



Original Article

One-layer pancreaticojejunostomy using reinforcing sutures in pancreaticoduodenectomy: A single surgeon's experience with 122 cases

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ABSTRACT

Background: Discussions about pancreaticojejunostomy (PJ), which can reduce the incidence of post-operative pancreatic fistula (POPF) in pancreaticoduodenectomy (PD), are ongoing. Here we introduce the surgical technique of PJ performed at our hospital and analyze its safety and advantages.

Methods: We retrospectively analyzed 122 patients who underwent one-layer PJ using reinforcing sutures in PD. PJ was performed with reinforcing sutures on the pancreatic stump, including the insertion of a soft silastic catheter for internal drainage followed by suturing of the pancreas and jejunum with one layer.

Results: Of the 122 patients who underwent PJ with this technique, 62 (50.8%) developed POPF. However, 37 (30.3%) had grade A that did not affect the hospital course. Critical POPF occurred in 25 patients: grade B in 20 (16.4%) and grade C in 5 (4.1%). There was no significant difference in the critical POPF patient group according to the pancreas related disease related to pancreatic texture.

Conclusion: Although this technique cannot prevent POPF, we noted no significant difference in POPF versus other surgical techniques. In addition, this technique, which was designed to increase pancreatic texture, is practical and simple for PJ. Therefore, the inexperienced hepatobiliary and pancreatic surgeon can perform it without major complications.

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1. Introduction

Pancreaticoduodenectomy (PD) is a commonly used surgical procedure for benign or malignant diseases of the periampullary lesion. Although morbidity and mortality of PD have been reduced by developments in intensive care medicine and surgical techniques, PD-related morbidity occurs in 30–50% of cases.^{1–4}

Postoperative pancreatic fistula (POPF), one of the most common complications after PD, is defined as “a drain output of any measurable volume of fluid on or after postoperative day 3 with an amylase content greater than 3 times the serum amylase activity” by the International Study Group of Pancreatic Fistula (ISGPF).⁵ When POPF occurs, it can affect length of hospital stay, medical care costs, quality of life, and postoperative mortality rates.^{6–8} For

this reason, POPF has attracted a great deal of attention from many surgeons.⁹ However, the incidence of POPF has not changed significantly over the past several decades. Several pancreaticojejunostomy (PJ) techniques for reducing POPF have been developed and reported to date.^{10–14} However, there is not yet a standard PJ technique for reducing POPF.

We introduced a surgical PJ technique to reduce the incidence of POPF in our hospital and aimed to confirm its safety. We also analyzed the factors that cause POPF using the data of patients who underwent operations using this technique. Finally, we analyzed its surgical implications and advantages.

2. Methods

Between August 2007 and December 2017, a total of 125 patients underwent PD performed by a single surgeon at Hanyang University Hospital, Seoul, Republic of Korea. We retrospectively reviewed the clinical data of 122 patients, excluding 3 patients who did not undergo PJ. All procedures were performed by a single

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surgeon using the PJ method described below. This retrospective study was approved by the Institutional Review Board (IRB) of Hanyang University Hospital, Seoul, Korea, and all research conducted adhered to the tenets of the Declaration of Helsinki (IRB No. 2018-09-020).

2.1. Operative technique of PJ

After the surgical specimen was removed, PJ was first performed in the 3 anastomoses that occurred during the reconstruction.

First, we checked the pancreatic stump of the safe margin and achieved hemostasis on the pancreatic stump using electrocoagulation or 5-0 polypropylene sutures (Prolene®, Ethicon). A soft silastic catheter of the appropriate size was inserted into the pancreatic duct of the pancreatic stump, and a reinforcing suture including the entire stump section was performed using 3-0 polyglactin sutures (vicryl®, Ethicon). This reinforcing suture was performed with a width of 8–10 mm, and total of 4–8 interrupted sutures were placed according to pancreatic stump size (Figs. 1A,2A).

Second, the proximal jejunum with a closed end was pulled up through the retrocolic space and an incision similar in size to that of the pancreatic stump was made on the contramesenteric wall of the jejunum. After the prepared pancreatic stump and jejunum

were placed close to each other, an interrupted anastomosis of the pancreatic stump and jejunum was performed using 4-0 polydioxanone sutures (PDS II®, Ethicon). The anastomosis was performed with the posterior wall first, followed by the anterior wall, and the whole layer of jejunum is sewn to the pancreas containing the reinforcing suture (Figs. 1B,C, 2B).

Finally, we checked the overall shape of the PJ and used additional 5-0 polypropylene sutures (Prolene®, Ethicon) if necessary so that the jejunum does not become tensioned and can completely cover the pancreas.

2.2. Other anastomoses

When the PJ was finished, hepaticojejunostomy (HJ) and duodenojejunosomy (DJ) were performed.

First, HJ was performed with an interrupted 5-0 polydioxanone suture (PDS II®, Ethicon) using an end-to-side method. No additional stent insertion was performed, and a continuous suture was rarely placed when the bile duct was too large for interrupted suture placement.

Thereafter, DJ was performed in the antecolic space at 30–50 cm from the HJ. A double-layer of 3-0 polyglactin suture (vicryl®, Ethicon) and 4-0 silk suture (Silk®, Ethicon) was placed using an end-to-side method.

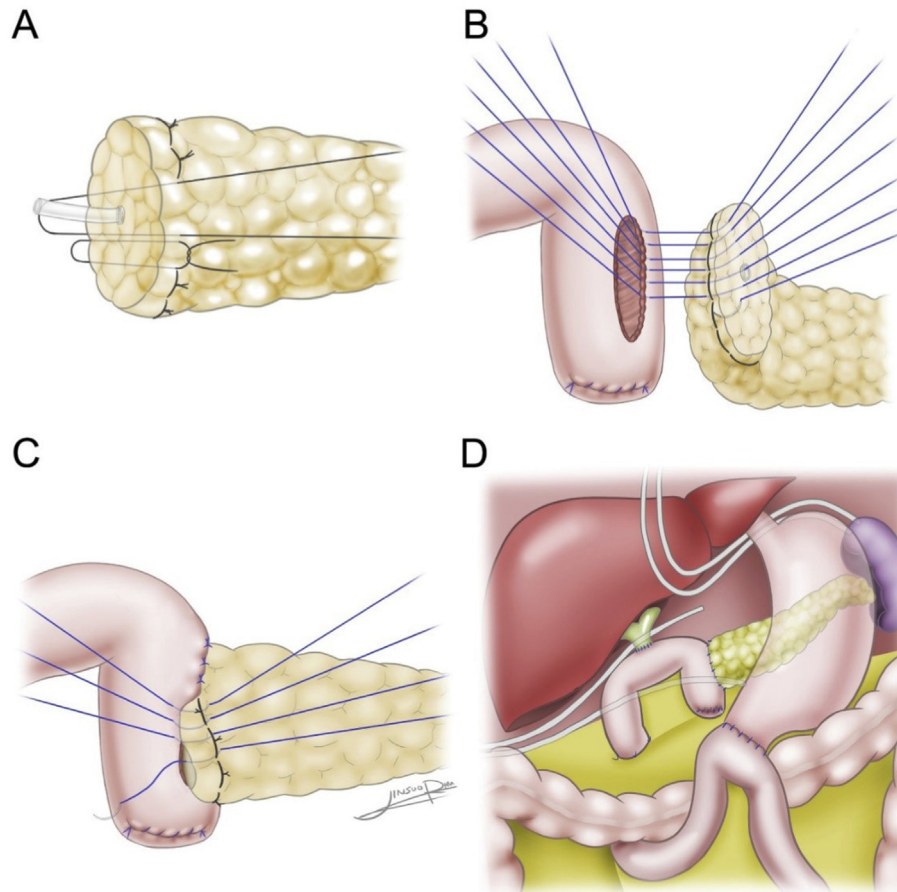


Fig. 1. Operative technique (illustration) (A) A soft silastic catheter of appropriate size was inserted into the pancreatic stump with bleeding control and safe margin, followed by reinforcing 4-0 polyglactin sutures (vicryl®, Ethicon) (B) After the pancreatic stump and jejunum are positioned close together, the jejunum is excised to the same size as the pancreatic stump. A pancreaticojejunostomy is performed from the posterior wall with interrupted 4-0 polydioxanone sutures (PDS II®, Ethicon). At this time, all interrupted sutures include the reinforcing sutures placed on the pancreatic stump (C) The anterior wall is used in the same way as the posterior wall. Care should be taken to ensure that the jejunum covers the pancreas. (D) After all anastomoses are complete, the drains are placed around the pancreaticojejunostomy and hepaticojejunostomy and in the left subphrenic area.

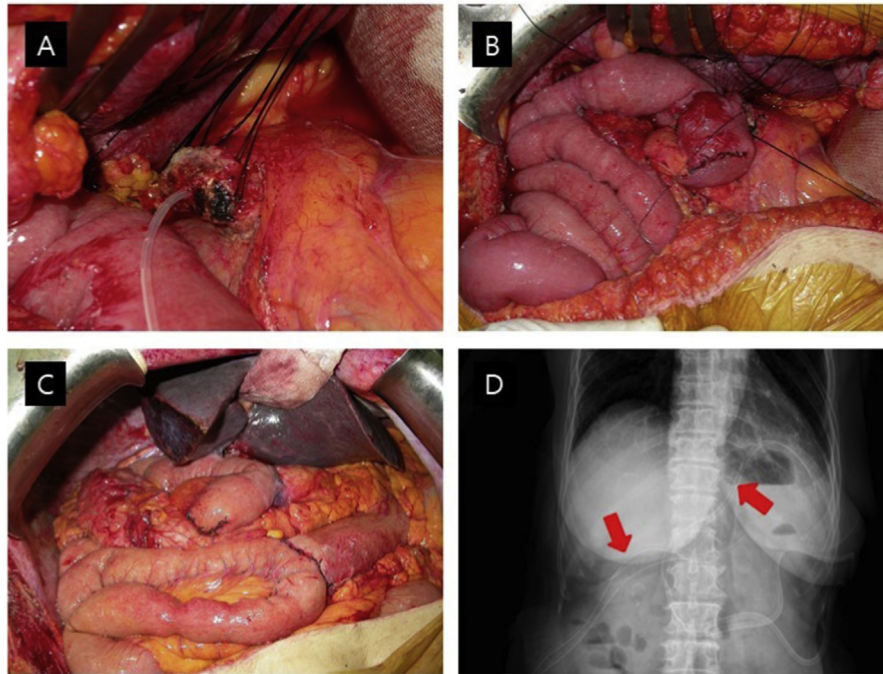


Fig. 2. Operative technique (pictures of operative field) (A) A soft silastic catheter of appropriate size was inserted into the pancreatic stump with bleeding control and safe margin, followed by reinforcing 4-0 polyglactin sutures (vicryl®, Ethicon) (B) A pancreaticojejunostomy is performed from the posterior wall to the anterior wall with interrupted 4-0 polydioxanone sutures (PDS II®, Ethicon). At this time, all interrupted sutures include the reinforcing sutures performed on the pancreatic stump. In addition, the jejunum is verified to cover the pancreas (C) After all anastomoses are complete, surgical glue is used to prevent a postoperative pancreatic fistula over the pancreaticojejunostomy. (D) Drain locations are confirmed postoperatively on radiography.

After all anastomoses were completed (Fig. 2C), the drain was inserted around the PJ, HJ, and left subphrenic area (Figs. 1D,2D) and the operation was terminated.

2.3. Definition of POPF

The 2016 ISGPF definition and grading of POPF were applied in this study.^{5,15} We classified POPF grade (A–C) according to drain amylase levels in a retrospective review of each patient's medical chart.

2.4. Statistical analysis

All statistical analyses were performed using SPSS version 21.0 (SPSS, Chicago, IL, USA). Pearson's chi-square test and the linear by linear association test were used to compare categorical variables, while the independent t-test was used to compare continuous variables. Logistic regression analysis was used to confirm the independent factors. P values < 0.05 were considered statistically significant in all analyses.

3. Results

3.1. General patient characteristics surgical outcomes

Table 1 shows the general characteristics and surgical outcomes of the 122 patients included in this study. The mean patient age was 65.53 years and 70 were male (57.4%). Cancer of the pancreatic head was the most common diagnosis (n = 48; 39.3%), followed by that of the bile duct (n = 38; 31.1%), ampulla of Vater (n = 28; 23.0%), and duodenum (n = 2; 1.6%). There were also benign diseases of the pancreas such as chronic pancreatitis (n = 6; 4.9%).

Postoperatively, POPF occurred in 62 patients (50.8%), of whom

37 were classified as grade A, which did not affect the normal hospital course. Twenty patients (16.4%) who received additional treatment such as persistent drainage (>21 days) or percutaneous drainage for intra-abdominal abscess as well as 5 patients (4.1%) who underwent reoperation with POPF were classified as grade C.

Postoperative complications were classified by Clavien-Dindo score¹⁶; grade 0, which did not involve complications, accounted for 46.7% of the 57 cases. Grade 1 included 4 patients with only wound complications. Grade 2 accounted for 37.7% (n = 46) of the total, of which 31 patients required a transfusion. Most of the transfused patients received only a small transfusion of packed red cells (1–2 pints). High transfusion rates are presumed to reflect the past characteristics of our center, which had strict hemoglobin criteria. Grade 3 occurred in 12 patients (9.8%), including reoperation (n = 8), percutaneous coronary intervention for myocardial infarction (n = 2), and percutaneous drainage for intra-abdominal abscess (n = 6). Eight patients (5.74%) who underwent reoperation had POPF (n = 5), bleeding (n = 2), and other organs that performed co-operation. Lastly, grade 4 included 1 patient (0.8%) who required intensive care unit care for a postoperative respiratory problem, and grade 5 included 2 patients (1.6%) who died within 30 days postoperative, one of bleeding after removal of the percutaneous transhepatic biliary drainage during the normal recovery phase and one after reoperation due to postoperative bleeding. There was no further death of patient until postoperative 90 days.

In addition, no new-onset diabetes mellitus occurred in patients who underwent long term follow up for more than one year.

3.2. Comparison of patients with fistula and without fistula

We compared and analyzed the groups in which POPF occurred (n = 62) and those in which it did not (n = 60) to analyze the factors

Table 1
General patient characteristics and surgical outcomes.

Total (N = 122)		
Age (years)	65.53 (35–84) ± 9.89	
Sex	Male	70 (57.4%)
	Female	52 (42.6%)
Height (cm)	161.43 (139–180) ± 8.03	
Weight (kg)	60.87 (38–90) ± 9.94	
Body mass index	23.31 (14.55–31.51) ± 3.05	
Diagnosis	Pancreas head cancer	48 (39.3%)
	Bile duct cancer	38 (31.1%)
	Ampulla of Vater cancer	28 (23.0%)
	Duodenal cancer	2 (1.6%)
	Benign pancreatic disease	6 (4.9%)
Pancreas-related diagnosis?	Yes	54 (44.3%)
	No	68 (55.7%)
ASA	1	15 (12.3%)
	2	80 (65.6%)
	3	27 (22.1%)
Operative time (min)	447.99 (255–635) ± 71.33	
Postoperative hospital day	23.84 (11–99) ± 12.05	
Postoperative pancreatic fistula	None	60 (49.2%)
	Grade A	37 (30.3%)
	Grade B	20 (16.4%)
	Grade C	5 (4.1%)
Clavien-Dindo score	Grade 0	57 (46.7%)
	Grade 1	4 (3.3%)
	Grade 2	46 (37.7%)
	Grade 3	12 (9.8%)
	Grade 4	1 (0.8%)
	Grade 5	2 (1.6%)
Reoperation	8 (5.74%)	
30-day Mortality	2 (1.64%)	
90-day Mortality	2 (1.64%)	

* ASA: American society of anesthesiologists.

affecting POPF and those affected by POPF (Table 2). The occurrence of POPF was not affected by age ($p = 0.343$), sex ($p = 0.210$), height ($p = 0.591$), or operative time ($p = 0.188$). However, there was a statistically significant difference in POPF incidence according to body weight ($p = 0.005$) and body mass index ($p = 0.002$). In addition, ASA score showed significant differences ($p = 0.031$) in

the occurrence of POPF. There was no significant difference in the occurrence of POPF according to the detailed diagnosis ($p = 0.398$). However, when the diagnosis was largely divided into pancreas-related diagnosis including pancreas head cancer and benign pancreatic disease versus other diagnoses, there was a significant difference ($p = 0.019$) in the occurrence of POPF. Finally, mean

Table 2
Comparison of patients with or without fistula.

		Fistula		P value
		Yes (n = 62)	No (n = 60)	
Age (years)		64.69 (± 9.89)	66.40 (± 9.89)	0.343
Sex	Male	39 (62.9%)	31 (51.7%)	0.210
	Female	23 (37.1%)	29 (48.3%)	
Height (cm)		161.83 (± 8.39)	161.04 (± 7.70)	0.591
Weight (kg)		63.36 (± 9.97)	58.34 (± 9.32)	0.005
Body mass index		24.12 (± 2.85)	22.47 (± 3.04)	0.002
Cancer diagnosis	Pancreatic head	19 (30.6%)	29 (48.3%)	0.398
	Bile duct	23 (37.1%)	15 (25.0%)	
	Ampulla of Vater	17 (27.4%)	11 (18.3%)	
	Duodenum	1 (1.6%)	1 (1.7%)	
	Benign disease of pancreas	2 (3.2%)	4 (6.7%)	
Pancreas-related diagnosis?	Yes	21 (33.9%)	33 (55.0%)	0.019
	No	41 (66.1%)	27 (45.0%)	
ASA	1	9 (15.0%)	6 (9.7%)	0.031
	2	43 (71.7%)	37 (59.7%)	
	3	8 (13.3%)	19 (30.6%)	
Operative time (min)		456.37 (± 65.24)	439.33 (± 76.71)	0.188
Postoperative hospital day		28.55 (± 14.63)	18.97 (± 5.39)	<0.001

* ASA: American society of anesthesiologists.

postoperative hospital stay was significantly shorter in the group without POPF than in the group with POPF (18.97 ± 5.39 vs 28.55 ± 14.63 days, $p < 0.001$).

We also analyzed patient factors independently associated with POPF (Table 3). The statistically significant independent factors related to the occurrence of POPF were BMI ($p = 0.034$) and pancreas-related diagnosis ($p = 0.040$). However, the only independent factor significantly related to the occurrence of severe POPF including grade 2 and grade 3 was BMI ($p = 0.016$).

3.3. Comparison of fistula occurrence according to pancreas-related diagnosis

As mentioned above, when patients who underwent surgery with this technique were classified by the presence or absence of POPF, there was a statistically significant difference in the incidence of POPF among those with a pancreas-related diagnosis versus those with other diagnoses and the other patients. However, there was no statistically significant difference in the occurrence of POPF B and C between patients with pancreas-related diagnoses and those with other diagnoses when classified into two groups according to POPF grade (Table 4).

4. Discussion

POPF is one of the most critical complications that can occur after PD.^{6–8} For each study reported so far, the incidence rate varies greatly depending on the surgical method, the definition of pancreatic fistula, the distribution of the patient's preoperative diagnosis, and many other conditions. Therefore, the incidence rate of POPF is variously reported up to 3–45%, which is high on average.¹⁷ For this reason, several studies have investigated how to reduce POPF, including variations in surgical techniques.^{10–13} However, despite the studies of various surgical techniques to date, even in the latest study, the fistula rate of PJ in soft pancreas was reported up to 25–38%, and there is still no gold standard for PJ.¹⁸ Nevertheless, with constant research and effort, especially in high-volume centers, the rate of complications after PD was significantly reduced regardless of procedure used.^{19,20}

However, in the Republic of Korea, there are fewer than 10 centers treating >20 cases of PD per year. For this reason, it is not easy to learn a conventional surgical technique for PJ considering the complex and long learning curve for inexperienced hepatobiliary and pancreatic surgeons. Therefore, it is true that the incidence of complications including POPF is greatly influenced by experience.²¹

We have conducted several studies to reduce complications

Table 4
Comparison of fistula occurrence according to pancreas-related diagnosis.

		Fistula?		P value
		Yes (n = 62)	No (n = 60)	
Diagnosis	Pancreatic disease	21 (33.9%)	33 (55.0%)	0.019
	Non-pancreatic disease	41 (66.1%)	27 (45.0%)	
		Fistula grade		P value
		None, A (n = 97)	B, C (n = 25)	
Diagnosis	Pancreatic disease	44 (45.4%)	10 (40.0%)	0.630
	Non-pancreatic disease	53 (54.6%)	15 (60.0%)	

including POPF in our center, which encounters 15–30 cases of PD per year. In doing so, we developed a new surgical technique for PJ that can reduce complications including POPF and is simple and easy to perform and not significantly affected by experience.²²

A single surgeon has performed this surgical technique over the past 10 years, and analysis of these 122 cases showed that rates of POPF and complications did not differ from those of the various studies reported previously.

According to recently published studies, pancreatic texture has the greatest influence on the occurrence of POPF.^{23–26} Berger et al (2009) confirmed a high POPF ratio in soft versus hard pancreas in a randomized prospective dual-institution trial.²⁷ In fact, our procedure is designed to reduce the incidence of POPF by greatly hardening the texture around the pancreatic stump using the reinforcing suture. Because the pancreatic texture is subjectively evaluated by the surgeon, objective evaluations were difficult to make. For this reason, we classified and analyzed the patients in two groups: pancreas-related diagnoses with a generally hard pancreas; and other diagnoses. There was a significant difference in diagnosis according to the presence or absence of POPF. However, there was no significant difference according to diagnosis when classified into grades B and C (that affect the patient's hospital course) and other groups. In other words, critical problems such as POPF grade B and C do not differ significantly among diagnoses. These results suggest that this surgical technique cannot prevent POPF. However, at least for critical problems such as POPF grades B and C group (that affect the patient's hospital course), we suggest that this technique can minimize the effect of pancreatic texture.

This study's main limitation is its small number of patients who underwent PJ performed by a single surgeon in a single center. In addition, it is limited by its classification of pancreatic texture by diagnosis. However, this surgical technique may have surgical implications for the following reasons. First, it was developed to increase the pancreatic texture around the pancreatic stump, which is highly correlated with the occurrence of POPF. Second, it is easy and

Table 3
Patient factors independently associated with postoperative pancreatic fistula.

POPF (Grade 1, Grade 2, Grade 3)		
	Multadjusted* OR (95% CI)	p-value
Age	0.958 (0.914–1.004)	0.073
BMI	1.138 (1.010–1.282)	0.034
Pancreas-related diagnosis	2.251 (1.036–4.889)	0.040
ASA score		0.053
1	Reference	
2	2.889 (0.690–12.095)	0.146
3	6.914 (1.353–35.331)	0.020
Severe POPF (Grade 2, Grade 3)		
	Multadjusted* OR (95% CI)	p-value
BMI	1.209 (1.035–1.413)	0.016

*Adjusted for Age, Sex, Body mass index, Pancreas-related diagnosis, and ASA score; POPF: postoperative pancreatic fistula; OR: odds ratio; CI: confidence interval; BMI: body mass index; ASA: American society of anesthesiologists.

simple to perform, so it is not significantly affected by surgeon experience or ability. These surgical implications may be more significant in patients with a soft pancreas or who are at higher risk of complications due to older age.

To evaluate this surgical technique properly in the future, more patients should be analyzed. In addition, analyses of cases of this surgical technique performed by several surgeons should be performed to confirm that its usefulness is truly not influenced by surgeon experience. Finally, this surgical technique will be the cornerstone of a better technique for decreasing the incidence of POPF in the future.

In conclusion, although one-layer PJ using reinforcing sutures cannot prevent POPF, it can prevent the life-threatening complications by hardening the texture around the pancreatic stump. In addition, this surgical technique is simple and quick, so it can be performed without being greatly influenced by surgeon experience or ability.

Declaration of competing interest

Yun Kyung Jung, Dongho Choi and Kyeong Geun Lee have no conflicts of interest or financial ties to disclose.

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