PG, all survived, and only 1 newly developed diabetes. Govil [24] also reported similar results for salvage PG. In the present study, all 4 patients who underwent conversion to PG survived and did not experience long-term pancreatic fistulae, remnant pancreas atrophy, or newly developed diabetes after a median follow-up period of 11.5 months. These studies, including ours, demonstrated that conversion to PG for the salvage of disrupted PJ is a safe and effective procedure for maintaining pancreatic function. In addition, conversion to PG may be a technically easier procedure than complete pancreatectomy if only the proximal part of the remnant pancreas can be isolated from the splenic vessels. Compared with previous studies, our study has the advantage of describing these surgical procedures in relative detail.

Despite the relatively good results of salvage PG, it is impossible to perform conversion to PG in all patients with

grade C POPF with disrupted PJ. Conversion to PG is technically difficult in cases of little remaining pancreatic parenchyma due to severe necrosis of the pancreas or if cannulation of the main pancreatic duct is impossible because the main pancreatic duct is difficult to identify. In addition, if the index operation involves conventional PD (including antrectomy of the stomach), the length of the remaining stomach is short, so conversion to PG may not be possible. However, conversion to PG can be a life-saving procedure in cases of severe POPF with PJ disruption in selective patients as it can preserve the pancreatic parenchyma without the need for a second relaparotomy.

According to our study findings, conversion to PG is an excellent solution for salvage of severe POPF with disrupted PJ on behalf of completion pancreatectomy. However, our results should be interpreted with caution because this was a small retrospective study. Since severe POPF is life-threatening and rare, the present study showed relatively good results of conversion to PG similar to previous studies.

In conclusion, our findings demonstrate that conversion to PG for the salvage of disrupted PJ following PD is a safe and effective treatment in selected patients that can lower mortality rates while maintaining pancreatic function.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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