

A novel pancreaticogastrostomy method using only two transpancreatic sutures: early postoperative surgical results compared with conventional pancreaticojejunostomy

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Purpose: To evaluate the surgical outcomes of pancreaticogastrostomy (PG) using two transpancreatic sutures with a buttress method through an anterior gastrostomy (PGt), and compare these results with our previous experience with pancreaticojejunostomy (PJ) including the dunking and duct to mucosa methods after pancreaticoduodenectomy (PD).

Methods: In this study, 171 patients who had undergone PD between January 2005 and April 2013 were classified into three groups according to the method of the pancreaticoenteric anastomosis: dunking PJ (PJ_d group; n = 67, 39.1%), duct to mucosa PJ (PJ_m group; n = 41, 23.9%), and PGt (PGt group; n = 63, 36.8%). We retrospectively analyzed patient characteristics, perioperative outcomes, and surgical results.

Results: Both groups had comparable demographics and pathology, and there were no significant differences in operative time, estimated blood loss, or postoperative hospital stay. Within the two groups, morbidities occurred in 49 cases (10.7%), and were not significantly different between the two groups, excepting postoperative pancreatic fistula (POPF). The PGt group had a lower rate of POPF (18/63, 28.6%) than the PJ_d and PJ_m groups [21/67, 31.3% and 19/41, 46.3%; P = 0.048], especially in terms of grades B and C POPF [4/63 [6.3%] in the PGt group vs. 7/67 [10.4%] in the PJ_d group and 9/41 [22.0%] in the PJ_m group, P = 0.049].

Conclusion: The PGt method showed feasible outcomes for POPF and had advantages over dunking PJ and duct to mucosa PJ with respect to immediate postoperative results. PGt may be a promising technique for pancreaticoenteric anastomosis after PD.

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Key Words: Pancreaticoduodenectomy, Pancreaticogastrostomy, Pancreaticojejunostomy

INTRODUCTION

Pancreaticoduodenectomy (PD) is the surgical treatment of choice for patients with malignant or benign disease of pancreatic head and periampullary region. With improvement in surgical techniques and instruments, the mortality rate of PD has decreased, but the morbidity rate still remains high at

30%–50% [1,2]. Postoperative pancreatic fistula (POPF) is the most common and critical complication after PD, affecting the quality of life of patients, the length of hospital stay, medical costs, and even postoperative mortality [1]. Therefore, numerous surgeons have proposed various methods for performing the pancreaticoenteric anastomosis to reduce the risk of POPF.

For pancreaticoenteric anastomoses, two kinds of procedures

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have been commonly used: pancreaticojejunostomy (PJ) and pancreaticogastrostomy (PG). Although PG has been reported to be superior to PJ in some studies [3-7], there is no consensus regarding the best method [8-11].

We have already reported a novel reconstructive technique for pancreatoenteric anastomosis, which is PG using two transpancreatic sutures with a buttress method through an anterior gastrostomy (PGt) [12]. This straightforward method has shown favorable surgical outcomes in our previous study. In this report, we evaluated the surgical outcomes of the PGt procedure and compared them with our previous experiences with PJ including the dunking and duct to mucosa methods.

METHODS

Between January 2005 and April 2013, 198 patients had undergone PD by one of three surgeons in the Department of Hepatobiliary and Pancreas Surgery. After reviewing the medical records of these patients, we excluded all cases which were performed via laparoscopy or with concomitant operations. As a result, a total of 171 patients were classified into three groups according to the method of pancreatoenteric anastomosis: 67 patients underwent dunking PJ (PJ_d group), 41 underwent duct to mucosa PJ (PJ_m group), and 63 underwent PGt (PGt group). We analyzed the demographic findings of patients including age, sex, body mass index, primary site of lesion, pathologic diagnosis, and presence of preoperative external biliary drainage. Likewise, perioperative outcomes and surgical results were evaluated including mean operative time, number of harvested lymph nodes, estimated blood loss (EBL), type of PD (pancreas-preserving PD [PPPD] or classic Whipple), texture of pancreatic tissue (soft or firm), presence of pancreatic duct dilatation, length of postoperative intensive care unit (ICU) stay, number of days until Levin tube removal, length of postoperative hospital stay, rate of POPF, and other postoperative complications including delayed gastric emptying (DGE), postoperative pneumonia, intra-abdominal abscess, wound infection, and postoperative mortality.

POPF was defined as 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 level, according to the definition of the International Study Group on Pancreatic Fistula [13]. POPF was classified into three grades: grades A, B, and C. Grade A POPF requires little change in management or deviation from the normal clinical pathway. Grade B POPF needs a change in management or adjustment of the clinical pathway with noninvasive treatment such as parenteral nutrition or antibiotics. Grade C POPF includes a major change in clinical management due to life-threatening complications. These patients required nutritional support, intravenous antibiotics, and percutaneous drainage or surgical intervention.

In this study, we considered grades B and C POPF to be clinically significant, and analyzed the incidence of grades B and C POPF among the three groups.

DGE was defined as the inability to return to a normal diet at postoperative day 10 and the need to maintain or reinsert nasogastric intubation [14]. Pneumonia was defined as fever (>38°C) or leukocytosis accompanied by respiratory symptoms such as cough, sputum production, or dyspnea, as well as abnormal radiologic findings on a chest x-ray such as consolidation or haziness. Intra-abdominal abscess was defined as clinical signs of inflammation such as abdominal tenderness, leukocytosis, or fever, as well as radiologic findings of fluid collection on a CT scan and a positive bacterial culture of the percutaneously drained abdominal fluid. Postoperative mortality was defined as death within 30 days of the operation.

Surgical techniques

All patients underwent classic PD or PPPD depending on the indications, and standard lymph node dissection was performed in cases of malignancy. After PD, one of three methods was used for pancreatoenteric anastomosis: dunking PJ, duct to mucosa PJ, or PGt at the discretion of the surgeon.

We performed dunking PJ and duct to mucosa PJ as previously described by Z'graggen et al. [15] and Kennedy and Yeo [16], and digestive tract reconstruction was performed using Child's technique. In cases of dunking PJ, the jejunal loop was anastomosed to the remnant pancreas using an end-to-end method. The interrupted 3-0 silk sutures were placed in the posterior external layer between the pancreatic capsule and the jejunal sero-muscular layer. The full thickness of the internal layer was then sutured between the pancreas and jejunum using 3-0 polydioxanone sutures (PDS, Ethicon Inc., Somerville, NJ, USA). The same technique was used for the posterior external layer and the anterior external layer, between the pancreatic capsule and the jejunal loop. An internal P-duct stent was routinely used with the exception of those with a pancreatic duct that was too small to cannulate.

Duct to mucosa PJ was performed in an end-to-side fashion. The posterior outer row was sutured with 3-0 silk between the remnant pancreas and the jejunal loop. A small jejunostomy was created using electrocautery, and the anastomosis between the jejunostomy and the pancreatic duct was performed with 5-0 PDS, first the posterior layer followed by the anterior layer, at least three ductal sutures on each side. Additionally, the anterior outer row was completed with interrupted sutures using 3-0 silk. Internal P-duct stents of various calibers were inserted according to the size of pancreatic duct in the remnant pancreas.

PGt was done as described by Hong et al. [12] in 2011. The pancreatic stump was mobilized approximately 4 cm from the retroperitoneum. The pancreatic duct was identified and

incannulated with a short stent tube. Two stay sutures were applied to both ends of the pancreatic stump. A gastrostomy was made in the anterior wall of the stomach, just above the expected PG site. At the posterior gastric wall, a gastrostomy for PG was performed which was about 3/4 the diameter of the pancreatic stump in length. Two stay sutures were brought anteriorly through the posterior gastric wall, and traction was applied. The pancreatic stump was inserted into the gastric lumen and implanted firmly. PG was completed with two transpancreatic sutures with buttresses on both the upper and lower borders of the pancreas through the anterior gastrostomy. We used two 4-0 monofilament polypropylene threads with a straightened needle at each end (Prolene, Ethicon Inc.) and four buttresses (TFE Polymer Pledget, Ethicon Inc.). The first suture passed straight from the proximal surface of the posterior gastrostomy through the full thickness of the posterior gastric wall, then from the dorsal surface to the ventral surface of the pancreas, and finally through the distal full-thickness of the posterior gastric wall. These sutures were placed at both corners of the gastrostomy. A suture buttress was inserted through each needle and knotted (Fig. 1). The anterior gastrostomy was closed in two layers.

After the completion of the pancreaticoenteric anastomosis, two Jackson-Pratt drains were placed in each patient; one posterior to the anastomosis site and the other in the right subhepatic space. Octreotide was not routinely used unless

there was definite evidence of pancreatic leakage. A Levin tube was routinely inserted in all cases and removed as soon as possible after the passage of gas in PJ patients, while the tube kept in place for 5 days after the operation for gastric decompression and protection of the anastomosis in PGt patients. On postoperative day 7, a CT scan was done to identify any complications.

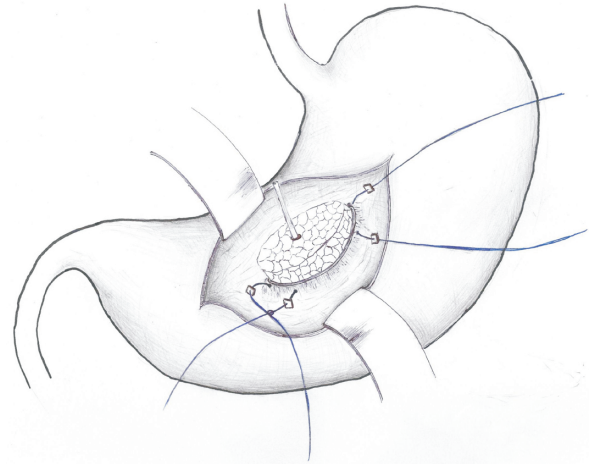


Fig. 1. Schematic drawing of a pancreaticogastrostomy using two transpancreatic sutures with buttresses through an anterior gastrostomy.

Table 1. Demographics and characteristics of the patients

Variable	PJu (n = 67)	PJm (n = 41)	PGt (n = 63)	P-value
Age (yr)	60.4 ± 9.8	61.1 ± 13.0	61.1 ± 10.6	0.919
Sex				0.592
Male	40	23	32	
Female	27	18	31	
Body mass index (kg/m ²)	23.3 ± 3.2	23.6 ± 3.1	23.3 ± 3.1	0.791
Diagnosis				0.266
Pancreatic head cancer	24	21	28	
Distal bile duct cancer	17	5	7	
Ampulla of Vater cancer	14	7	15	
Duodenal cancer	2	2	1	
IPMN	3	1	4	
NET	1	0	2	
Other malignancy	2	2	3	
Other benign disease	4	3	3	
Texture of pancreas				0.081
Firm	46 (68.7)	29 (70.7)	33 (52.4)	
Soft	21 (31.3)	12 (29.3)	30 (47.6)	
Dilated pancreatic duct	38 (56.7)	33 (80.4)	30 (47.6)	0.003
Preoperative external biliary drainage ^{a)}	24 (35.8)	12 (29.2)	25 (39.6)	0.556

Values are presented as mean ± standard deviation or number (%).

PJu, dunking pancreaticojejunostomy; PJm, duct to mucosa pancreaticojejunostomy; PGt, pancreaticogastrostomy using two transpancreatic sutures; IPMN, intraductal papillary mucinous neoplasm; NET, neuroendocrine tumor.

^{a)} Percutaneous transhepatic biliary drainage or percutaneous transhepatic gallbladder drainage.

Statistical analysis

For categorized data using frequency distributions and percentages, chi-square tests were used. For continuous variables, we used Student t-tests to compare outcomes between two groups, and one-way analysis of variance to compare results among all three groups. Descriptive statistics were expressed as means \pm standard deviations. The 95% confidence interval for differences in proportions were estimated, and P-values were two sided, with statistical significance set at <0.05 .

RESULTS

The demographic findings of the patients are shown in Table 1. The mean age was 61.6 ± 10.6 years. Among 171 patients, 73 patients were diagnosed with cancer of the pancreatic head, 29 with cancer of the distal bile duct, 36 with cancer of the ampulla of Vater, and 5 with duodenal cancer. Eight patients were diagnosed with intraductal papillary mucinous neoplasms, and 3 patients had neuroendocrine tumors. Seven patients had

other malignancies, and 10 patients underwent surgery for other benign disease such as chronic pancreatitis, duodenal adenoma, or cystic lesion. The disease distribution among the groups was not significantly different ($P = 0.266$). One hundred eight patients were classified as having firm pancreatic tissue while 63 patients had soft tissue. This was not significantly different among the groups ($P = 0.081$). In total, 101 cases of dilated pancreatic ducts were identified, with 38 (56.7%) in the PJu group, 33 (80.4%) in the PJm group, and 30 (47.6%) in the PGt group ($P = 0.003$).

The surgical outcomes of the three groups are summarized in Table 2. The overall mean operative time was 370.3 ± 43.8 minutes: 365.6 ± 51.8 in the PJu group, 366.3 ± 35.3 in the PJm group, and 378.4 ± 42.1 in the PGt group ($P = 0.085$). The mean number of harvested lymph nodes was 16.4 ± 5.2 : 14.0 ± 4.1 in the PJu group, 17.7 ± 5.7 in the PJm group, and 17.8 ± 6.1 in the PGt group ($P = 0.126$). Overall mean EBL during the operation was 930.1 ± 526.2 mL: 867.1 ± 518.6 mL in the PJu group, 971.5 ± 541.4 mL in the PJm group, and 963.5 ± 522.1 mL in the PGt group ($P = 0.187$).

Table 2. Perioperative outcomes and surgical results

Variable	PJu (n = 67)	PJm (n = 41)	PGt (n = 63)	P-value
Operative time (min)	365.6 ± 51.8	366.3 ± 35.3	378.4 ± 42.1	0.085
No. of harvested lymph nodes	14.0 ± 4.1	17.7 ± 5.7	17.8 ± 6.1	0.126
Estimated blood loss (mL)	867.1 ± 518.6	971.5 ± 541.4	963.5 ± 522.1	0.187
Type of PD				0.866
Classic Whipple	28 (41.8)	15 (36.6)	25 (39.7)	
PPPD	39 (58.2)	26 (63.4)	38 (60.3)	
Postoperative ICU stay (day)	1.9 ± 0.8	1.9 ± 0.6	2.1 ± 0.7	0.206
Postoperative hospital stay (day)	15.7 ± 4.4	17.1 ± 6.2	15.5 ± 4.5	0.142
Levin tube removal (day)	3.8 ± 1.1	3.6 ± 1.0	4.9 ± 0.8	0.038

Values are presented as mean \pm standard deviation or number (%).

PJu, dunking pancreaticojejunostomy; PJm, duct to mucosa pancreaticojejunostomy; PGt, pancreaticogastrostomy using two transpancreatic sutures; PD, pancreaticoduodenectomy; PPPD, pylorus-preserving PD; ICU, intensive care unit.

Table 3. Postoperative complications

Postoperative complication	PJu (n = 67)	PJm (n = 41)	PGt (n = 63)	P-value
POPF	21 (31.3)	19 (46.3)	18 (28.6)	0.048
Grade A	14 (20.9)	10 (24.4)	14 (22.2)	
Grade B	5 (7.5)	7 (17.1)	3 (4.8)	
Grade C	2 (3.0)	2 (4.9)	1 (1.6)	
Grade B + C	7 (10.4)	9 (22.0)	4 (6.3)	0.049
DGE	9 (13.4)	7 (17.1)	7 (11.1)	0.684
Pneumonia	5 (7.5)	7 (17.1)	4 (6.3)	0.147
Intra-abdominal abscess	4 (6.0)	5 (12.2)	2 (3.2)	0.183
Wound infection	8 (11.9)	8 (19.5)	12 (19.0)	0.453
Mortality	2 (3.0)	1 (2.4)	1 (1.6)	0.869

Values are presented as number (%).

PJu, dunking pancreaticojejunostomy; PJm, duct to mucosa pancreaticojejunostomy; PGt, pancreaticogastrostomy using two transpancreatic sutures; POPF, postoperative pancreatic fistula; DGE, delayed gastric emptying.

group ($P = 0.187$). Patients underwent one of two types of PD, the classic Whipple operation (68/171, 39.8%) or PPPD (103/171, 60.2%), and there was no significant difference between the three groups ($P = 0.866$). During the postoperative course, the overall mean length of ICU stay was 2.0 ± 0.7 days: 1.9 ± 0.8 days in the PJu group, 1.9 ± 0.6 days in the PJm group, and 2.1 ± 0.7 days in the PGt group ($P = 0.206$). The mean total length of the postoperative hospital stay was 16.0 ± 4.9 days: 15.7 ± 4.4 days in the PJu group, 17.1 ± 6.2 days in the PJm group, and 15.5 ± 4.5 days in the PGt group ($P = 0.142$). The overall mean time to Levin tube removal after the operation was 3.8 ± 1.0 days: 3.8 ± 1.1 days in the PJu group, 3.6 ± 1.0 days in the PJm group, and 4.9 ± 0.8 days in the PGt group ($P = 0.038$).

In terms of postoperative complications (Table 3), the PGt group had a lower rate of POPF than the other two PJ groups. The overall number of cases with POPF was 58 (33.9%); 21 (31.3%) in the PJu group, 19 (46.3%) in the PJm group, and 18 (28.6%) in the PGt group ($P = 0.048$). Additionally, the rate of grades B and C POPF was less in the PGt group at 4 (6.3%) compared with 7 (10.4%) in the PJu group and 9 (22.0%) in the PJm group ($P = 0.049$). There were 23 cases (16.0%) of DGE: 9 (13.4%) in the PJu group, 7 (17.1%) in the PJm group, and 7 (11.1%) in the PGt group ($P = 0.684$). The number of cases with wound infections was 28 (16.4%); 8 (11.9%) in the PJu group, 8 (19.5%) in the PJm group, and 12 (19.0%) in the PGt group ($P = 0.453$), with no statistical differences among the groups. Mortality was observed in four patients in this study. Two of these deaths were the result of septic shock with multiorgan failure, one in the PJm group and the other in the PGt group. Additionally, one patient in the PJu group died from postoperative bleeding, and one in the PJu group died from pneumonia.

DISCUSSION

Despite the development of new surgical techniques and instruments, pancreaticoenteric anastomosis remains a major challenge because of the risk of the anastomotic failure. This risk arises from unique features of the pancreaticoenteric anastomosis, which are dissimilar to other entero-enterostomies. In pancreaticoenteric anastomoses, an attachment between two vastly different organs is performed. The pancreas is a solid organ within the retroperitoneum, whereas the intestine is a hollow organ that works via peristalsis, which can disrupt even a stable anastomosis site. Additionally, pancreatic juice is secreted at the pancreatic stump, not only from the main duct but from several minor ducts, which can weaken the anastomosis and affect the development of POPF.

Generally two kinds of pancreaticoenteric anastomoses are performed: PJ and PG. Many surgeons have reported postoperative outcomes comparing PJ and PG, but there have

been no firm conclusions to date about the superiority of one method or the other [8-11]. In this study, we used the PGt method for the pancreaticoenteric anastomosis and compared the results with our previous experience with dunking PJ and duct to mucosa PJ. We identified fewer episodes of POPF in patients who had undergone PGt compared with dunking or duct to mucosa PJ. Furthermore, the rates of grade B or C POPF, which are considered to be clinically relevant, were far less in the PGt group at 6.3%. These results might stem from the potential advantages of PG associated with POPF, including sufficient blood supply at the anastomosis site, inactivation of pancreatic enzymes by gastric acid, thickness of the stomach wall, and ease of creating a tension-free anastomosis due to the proximity of the pancreas to the stomach [11,17].

Figueras et al. [6] reported rates of POPF after PD that compared PG to PJ, showing grades B and C POPF after PG to occur in 11% of patients compared with 33% after PJ. Additionally, Klein et al. [18] reported 10.7% grades B and C POPF after PG using mattress sutures. In our study, the rate of grades B and C POPF was only 6.3%, and this favorable outcome may be derived from the advantages of our PGt method. Using PGt, we applied only two sutures at the edges of the pancreas, which enabled us to reduce crush injuries and damage to the pancreatic tissue. Also, we used a straightened needle instead of the conventional curved needle for the transpancreatic sutures, which can reduce the tangential shear and the disruption of the pancreatic stump.

Moreover, a bulky pancreatic stump accompanied by swelling and edematous change makes anastomosis with the viscera very difficult, particularly in cases of end to end anastomosis such as the dunking PJ method [19]. The mismatch in size between the pancreas and jejunum may be the only reason to give up this method. The PGt method can be applied in such cases easily by adjusting the gastrostomy length to the size of the pancreatic stump.

The pancreatic duct is directly sutured to the jejunal mucosa in cases of duct to mucosa PJ, which is technically difficult if the pancreatic duct is narrow and not dilated. The rate of dilated pancreatic ducts in the PJm group was high (up to 80%) in the present study, which indicates that the duct to mucosa method was preferred. Consequently, the duct to mucosa method should be applied in specific patients, depending on the diameter of the pancreatic duct. Likewise, PJm was used in remarkably fewer cases compared with other groups in our study. Meanwhile, pancreatic juice from the minor pancreatic ducts which are exposed at the pancreatic stump after resection also could cause POPF. This minor leakage could be a fatal disadvantage of the duct to mucosa method, whereas our PGt method can be used easily without the limitation of pancreatic duct diameter. This method also compensates for the weakness of the duct to mucosa PJ as an invagination method that could

drain the pancreatic juice from all the minor ducts at the pancreatic stump.

This study has some limitations, and our results should be carefully interpreted. This is a retrospective study at a single institution including a small number of patients, and the information regarding postoperative complications is limited. Also, the method of pancreaticoenteric anastomosis was at the discretion of the surgeon rather than randomization, and as a result selection bias was likely present. In addition, the PGt method was recently developed, while dunking and duct to mucosa PJ have been conventionally performed, which means that PGt might have been performed by more experienced surgeons. Meanwhile, long-term outcomes of pancreatic exocrine and endocrine function according to the type of pancreaticoenterostomy should also be considered. As survival after PD increases, surgeons have growing concerns

about the possible metabolic derangements of PG, particularly its potential to inactivate the pancreatic enzyme in the acidic environment of the stomach and deteriorate pancreatic function due to gastric reflux into the pancreatic duct in the end [20]. Thus, further large-scale, comprehensive studies are needed to determine which anastomosis method is best for each individual under various conditions.

In conclusion, the PGt method may help to reduce the rates of POPF. We propose that our PGt method may be a promising technique for pancreaticoenteric anastomosis after more comprehensive evaluation in a larger series.

CONFLICTS OF INTEREST

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

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