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Blumgart's technique of pancreaticojejunostomy: Analysis of safety and outcomes

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ABSTRACT

Background: Blumgart's pancreaticojejunostomy (PJ) has been described with low pancreatic leak rates. This study aimed to evaluate our experience with this technique regarding the pancreatic leak and other perioperative outcomes.

Methods: We performed a single-center retrospective analysis of a cohort of 81 patients who underwent pancreaticoduodenectomy in our department from January 2011 to February 2018. The primary endpoint was the occurrence of a clinically relevant postoperative pancreatic fistula (CR-POPF) and analysis of its risk factors.

Results: The CR-POPF rate was 12.3%. Fistula risk score (FRS) was the only significant risk factor for the occurrence of overall POPF in multivariate analysis. However, none of the other factors including FRS was found to be significantly associated with CR-POPF risk. A strong positive correlation was found between the CR-POPF and the incidence of delayed gastric emptying, post-pancreatectomy hemorrhage and increased length of hospital stay.

Conclusion: Blumgart's technique is a safe technique of pancreatico-enteric anastomosis with low rates of CR-POPF. CR-POPF with this technique is independent of most of the preoperative and intraoperative factors. Therefore, this technique can be used for all types of the pancreas with consistently good results.

Introduction

Pancreaticoduodenectomy (PD) is the standard surgical procedure for pancreatic and periampullary malignancy [1,2]. There have been more than 70 technical modifications in PD since its first description in 1937 [2–4]. The mortality has decreased drastically in last 4 decades to less than 2%–3% in high-volume centers. Morbidity, however, has changed very little and remains around 30%–50% in most of the centers [5–7]. The substantial improvement in mortality is related directly to improved patient selection, better perioperative management, and to the availability of better radiological interventions facilities to tackle postoperative complications [8].

Pancreatic anastomosis is considered as the Achilles' heel of the PD. Pancreatic anastomotic leak termed as postoperative pancreatic fistula (POPF) with subsequent secondary complications [post-pancreatectomy hemorrhage (PPH), abscess with sepsis, and delayed gastric emptying (DGE)] is the primary reason for persistently high morbidity [9]. Many modifications of pancreaticoenteric anastomosis with pharmacological and other interventions have been described in an attempt to reduce the POPF rates although currently, no specific technique can eliminate the development of clinically relevant postoperative pancreatic fistula (CR-POPF) [10]. One of the recently described techniques of pancreaticojejunostomy (PJ) is the Blumgart's technique that has shown promising results in very few studies reported so far. These studies have shown lower rates of CR-POPF (2.5%–10%) [5,7,11–17].

Hereby, we report our 7 years' experience with this technique of PJ with the aim to evaluate its impact on the incidence of POPF and other perioperative outcomes.

Methods

A retrospective analysis of 105 patients who underwent PD at our center from January 2011 to February 2018 was performed from a prospectively maintained database. Out of 105 patients, PJ was done using Blumgart's technique in 82 patients and this constituted the study cohort. Dunking PJ and pancreaticogastrostomy (PG) were done in remaining patients (23/105) with soft pancreas

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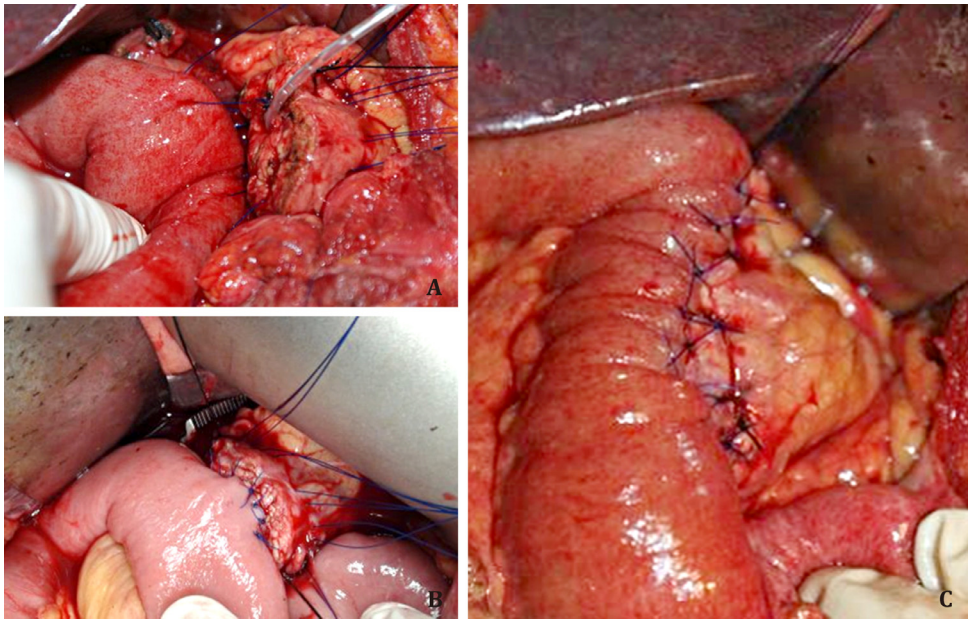

Fig. 1. Blumgart's technique of pancreaticojejunostomy. (**A**) transpancreatic "U" sutures passing through seromuscular layer of jejunum; (**B**) completed duct to mucosa anastomosis; (**C**) completed anastomosis with anterior jejunal seromuscular sutures.

and/or small duct as per the operating surgeon's discretion. One patient was excluded from analysis due to R2 resection. Standard PD with single loop reconstruction was used in these patients as per the unit practice. All patients were optimized before surgery for nutrition, sepsis control, preoperative biliary drainage for cholangitis and high serum bilirubin levels (>15 mg/dL) and optimization of cardiac and pulmonary functions.

Surgical technique of Blumgart's PJ

Blumgart's technique of PJ (Fig. 1) was performed as described by Grobmyer and co-workers [5,7,11]. After the resection of pancreatic head, the main pancreatic duct was identified. The pancreas was mobilized for 1–2 cm circumferentially. Transpancreatic U sutures were taken through the pancreas on both sides of the duct using polypropylene 3–0. Each stitch started from the anterior surface of the pancreas, going from anterior to posterior about 1 cm away from the transected edge of the pancreas, then a seromuscular bite was taken on the posterior wall of the jejunum, followed by transpancreatic pass back-forth so that both the ends of these U sutures remain on the anterior surface of pancreas. Four to five such sutures were required to cover the entire width of the pancreas. They were retained to be tied later. Pancreatic duct was then assessed and duct-to-mucosa anastomosis was completed using 4–0 or 5–0 polypropylene interrupted sutures with an internal stent to facilitate suture placement. The U sutures were then tied on the anterior surface of the pancreas, and the anterior layer was completed by taking a seromuscular bite on the anterior wall of the jejunum and tying each one of them thus covering the anterior cut edge of the pancreas.

Postoperative management

The drain output was measured and documented every day. Drain fluid amylase was routinely obtained on postoperative day (POD) 1 and POD 3 and if required on POD 5 and POD 7. The drains were removed when the output was less than 50 mL, serous in character and the fluid amylase was normal. Octreotide was administered routinely in all the patients (100 μg subcutaneously 3 times per day for 5 days). The nasogastric tube was removed on or after POD 1 when the output was less than 200 mL and urinary catheter removed on POD 2 or POD 3. Enteral feeding via intraoperatively placed feeding jejunostomy (FJ) was started routinely on POD 1 and escalated as per tolerance. Later, with the increase in oral diet, the jejunostomy feeds were reduced.

Data collection

The postoperative outcome of these 81 patients was analyzed for operative time, blood loss, pancreatic texture, main pancreatic duct size, POPF, fistula risk score (FRS), post-pancreatectomy hemorrhage (PPH), delayed gastric emptying (DGE), Clavien–Dindo morbidity grade and postoperative hospital stay.

Postoperative morbidity was classified as per Clavien–Dindo definition [18]. International Study Group of Pancreatic Surgery (ISGPS) definitions for standard PD, POPF, DGE, and PPH were followed [19–22]. With the recent modification of POPF definition and grading criteria, grade A POPF was reclassified as "biochemical leak" (BL) and grade B or grade C POPF was considered to be CR-POPF [23]. Postoperative mortality was defined as deaths after surgery during hospital stay or within 30 days after surgery. FRS was also calculated as described earlier based on main pancreatic duct size, pancreatic consistency, type of periampullary malignancy and intraoperative blood loss [24]. Other parameters analyzed were age, preoperative bilirubin, preoperative albumin, presence or absence of cholangitis, the status of preoperative biliary stenting, and type of malignancy.

Outcome measures

The primary endpoint was the occurrence of a CR-POPF and analysis of risk factors for CR-POPF. The secondary endpoints were postoperative morbidity and its association with CR-POPF.

Statistical analysis

SPSS version 22.0 software (SPSS Inc., IBM, NY, USA) was used for all statistical analyses. Continuous variables were expressed as the mean ± standard deviation (SD) or a median (range). Student's *t*-test was used for comparing mean. Predictive factors for CR-POPF

were identified by the univariate and multivariate analyses in stepwise logistic regression model. A P value of <0.05 was considered statistically significant.

Results

Eighty-one patients who underwent PJ by Blumgart's technique were analyzed (Table 1). There were 48 males (59.3%) and 33 females (40.7%) with a mean age of 48.04 years. Cholangitis at presentation was noted in 46.9% patients, and was managed with antibiotics alone (4 patients) and with additional endoscopic biliary drainage (34 patients). Ampullary malignancy was the most common pathology (65.4%), followed by pancreatic head malignancy (18.5%), distal cholangiocarcinoma (8.6%), and duodenal malignancy (4.9%). The mean duration of surgery was 480 ± 138 min and the mean blood loss was 237 ± 138 mL. The average size of pancreatic duct was 4.51 ± 3.00 mm. The median postoperative length of hospital stay was 15 days (range 7–65).

Postoperative complications

Significant postoperative morbidity (Clavien–Dindo grade 3 or more) was seen in 14.8% (12/81) patients and there were 2 mortalities (2.5%) due to respiratory failure and multi-organ dysfunction. Neither of the two patients had documented biochemical or clinical POPF (Table 2).

The most common complications were DGE (46.9%), surgical site infection (39.5%), PPH (13.6%) and CR-POPF (12.3%). Hepaticojejunostomy leak occurred in 2 patients. The overall incidence of POPF (including BL) was 54.3% (44/81), however, only 10 (12.3%) patients developed CR-POPF. Two of CR-POPF patients had concomitant grade C PPH and were re-explored, and the remaining 8 were managed successfully with conservative management. Five patients required re-exploration for PPH (2 of these had concomitant CR-POPF).

Table 1
Demographics of patients with pancreaticojejunostomy by Blumgart's technique (n = 81).

Variables	Data
Age (yr)	48.04 ± 10.14
Sex (male/female)	48/33
Serum bilirubin (mg/dL)	6.65 ± 6.17
<10	60 (74.1%)
≥10	21 (25.9%)
Serum albumin (g/dL)	3.53 ± 0.49
<3.5	38 (46.9%)
≥3.5	43 (53.1%)
Preoperative cholangitis	38 (46.9%)
Preoperative biliary stenting	51 (63.0%)
For cholangitis	34 (42.0%)
For high bilirubin (>15 mg/dL)	17 (21.0%)
Pathology	
Ampullary carcinoma	53 (65.4%)
Pancreas head carcinoma	15 (18.5%)
Distal cholangiocarcinoma	7 (8.6%)
Duodenal carcinoma	4 (4.9%)
Others	2 (2.5%)
Operative time (min)	480 ± 138
Blood loss (mL)	237 ± 138
≤400	72 (88.9%)
401–700	6 (7.4%)
701–1000	2 (2.5%)
>1000	1 (1.2%)
Pancreatic duct size (mm)[a]	4.51 ± 3.00
≤1	2 (2.6%)
1–2	18 (23.1%)
2–3	10 (12.8%)
3–4	16 (20.5%)
≥5	32 (41.0%)
Pancreatic consistency	
Soft	37 (45.7%)
Firm	44 (54.3%)

[a] Records were not available for duct size in 3 patients.

Table 2
Postoperative complications in patients with pancreatoduodenectomy with Blumgart's pancreaticojejunostomy (n = 81).

Variables	Data
Clavien–Dindo grade	
Grade 1	39 (48.1%)
Grade 2	30 (37.0%)
Grade 3	8 (9.9%)
Grade 4	2 (2.5%)
Grade 5	2 (2.5%)
Surgical site infections	32 (39.5%)
POPF	44 (54.3%)
Biochemical leak (BL) only	32 (39.5%)
CR-POPF (grade B + grade C)	10 (12.3%)
Grade B	7 (8.6%)
Grade C	3 (3.7%)
PPH	11 (13.6%)
Grade A	4 (4.9%)
Grade B	4 (4.9%)
Grade C	3 (3.7%)
DGE	38 (46.9%)
Grade A	22 (27.2%)
Grade B	13 (16.0%)
Grade C	3 (3.7%)

POPF: postoperative pancreatic fistula; CR-POPF: clinically relevant postoperative pancreatic fistula; PPH: post-pancreatectomy pancreatic hemorrhage; DGE: delayed gastric emptying.

Table 3
Univariate and multivariate analysis of various factors in relation to POPF (BL + grades B and C).

Variables	Univariate analysis		Multivariate analysis	
	Odds ratio	P value	Odds ratio	P value
Preoperative biliary stenting	1.27	0.60	3.01	0.13
Operative blood loss	0.44	0.24	0.19	0.24
Cancer type	0.44	0.15	0.29	0.17
Preoperative cholangitis	2.16	0.06	1.51	0.45
Fistula risk zone	0.25	**<0.001**	0.55	0.45
Pancreatic consistency	0.25	**<0.001**	1.31	0.79
Fistula risk score	0.64	**<0.001**	0.55	**0.04**
Preoperative albumin	1.38	0.48	0.48	0.26
Preoperative serum bilirubin	1.01	0.81	1.00	0.99
Size of main pancreatic duct	1.32	**0.03**	1.04	0.81

POPF: postoperative pancreatic fistula; BL: biochemical leak.

Predictive factors for POPF

Various preoperative and intraoperative parameters were evaluated in relation to POPF (BL + Grade B + Grade C) and CR-POPF by univariate and multivariate analyses (Tables 3 and 4). Analysis of various risk factors revealed that small main pancreatic duct diameter, soft pancreatic consistency, fistula risk zone, and FRS had a significant influence on the occurrence of POPF (BL+ Grade A and Grade B) in univariate analysis. Multivariate analysis showed that only FRS was the significant risk factor for the occurrence of POPF (Odds ratio = 0.55, P = 0.04). However, none of these factors including FRS was found to be significantly associated with CR-POPF risk. Therefore, the safety of Blumgart's technique of PJ in terms of CR-POPF is independent of these risk factors and hence, Blumgart's technique can be used in all such cases.

Impact of POPF on postoperative morbidity

CR-POPF was found to increase the postoperative morbidity and prolong the postoperative hospital stay (Table 5). The median hospital stay was prolonged from 13 days in patients with no fistula

Table 4
Univariate and multivariate analysis of various factors in relation to CR-POPF.

Variables	Univariate analysis		Multivariate analysis	
	Odds ratio	*P* value	Odds ratio	*P* value
Preoperative biliary stenting	0.64	0.53	0.84	0.83
Operative blood loss	1.41	0.57	1.00	0.82
Cancer type	0.17	1.00	0.98	0.99
Preoperative cholangitis	1.40	0.54	0.27	0.06
Fistula risk zone	1.83	0.24	1.25	0.84
Pancreatic consistency	2.10	0.28	1.24	0.83
POPF fistula risk score	1.15	0.37	1.24	0.38
Preoperative serum albumin	0.32	0.12	0.61	0.65
Preoperative serum bilirubin	1.00	0.97	0.97	0.65
Size of main pancreatic duct	0.88	0.50	1.09	0.72

POPF: postoperative pancreatic fistula; CR-POPF: clinically relevant postoperative pancreatic fistula.

Table 5
Correlation of CR-POPF with postoperative morbidity and hospital stay.

Correlation	Factors	*r*	*P* value
CR-POPF	Post-pancreatectomy hemorrhage	0.383	**<0.001**
	Delayed gastric emptying	0.269	**0.014**
	Clavien–Dindo grade	0.331	**0.002**
	Hospital stay	0.499	**<0.001**

CR-POPF: clinically relevant pancreatic fistula.

or biochemical leak (16 days) to 33 days in CR-POPF group ($P = 0.0002$). A strong positive correlation was found between the CR-POPF and the incidence of both DGE and PPH, suggesting a significant impact of CR-POPF on the occurrence of these secondary complications.

Discussion

Advancements in the perioperative care (i.e. improved imaging, better patient selection, standardized surgical procedures, improved postoperative care, better intensive care and radiological interventions, and efficient management of sepsis) have brought down the mortality rates following PD to less than 2%–3% in high-volume specialized centers [25].

Most of the preoperative factors like preoperative bilirubin and albumin, the presence of infection, cardiopulmonary and renal functions can be optimized prior to the definitive treatment in an attempt to improve postoperative outcome [26]. Despite optimization, the morbidity rate following PD still approaches 30%–50% in most of the series [5]. A major contributor of this high morbidity is the pancreatico-enteric anastomotic leak [9]. CR-POPF remains the most troublesome complication after PD as often it leads to potentially life-threatening secondary complications [10], and also has been strongly linked with mortality after PD [5,8].

The primary reason for pancreatico-enteric anastomosis to be of major concern is that this anastomosis is created between a hollow organ and a solid organ. Moreover, various digestive enzymes like proteases present in the pancreatic juice adversely affect the healing process [27].

A search for an ideal technique of pancreatico-enteric anastomosis with zero or minimal POPF rate is yet to over. Various techniques of pancreatico-enteric anastomosis have been described with variable results [10]. No clear consensus has been reached despite multiple trials comparing diverse pancreatico-enteric anastomosis techniques and other strategies like pancreatic duct stenting, somatostatin analogues, etc [10]. The common techniques of pancreatico-enteric reconstruction include invagination or dunking (end-to-side/end-to-end), duct-to-mucosa (Cattell–Warren), binding technique of PJ, and PG [7,8,10,28–31]. Despite all these variations, the rate of CR-POPF is still unsatisfactorily high, at about 10%–15% after pancreatic head resection even in high-volume centers. A recent review found no significant difference in POPF rate between different pancreatic anastomosis techniques [32]. Common risk factors in all these techniques might be the fact that the sutures pass tangentially through the pancreatic capsule during anastomosis and excessive shear forces during knot tying may cut through the parenchyma contributing to pancreatic juice leak [14].

Initial studies have reported lower CR-POPF rates with Blumgart's technique of PJ [5,7,12–17]. In this technique, tangential shear force is avoided by using transpancreatic U sutures. In addition, these transpancreatic buttress sutures take care of the minor ducts and prevent minor bleeding from the pancreatic stump, interrupted suturing preserves the blood supply to the anastomotic area, and the jejunal wrapping prevents the peripheral leaks, especially posterior leaks which are ominously associated with life-threatening PPH. This method works equally well for the soft or firm pancreas. These theoretical assumptions seem to be working as evident by the low CR-POPF rates (2.5%–10.3%) in recent series of Blumgart's PJ (Table 6). Only one randomized trial has

Table 6
Comparison of published series with Blumgart's technique of pancreaticojejunostomy.

Studies	PJ technique (*n*)	Overall complications[a]	Postoperative morbidity (Clavien–Dindo grade 3 or more)	POPF (BL+ grades B and C)	CR-POPF	PPH (grades B and C)	DGE (grades B and C)	Re-explorations	Mortality	Hospital stay (d, median, range)
Mishra et al. [5]	Blumgart (98)	39.8%[b]		15.6%	7.1%	5.1%	3.1%	5.1%	3.1%	13 (6–41)
Grobmyer et al. [7]	Blumgart (187)			20.3%	6.9%	3.2%		5.3%	1.6%	10 (7–58)
Hirche et al. [12]	Blumgart (133)	6%[c]		15.8%	5.3%	1.8%		5.3%	1.5%	17 (10–120)
Wang et al. [13]	Modified Blumgart (103)	49.0%[d]			7.0%	1.2%	12.0%		0	25 (10–99)
Kleespies et al. [14]	Modified Blumgart (92)	28.0%[b] 15.0%[d]			4.0%	3.3%		7.0%	3.3%	15 (7–101)
Fujii et al. [15]	Modified Blumgart (120)	26.0%[b]			2.5%	0	2.0%	1.0%	0	24 (12–60)
Hirono et al. [16]	Modified Blumgart (107)	42.9%[b]	17.8%	32.7%	10.3%	0.9%		1.9%	0	15 (8–52)
Wang et al. [17]	Modified Blumgart (178)		4.1%		9.6%	2.8%	10.1%		0	24 (9–136)
Present study	Blumgart (81)	51.8%[b]	14.8%	54.3%	12.3%	8.6%	19.7%	6.2%	2.5%	15 (7–65)

PJ: pancreaticojejunostomy; POPF: postoperative pancreatic fistula; CR-POPF: clinically relevant pancreatic fistula; BL: biochemical leak; DGE: delayed gastric emptying; PPH: post-pancreatectomy hemorrhage.

[a] Overall complications were defined as any postoperative surgical (surgical site infection, DGE, PPH, CR-POPF, HJ leaks) or general (systemic) complication like pulmonary, cardiac complications and others. Some patients had plural complications.

[b] Overall morbidity.

[c] Anastomotic failure excluded.

[d] Surgical complications.

evaluated the modified Blumgart mattress suture technique during PJ and found no differences in the occurrence of CR-POPF between the modified Blumgart mattress suture group and the interrupted suture group [16]. CR-POPF rate was 12.3% in our series which is slightly higher than these reports. This may be because of predominant ampullary tumors in the current series and because five different surgeons performed PJ.

Recently, PG has garnered a lot of interest among the pancreatic surgeons, citing potential advantages like lack of activation of pancreatic enzymes in the acidic medium of the stomach, close proximity of the stomach to the pancreas avoiding tension at the anastomosis and remarkable vascularity of the stomach that may lead to lower POPF. However, such theories were never proven clearly in well-designed trials [10]. Few trials and systematic reviews have demonstrated the superiority of PG over PJ in terms of anastomotic leak [29,30]. However, in most of these trials, the technique used for PJ reconstruction was not Blumgart's technique. In a recent study by Wang et al. [13], PJ with modified Blumgart's technique was compared with a matched group of patients with reconstruction using PG. This study has shown the superiority of PJ with modified Blumgart's technique over PG in terms of pancreatic leak (CR-POPF 7% vs. 20%, $P = 0.007$), hospital stay (median 25 vs. 27 days, $P = 0.022$), and postoperative mortality (0% vs. 5%, $P = 0.030$). Prospective randomized trials comparing PG (with standardized technique) with Blumgart's PJ are needed to find out the better technique to reduce CR-POPF.

Use of stents to bridge the anastomosis has remained debatable. The proponents of stenting state that it protects the anastomotic site to come in direct contact with the pancreatic juice, thus promoting healing. Recently, external stenting has been shown to significantly reduce fistula rates in various trials and systematic reviews [33]. However, recent Cochrane systematic review has failed to identify convincing direct evidence for the use of stent (internal or external) or the superiority of external over internal stents [34], and this is supported by the current ISGPS consensus statement [10]. In the current study, the internal stent was used at surgeon's discretion mainly to facilitate anastomosis, rather than to avert POPF, and the external stent was used in only 5 cases. The effect of internal or external stenting on POPF was not evaluated in the current study.

Pharmacological intervention with somatostatin analogues (octreotide/pasireotide) have been studied and have been found to reduce the POPF rate but not mortality [10]. We used octreotide in all patients though this can be used selectively in patients with high risk of POPF.

Pancreatic leak negatively affects the postoperative outcomes. Grade A fistula has recently been renamed as "biochemical leak" as it does not alter the postoperative course [23]. In grade B fistula, there is a clinically relevant change in the management of the patient. There can be a persistent leak for >3 weeks, or radiological intervention is required to drain collection or control bleeding, and/or sepsis may be present without organ failure leading to a prolonged hospital stay. If the patient requires reoperation for POPF, or develops organ failure or expires due to POPF, then it is considered as grade C fistula. In our study, overall fistula rate was quite high (54.3%), however, the CR-POPF (grades B and C) occurred in only 12.3% (10/81) which is similar to other published series using different techniques of PJ (Table 7) [35–38], but higher than other reports of Blumgart's technique (Table 6). Jejunal wrap around the pancreatic stump with buttress sutures might be the reason that most of the leaks that occurred remained contained and were minor with no clinical consequence.

Several risk factors for POPF have been evaluated in the literature. The well-known risk factors for CR-POPF include a soft pancreas, small main pancreatic duct diameter (<3 mm), posterior location of main pancreatic duct, underlying disease pathology that does not cause main pancreatic duct dilatation (e.g. bile duct cancer), decreased regional blood supply, intraoperative blood loss, and surgeon's experience [39–43]. Mass in the head of the pancreas induces fibrosis of the gland and causes more dilated main pancreatic duct, more than as found in periampullary tumors, thus making the anastomosis safer, akin to that in chronic pancreatitis [14]. In our study, most of the tumors were located in the ampulla. This may be the reason for relatively high overall fistula rate (BL + CR-POPF), but this did not translate into higher CR-POPF rate as discussed previously.

Table 7
Comparison of clinical relevant POPF rates with various other series with variable techniques of pancreaticojejunostomy.

Studies	*n*	Technique of pancreaticoenteric anastomosis	CR-POPF rates
Pratt et al. [35]	176	Duct-to-mucosa	15%
Reid Lombardo et al. [36]	1507	Duct-to-mucosa (66%) Dunking (33%)	13.2%
Liang et al. [37]	100	Duct-to-mucosa (39%) Dunking (61%)	11%
Fuks et al. [38]	680	PG (50.4%) PJ (49.6%)	10%
Current study	81	Blumgart	12.3%

POPF: post-operative pancreatic fistula; PG: Pancreaticogastrostomy; PJ: Pancreaticojejunostomy.

Many of these risk factors have been combined to formulate a risk score for better stratification and prediction of POPF. The fistula risk score (FRS or the Callery score) is a validated tool for predicting POPF as well as for comparing outcomes of pancreaticoenteric anastomosis across studies [24]. In the current study FRS correlated well with the occurrence of overall POPF (BL + CR-POPF), but could not predict the occurrence of CR-POPF. This lack of correlation might be due to a small number of cases with CR-POPF (only 10).

Besides FRS, none of the other preoperative (albumin level, bilirubin level, prior stenting or cholangitis) or intraoperative factors (soft pancreas, duct <3 mm or blood loss) correlated with the occurrence of overall POPF in multivariate analysis. This is similar to the finding reported by Hirche et al. in their report on the safety of Blumgart's technique [12]. Kleespies et al. also concluded that the type of anastomosis for PJ was the only independent risk factor for a major local or systemic postoperative complication when they compare Blumgart's and Cattell–Warren anastomosis in a heterogeneous patient population of 182 [14]. While comparing modified Blumgart's PJ with Kakita method of PJ, Fujii et al. also found that modified Blumgart's anastomosis was an independent predictor of lower rate of POPF [15]. Given results of others reports and as well as from this study, it appears that Blumgart's anastomosis is independent of possible risk factors (physiological and morphological) for CR-POPF, hence, this technique can be utilized in all situations.

CR-POPF has several potentially serious consequences during the postoperative course. The extravasation of pancreatic juice may cause local inflammation, abscess formation, or vascular erosions leading to variety of complications manifesting as DGE, PPH or sepsis that may become life-threatening. In our study, a strong positive relationship was found between the occurrence of CR-POPF and occurrence of DGE and PPH, and higher overall postoperative morbidity. This is not a new observation, however, it does reconfirm the fact that the pancreatico-enteric anastomosis remains the Achilles' heel of the entire surgical procedure, and it also reemphasizes the need to develop a strategy for a more secure pancreaticoenteric anastomosis or any other adjunct that can significantly reduce the CR-POPF rates.

There are certain limitations of this study. Being retrospective in nature, only those patients who underwent Blumgart's PJ were

included in the study. Patients who underwent other methods of pancreatico-enteric anastomosis (due to the very soft pancreas or non-identification of PD) as per operating surgeon's discretion were excluded from this study leading to difficulty in assessing the role of Blumgart's PJ in this subgroup of patients. In addition, there was no comparison of Blumgart's technique with other technique of anastomosis.

In conclusion, Blumgart's technique of PJ is a safe technique of pancreatico-enteric anastomosis with low CR-POPF rates. CR-POPF with this technique is independent of most of the preoperative and intraoperative risk factors including FRS, and therefore, this technique can be applied to all types of the pancreas with consistently good results. The occurrence of CR-POPF correlates with high postoperative morbidity and prolonged hospital stay. A prospective randomized controlled trial is imperative to confirm the safety of this technique, and to establish its place in the armamentarium of pancreatic surgeons.

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Contributors

Vishal Gupta and CA proposed the study. Vishal Gupta, RR, DA and CA wrote the first draft. Vishal Gupta, KS, Vivek Gupta, JP, RR, YRK, DA and CA collected and analyzed the data. All authors contributed to the design and interpretation of the study and to further drafts. Vishal Gupta and CA are the guarantor.

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Ethical approval

This study was approved by the Ethics Committee of King George's Medical University. Written informed consent was obtained before the surgical procedure.

Competing interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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