ORIGINAL ARTICLE

Comparison of Modified Blumgart pancreaticojejunostomy and pancreaticogastrostomy after pancreaticoduodenectomy

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Abstract

Background: The aim of this study was to compare perioperative outcomes after Blumgart pancreaticojejunostomy (PJ) and pancreaticogastrostomy (PG) for pancreatic-enteric reconstruction following pancreaticoduodenectomy.

Methods: Data of patients undergoing Blumgart PJ and PG were retrieved from prospectively-collected database. Matched patients in each surgical groups were included based on the Callery risk scoring system for clinically relevant postoperative pancreatic fistula (CR-POPF) (grades B and C). Surgical parameters and risks were compared between these two groups.

Results: A total of 206 patients undergoing PD were included. Blumgart PJ was associated with shorter postoperative hospital stay (median (range) 25 (10–99) vs. 27 (10–97) days, $P = 0.022$). There was no surgical mortality in the Blumgart PJ group, but a 4.9% perioperative mortality in the PG, $P = 0.030$. The CR-POPF by Blumgrt PG is significantly lower than that by PG for overall patients (7% vs. 20%, $P = 0.007$), especially for those in intermediate fistula risk zone (6% vs. 21%, $P = 0.048$) and high fistula risk zone (14% vs. 47%, $P = 0.038$).

Conclusions: Blumgart PJ is superior to PG in terms of pancreatic leakage and surgical mortality. Blumgart PJ can be recommended for pancreatic reconstruction after PD for all pancreatic remnant subtypes.

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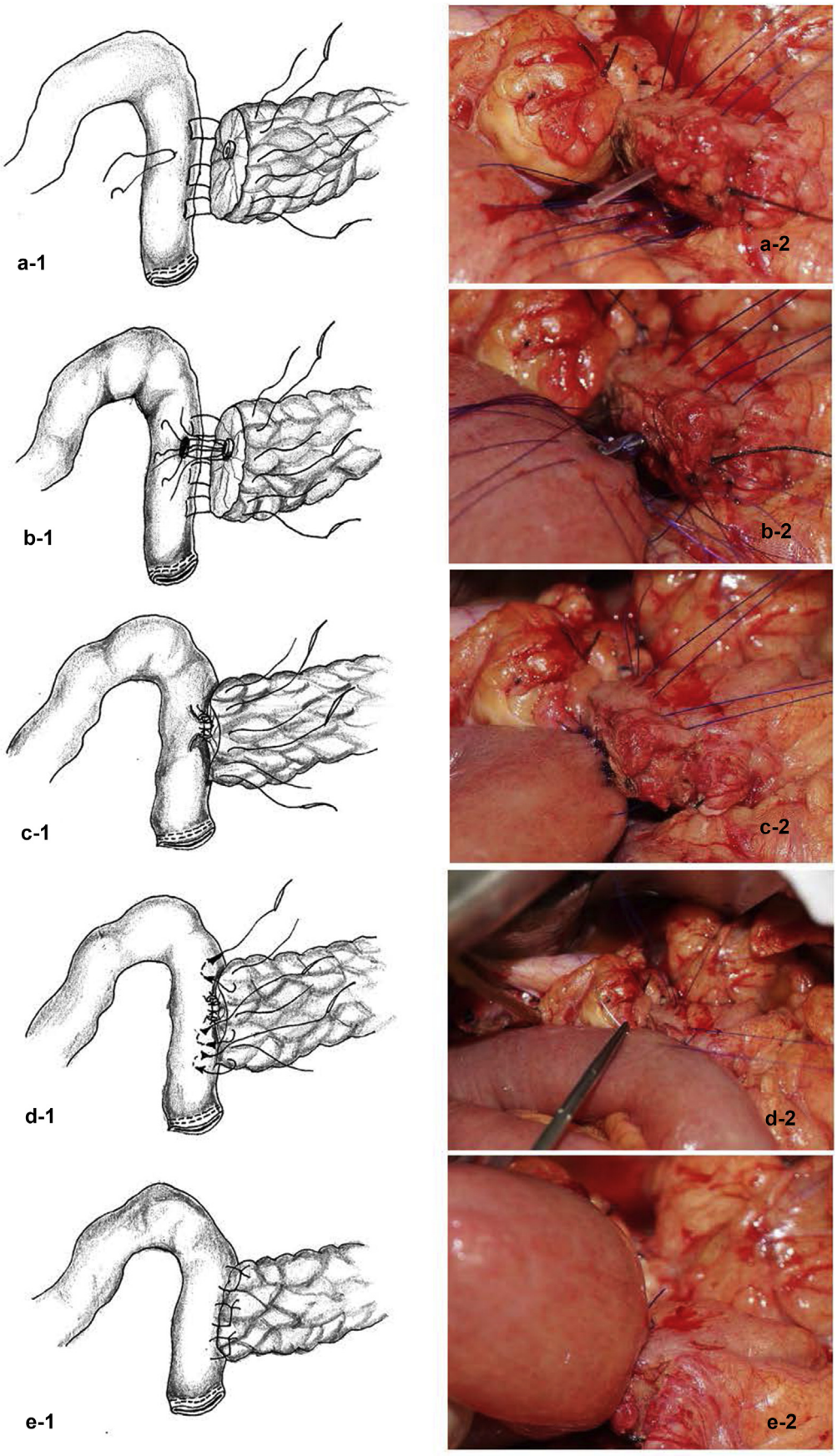
Introduction

Despite improvements in perioperative outcomes following pancreaticoduodenectomy (PD), morbidity remains as high as 30–50%.[1–3] Most morbidity relate to failure of the pancreatic anastomosis resulting in intraabdominal hemorrhage, intra-abdominal abscess, prolonged hospital stay, or occasional mortality. In the effort to prevent postoperative pancreatic fistula (POPF), numerous modifications of the pancreatic reconstruction after PD have been described.[4] However, there is currently no universally accepted standard technique for pancreatic reconstruction after PD.

In recent meta-analyses of randomized controlled trials, pancreaticogastrostomy (PG) has been shown to be associated with lower rate of POPF after PD as compared with pancreaticojejunostomy (PJ).[5–8] Blumgart has described a simple and effective PJ which combined the principle of duct-to-mucosa anastomosis with jejunal covering over the raw surface of the pancreas.[1,4,9] The Blumgart PJ involves placement of 3–6 transpancreatic and jejunal seromuscular U-sutures to approximate the pancreas stump and the jejunum. The Blumgart PJ has been reported to decrease the pancreatic fistula rate to 4.3–6.9%, significantly lower than the 10–20% of other techniques.[1,2,4,10] However, the POPF rate will vary depending on the definition of POPF and frequency of high risk pancreatic remnants as previously described by Callery *et al.*[11]

Bor-Uei Shyr and Yi-Ming Shyr contributed equally to this work.



The aim of this study was to compare perioperative outcomes between matched patients undergoing Blumgart PJ and PG based on the Callery risk score[11] for predicting POPF by the same pancreatic team in the same institute.

Materials and methods

Data of patients with periampullary lesions undergoing Blumgart PJ and PG after PD were retrieved from a prospectively-collected computer database from 2005 to 2014. This study was proved by the Institute Review Board. A standard resection without extensive retroperitoneal lymph node dissection was performed for all patients. The execution of a classic PD with either limited antrectomy or pylorus-preserving resection was decided upon by the surgeon. Octreotide was not used perioperatively. PG had been the procedure of choice for pancreatic reconstruction after PD at the authors institute since 1997.[12] In 2012, this was replaced with the Blumgart PJ. All the procedures were performed by or under the supervision of one of two experienced pancreatic surgeons, Shyr YM and Wang SE. For each patient who underwent a Blumgart PJ, a randomly matched patient was included in PG group in terms of pancreatic parenchyma, pancreatic duct, blood loss and underlying pathology based on the Callery risk scoring system[11] for predicting clinically relevant postoperative pancreatic fistula (CR-POPF) (grades B and C). The demographics, intraoperative variables and outcomes were compared between these two groups.

In the Blumgart PJ group, a pancreatic stump of only about 1–2 cm was freed from the splenic artery and vein. Blumgart PJ (Fig. 1) was constructed using 3 or 4 transpancreatic U-sutures with 3-0 monofilament synthetic absorbable sutures made of polydioxanone (PDS™), with 1 or 2 placed cranial and 2 caudal to the pancreatic duct. The jejunal limb was brought in a retrocolic fashion to the right of the middle colic vessels. The U-sutures, as the outer row, were placed about 1 cm distal to the transected edge of the pancreas and went through the whole pancreas parenchyma from front to back. A seromuscular bite with horizontal mattress, instead of a 2 vertical mattress described in the original Blumgart PJ[4] over the jejunum near the mesenteric edge was taken as the posterior outer layer, and the same suture reverted back to front through the whole pancreas again to complete the U suturing, about 5 mm away from the initial entry point of the suture into the pancreas. Each of the U-sutures was placed at a distance of 5–8 mm to the next one. These sutures with needles on them were not tied at this time, but instead were left loose and kept separately and held with clamps until all of the inner duct-to-mucosa sutures were placed and tied. After creating a small hole on the jejunum opposite the location of the pancreatic duct opening, a series of simple interrupted sutures with 4-0 absorbable synthetic monofilament suture made of polydioxanone (MonoPlus®) were then carefully and accurately placed for duct-to-mucosa anastomosis. These inner sutures were pre-set without tying and organized in order, usually 6 sutures for a non-dilated pancreatic duct and 8 for a dilated pancreatic duct. Once all duct-to-mucosal sutures were placed, the pancreas and the jejunum were approximated by parachuting the pancreas and the jejunum together along both the outer PDS and inner MonoPlus sutures. After the duct-to-mucosal sutures were tied, the outer anterior horizontal mattress sutures on the jejunum using previously held U-sutures were completed and tied one-by-one on the anterior surface of the pancreas. Thus, the pancreatic remnant was completely covered and compressed by jejunal serosa. Pancreatic duct stents were not routinely used except for a small pancreatic duct using a short internal stent.

For PG reconstruction, the proximal 3–4 cm of the pancreatic remnant was freed from the splenic vein and retroperitoneum. The pancreatic stump was anastomosed and invaginated into the posterior wall of the low body of the stomach. PG was performed with interrupted two-layer sutures, with 3-0 silk for the outer layer placed between the pancreatic capsule and seromuscular layer of the posterior gastric wall, and 3-0 polyglactin (Vicryl; Ethicon, Inc., Somerville, NJ, USA) for the inner layer placed between the cut edge of the pancreas and the full thickness of the posterior gastric wall. No pancreatic duct stent was used in the PG.

The clinically relevant postoperative pancreatic fistula (CR-POPF) included grade B or C postoperative POPF based on the definition of the International Study Group on Pancreatic Fistula (ISGPF).[13] Intraabdominal bleeding was defined as the post-pancreatectomy hemorrhage proposed by the International Study Group of Pancreatic Surgery (ISGPS).[14] Gastric atonia included grade B or C delayed gastric emptying according to consensus definition by ISGPS.[15] Surgical mortality was defined as perioperative death within the first 30 days following surgery or during the original hospital stay if longer than 30 days.

Statistical analyses were performed using Statistical Product and Service Solutions (SPSS) version 21.0 software (SPSS Inc., IBM, Armonk, NY, USA). All continuous data were presented as median (range) and mean ± standard deviation (SD), and frequencies were presented when appropriate to the type of data.

Figure 1 Modified Blumgart pancreaticojejunstomy. (a-1 and a-2) Pre-set outer layer U-sutures for transpancreatic and posterior horizontal mattress suturing on jejunum without tying to allow a room for easy, accurate and reliable placement of inner layer interrupted sutures; (b-1 and b-2) Pre-set inner layers interrupted sutures for duct-to-mucosa anastomosis; (c-1 and c-2) Tied and completed inner layer sutures for duct-to-mucosa anastomosis; (d-1 and d-2) Outer layer U-sutures for anterior horizontal mattress suturing on jejunum; (e-1 and e-2) Tied and completed outer layer U-sutures

Mean values of continuous variables were compared with a 2-tailed Student's *t* test. Non-parametric statistical tests were used if the variables did not follow normal distribution. Categorical variables were presented as numbers and percentages. Categorical variables were compared using Pearson's χ^2 test or Fisher's exact test contingency tables. For all analyses, a *P* value less than 0.050 was considered statistically significant.

Table 1 Demographics of patients undergoing pancreaticoduodenectomy

Variable	Total (%)	Blumgart PJ[a] (%)	PG[b] (%)	*P* Value
n	206	103	103	
Gender				0.484
Male	112 (54)	59 (57)	53 (52)	
Age, y/o				0.533
Median	65 (27–90)	65 (30–87)	66 (27–90)	
Mean ± SD	64 ± 13	65 ± 12	63 ± 15	
Primary tumor origin				0.795
Pancreatic head adenocarcinoma	66 (32)	36 (35)	30 (29)	
Ampullary adenocarcinoma	65 (32)	34 (33)	31 (30)	
Distal CBD[c] adenocarcinoma	20 (10)	11 (11)	9 (9)	
Duodenal adenocarcinoma	7 (3)	3 (3)	4 (4)	
IPMN[d]	14 (7)	6 (6)	8 (8)	
NEC[e]	1 (1)	0	1 (1)	
NET[f]	3 (2)	1 (1)	2 (2)	
Other benign	9 (4)	5 (5)	4 (4)	
Chronic pancreatitis	10 (5)	4 (4)	6 (6)	
Others	11 (5)	3 (3)	8 (8)	
Duration of symptom, month				0.994
Median	1 (0–60)	0.8 (0–27)	1 (0–60)	
Symptom				
No symptom	14 (7)	5 (5)	9 (9)	0.407
Jaundice	129 (63)	66 (645)	63 (62)	0.773
Epigastric pain	88 (43)	47 (46)	41 (40)	0.481
Body weight loss	63 (31)	39 (38)	24 (24)	0.034
Nausea/vomiting	50 (24)	25 (24)	25 (25)	1.000
Gastrointestinal bleeding	13 (6)	6 (6)	7 (7)	0.783
Diabetes Mellitus	44 (22)	22 (21)	22 (22)	1.000

[a] PJ: pancreaticojejunostomy.
[b] PG: pancreaticogastrostomy.
[c] CBD: common bile duct.
[d] IPMN: intraductal papillary mucinous neoplasm.
[e] NEC: neuroendocrine carcinoma.
[f] NET: neuroendocrine tumor.

Results

There were a total of 206 periampullary lesions undergoing PD during study period, with 103 (50%) in each group. Demographics and presentation are shown in Table 1.

Intraoperative variables, histology and postoperative outcomes by pancreatic reconstruction technique are shown in Table 2. Subtype CR-POPF (grades B and C pancreatic fistula) rates by anastomosis type are listed in Table 3 based on the Callery risk scoring system.[11]

Discussion

Failure of pancreatic anastomosis has been the Achilles heel of PD, and POPF is the leading cause of morbidity and mortality after PD. The incidence of POPF is still unsatisfactorily high, at 10%–20% after PD, even in high-volume centers.[1,2,4,10] Currently, there are two major variants of pancreatic reconstruction after PD, PJ and PG.

A novel technique, Blumgart PJ has recently begun to attract attention with low rates of pancreatic leakage, morbidity and mortality.[2–4,9] The theoretical advantages of Blumgart PJ include the following: (i). Blood flow to the pancreatic stump is not

Table 2 Surgical variables and outcome by reconstruction method following pancreaticoduodenectomy

Variable	Total (%)	Blumgart PJ[a] (%)	PG[b] (%)	*P* Value
n	206	103	103	
Operation time, hours				0.213
Median	7 (3–16)	7 (4–16)	7 (3–13)	
Mean ± SD[c]	7 ± 7	7 ± 2	7 ± 2	
Hospital stay, day				0.022
Median	26 (10–99)	25 (10–99)	27 (10–97)	
Mean ± SD[c]	31 ± 17	28 ± 14	34 ± 20	
Surgical mortality	5 (2)	0	5 (5)	0.030
Surgical morbidity	107 (52)	50 (49)	57 (55)	0.403
Gastric atonia, grade B and C	28 (14)	12 (12)	16 (16)	0.543
PPH[d], grade B and C	4 (2)	1 (12)	3 (3)	0.621
Gastrointestinal bleeding	1 (1)	0	1 (1)	1.000
Intraabdominal abscess	8 (4)	2 (2)	6 (6)	0.353
Wound infection	8 (4)	5 (5)	3 (3)	0.462
Chyle leakage	14 (7)	8 (8)	6 (6)	0.783
Bile leakage	1 (1)	1 (1)	0	1.000

[a] PJ: pancreaticojejunostomy.
[b] PG: pancreaticogastrostomy.
[c] SD: standard deviation.
[d] PPH: post-pancreaticoduodenectomy hemorrhage.

Table 3 Incidence of clinically relevant postoperative pancreatic fistula (CR-POPF) based on Callery risk scoring system by reconstruction method following pancreaticoduodenectomy

Variable	Callery risk score[11]	Total (%)	Blumgart PJ[a] (%)	PG[b] (%)	*P* Value
n		206	103	103	
Overall		28 (14)	7 (7)	21 (20)	0.007
Pancreas parenchyma					
Firm (n = 86)	0	5 (6)	1/44 (2)	4/42 (10)	0.197
Soft (n = 120)	2	23 (19)	6/59 (10)	17/61 (28)	0.019
Pathology					
Pancreatic adenocarcinoma or pancreatitis (n = 76)	0	1 (1)	1/40 (3)	0/36	1.000
Others (n = 130)	1	27 (21)	6/63 (10)	21/67 (31)	0.002
Pancreatic duct diameter, mm					
≥ 5 (n = 70)	0	3 (4)	3/42 (7)	0/28	0.270
4 (n = 26)	1	3 (12)	0/10	3/16 (19)	0.280
3 (n = 37)	2	8 (22)	1/11 (9)	7/26 (27)	0.391
2 (n = 73)	3	13 (18)	3/41 (7)	10/32 (31)	0.012
≤ 1 (n = 1)	4	1 (100)	–	1/1 (100)	N/A
Intraoperative blood loss, mL					
≤ 400 (n = 96)	0	12 (9)	3/49 (6)	9/47 (19)	0.068
401–700 (n = 65)	1	6 (9)	1/27 (4)	5/38 (13)	0.388
701–1000 (n = 31)	2	5 (16)	3/24 (13)	2/7 (29)	0.562
≥ 1000 (n = 14)	3	54 (36)	0/3	5/11 (46)	0.258
Fistula risk zone					
Negligible risk (n = 23)	0	0	0/11	0/12	N/A
Low risk (n = 35)	1–2	1 (3)	1/21 (5)	0/14	1.000
Intermediate risk (n = 108)	3–6	15 (14)	3/50 (6)	12/58 (21)	0.048
High risk (n = 40)	7–10	12 (30)	3/21 (14)	9/19 (47)	0.038

[a] PJ: pancreaticojejunostomy.
[b] PG: pancreaticogastrostomy.

compromised by interrupted transpancreatic mattress U-sutures holding the pancreas in firm opposition to the jejunum; (ii). Duct-to-mucosal sutures can be easily, accurately and meticulously placed before securing the posterior and anterior seromuscular jejunum under a tension-free approximation and excellent visualization of the pancreatic duct; (iii). Tension of the jejunal covering may afford an extra compression on the pancreatic stump and prevent fewer leaks from accessory pancreatic ducts and minor bleeding from the stump; (iv). Transpancreatic, full thickness, mattress U-sutures, instead of tangential sutures, could eliminate tangential tension and shear force at the pancreatic stump, particularly during knot-tying which might cut through the fragile pancreas.[1,3,4,9]

PG has been proposed as an alternative to PJ. A number of theoretical advantages of PG have been suggested including: pancreatic enzyme inactivation due to gastric secretions and absence of enterokinase, tension-free anastomosis due to anatomical co-location, excellent blood supply and the thick stomach wall is less likely to dehisce, early detection of bleeding from the pancreatic remnant by routine postoperative gastric decompression, direct examination of the anastomosis by endoscopy if necessary; and easy exploration of the anastomosis without disassembling the pancreatic anastomosis by opening the anterior wall of stomach if bleeding occurs.[3,16,17]

PG has been claimed to be a better pancreatic reconstruction in reducing the incidence and severity of POPF (Table 4). Four recent meta-analyses based on 8 randomized control trials (RCTs) conclude that POPF rate is significantly lower in PG than that in PJ.[5,7,18] However, many of the original studies did not use the Blumgart PJ and in 4 retrospective studies the PJ seems to have lower incidences of POPF as compared to those achieved in the RCTs. The strength of this study is that it has matched the patients in both groups for risk of CR-POPF. As can be seen by the results of the current study this greatly affects the risk of CR-POPF. Therefore any analysis of the previously published data should take this into account. Studies with higher rates of low risk pancreatic remnants will be underpowered to detect any differences between the anastomotic techniques.

Table 4 Summary of literature reports for clinically significant postoperative pancreatic fistula (CR-POPF) after pancreaticoduodenectomy

Literature	Year	n	Blumgart PJ[a] %	PG[b] %	PJ[a] %	*P* Value
Meta-analysis for RCTs[c]						
Menahem B *et al*.[7]	2015	PG = 562 PJ = 559		11	19	<0.001
Hallet J *et al*.[5]	2015	PG = 339 PJ = 337		8	20	<0.001
Que W *et al*.[18]	2015	PG = 384 PJ = 382		9	17	<0.001
Liu FB *et al*.[6]	2015	PG = 562 PJ = 559		11	21	<0.001
Randomized control trials						
Nakeeb AE *et al*.[19]	2014	PG = 45 PJ = 45		16	9	NS[d]
Topal B *et al*.[20]	2013	PG = 162 PJ = 167		8	20	0.002
Figueras J *et al*.[21]	2013	PG = 65 PJ = 58		11	33	0.006
Wellner UF *et al*.[22]	2012	PG = 59 PJ = 57		11	33	NS[d]
Fernandez-Cruz L *et al*.[23]	2008	PG = 53 PJ = 55		4	18	<0.01
Duffas JP *et al*.[24]	2005	PG = 81 PJ = 68		16	20	NS[d]
Bassi C *et al*.[25]	2005	PG = 69 PJ = 51		13	16	NS[d]
Yeo CJ *et al*.[26]	1995	PG = 73 PJ = 72		12	11	NS[d]
Blumgart PJ[a] studies						
Fujii T *et al*.[2]	2014	B-PJ[e] = 120 PJ = 120	3		36	<0.001
Mishra PK *et al*.[9]	2011	B-PJ[e] = 98	7			
Grobmyer SR *et al*.[4]	2010	B-PJ[e] = 187	7			
Kleespies A *et al*.[1]	2008	B-PJ[e] = 90 PJ = 92	4		13	0.032
Present study	2015	B-PJ[e] = 103 PG = 103	7	20		0.007

[a] PJ: pancreaticojejunostomy.
[b] PG: pancreaticogastrostomy.
[c] RCTs: randomized controlled trials.
[d] NS: not significant.
[e] B-PJ: Blumgart pancreaticojejunostomy.

Ideally, an "optimal" technique for the pancreatic anastomosis should be associated with a zero rate of POPF regardless of pancreatic texture and ductal size, and, further, should be easily performed and taught. The Blumgart PJ seems to partially meet these criteria in terms of outcomes and is easily performed and taught. With the Blumgart PJ only a 1- to 2-cm free pancreatic stump is needed as opposed to a 3- to 4-cm free pancreatic stump for PG reconstruction. Moreover, only 3 or 4 transpancreatic U-sutures are used for the Blumgart PJ anastomosis, instead of the multiple tangential sutures needed for PG. Critically, the Blumgart PJ seemed to have a greater effect reducing POPF as the risk increased.

In conclusion, this single-institution matched historical control study has shown that Blumgart PJ appears to be superior to PG in reducing the incidence and severity of CR-POPF. CR-POPF and surgical mortality were significantly lower in the Blumgart PJ group compared to the PG group, irrespective of texture of pancreatic parenchyma and size of pancreatic duct, and underlying pathology. Blumgart PJ can therefore be recommended as a fast, simple and safe alternative for pancreatic reconstruction after PD.

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Conflicts of interest
None declared.

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