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ORIGINAL ARTICLE

Does modified Blumgart anastomosis without intra-pancreatic ductal stenting reduce post-operative pancreatic fistula after pancreaticojejunostomy?

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KEYWORDS
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Morbidity;
Mortality

Summary *Background:* Post-operative pancreatic fistula (POPF) is one of the most common and serious complications after pancreaticoduodenectomy (PD). The aim of this study is to retrospectively compare clinically relevant (CR) POPF and other complications after pacreaticojejunostomy (PJ) after modified Kakita (m-Kakita) or modified Blumgart (m-Blumgart) anastomoses without stenting in a single institution.
Methods: One hundred twenty-eight patients underwent PJ using m-Kakita anastomoses (two interrupted penetrating sutures) between January 2009 and December 2011. One hundred eighteen patients underwent m-Blumgart anastomoses (two transpancreatic/jejunal seromuscular sutures to cover the pancreatic stump with jejunal serosa) between January 2014 and December 2015. Demographics, clinical characteristics, and post-operative mortality and morbidity were retrospectively compared between the two groups.
Results: There were no significant differences in demographics or clinical characteristics between the two groups except operative time. A significantly lower rate of CR-POPF was found in the m-Blumgart group relative to the m-Kakita group (10% vs. 19%, $p = 0.038$). Univariate and multivariate analyses revealed that the m-Blumgart anastomosis and fistula risk category (Negligible, Low) were independently protective against CR-POPF ($p < 0.05$).
Conclusion: This retrospective single-center study demonstrated that the modified Blumgart method without pancreatic duct stenting was associated with a lower rate of CR-POPF.

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1. Introduction

Pancreatoduodenectomy (PD) is the standard operation for lesions of the pancreatic head or periampullary region. Although the operative mortality of PD in high-volume centers has decreased to less than 3%,[1,2] the surgical morbidity remains high. One-third of patients develop one or more complications, including postoperative pancreatic fistula (POPF), delayed gastric emptying (DGE), and surgical site infection.[2,3] Clinically-relevant (CR) POPF, one of the most common complications, occurs in approximately 10%—30% of patients after PD, and leads to increased morbidity, mortality, and prolonged hospitalization.[4,5]

Substantial efforts have been directed at reducing CR-POPF after PD. Technical modifications include the use of external stenting of the pancreatic duct,[6,7] use of a pancreatojejunal[8,9] or pancreatogastric anastomosis technique,[10,11] and reinforcement of the anastomosis with fibrin glue,[12] among others.

The Blumgart method for PJ anastomosis involves placement of 3—6 transpancreatic and jejunal seromuscular U-sutures to approximate the pancreatic stump and the jejunum.

Recently, several authors reappraised clinical results using the Blumgart method, and reported a less than 10% rate of CR-POPF.[13—17]

The purpose of this retrospective study is to examine whether the Blumgart anastomosis reduces CR-POPF compared to the Kakita anastomosis, which is our usual technique for anastomosis in the setting of no stenting into the pancreaticojejunostomy.

2. Patients and methods

This study involved 246 of 354 consecutive patients who underwent PJ during PD between January 2009 and December 2015 at Kansai Medical University. Exclusion criteria was patients who underwent other anastomotic methods for PJ and PJ with intrapancreatic ductal stenting. One hundred six patients were recruited into a prospective study of long internal stent placement between 2012 and 2013 and were excluded for this analysis,[18] as were two patients who underwent the dunking method for PJ. Study groups consisted of 118 patients who underwent the m-Blumgart method for PJ anastomosis between January 2014 and December 2015 (m-Blumgart group), and 128 patients who underwent the m-Kakita method for PJ between January 2009 and December 2011 (m-Kakita group). Data of patients from the m-Kakita group were partially collected from previous reports.[18—20] No eligible patients underwent external or internal stenting into the main pancreatic duct.

2.1. Surgical procedure

All operations were performed by members of the pancreato-biliary team, and supervised by S.S. The patients underwent standard PD with reconstruction of the digestive tract using the modified Child method. The diameter of the pancreatic duct was measured intra-operatively in each patient before PJ anastomosis. As shown in Fig. 1, the PJ anastomosis was performed with a duct-to-mucosa anastomosis in an end-to-side fashion using eight absorbable

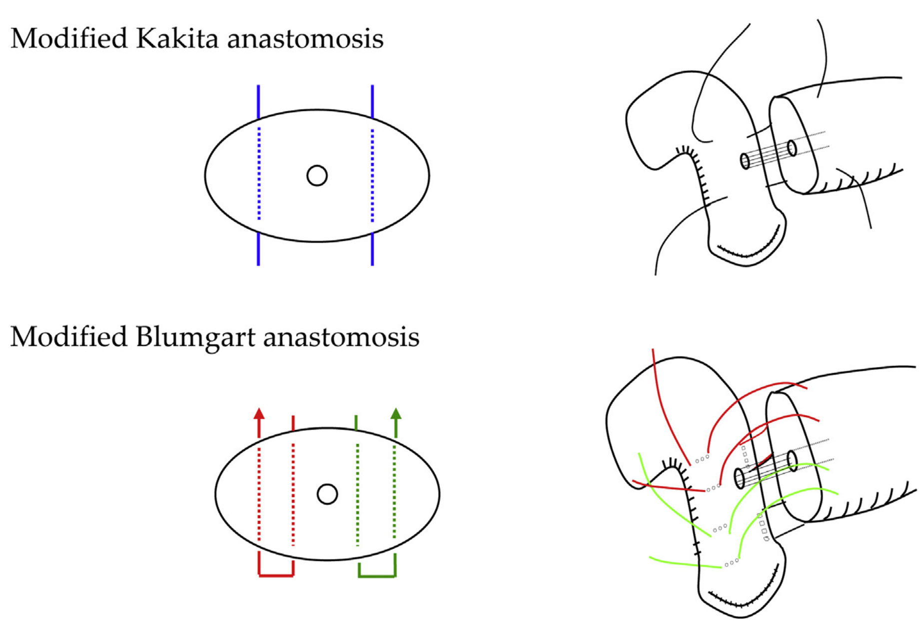


Figure 1 Schema of anastomoses of pancreaticojejunostomy in modified Kakita and modified Blumgart methods.

interrupted sutures without stenting of the main pancreatic duct. In the m-Kakita group, the pancreatic parenchyma of the stump was approximated to the jejunal seromuscular layer with two nonabsorbable interrupted penetrating sutures (Fig. 1). The m-Blumgart anastomosis was performed according to surgical technique reported by Fujii et al.[16] We used a double-armed 4-0 polypropylene suture to place a U-suture with both arms through the pancreatic stump and a 10–15 mm longitudinal suture through the seromuscular layer of the jejunum (Fig. 1). Two sutures were placed 0.5 cm apart from the main pancreatic duct in all patients to avoid stricture of the main pancreatic duct, which was different from m-Blumgart technique by Fujii et al.[16] After duct-to-mucosa anastomosis, the outer anterior horizontal mattress sutures on the jejunum using previously held U-sutures were completed and tied individually on the anterior surface of the pancreas to cover the duct-to-mucosa anastomosis by jejunal serosa. This procedure completely covered the pancreatic stump with jejunal serosa. Two closed-suction drains were placed near the PJ in all patients.

2.2. Perioperative management

Perioperative management was standardized according to previously reported departmental guidelines.[21] Briefly, the nasogastric tube was removed if the drained fluid volume was less than 200 ml on postoperative day (POD) 1. We used closed-suctioned drains, and peri-pancreatic drainage fluid was collected and the amylase level measured and monitored on POD 3 and 6, and every 3 days thereafter as needed. The drainage tubes were removed from patients without infection-induced systemic inflammatory response syndrome (SIRS) or POPF as defined by the International Study Group on Pancreatic Surgery (ISGPS).[22] For patients with POPF who were clinically diagnosed as having infection-induced SIRS, the peri-anastomotic drains were replaced with the other drain on postoperative day 6. For patients with continuous signs of infection, closed lavage with normal saline was performed to treat the infection focus and dilute the pancreatic juice, according to the departmental criteria for drain removal. On POD 3, patients were allowed to ingest a clear liquid diet. Not all patients received somatostatin analogs.

2.3. Definition of postoperative complications

Overall general and surgery-related complications were recorded in the patient's clinical records. These included POPF, DGE, intra-abdominal infection, abdominal abscess formation, and hemorrhagic complications, among others. We diagnosed intraabdominal abscess by CT or US. If the drainage tube was already removed from the patients when we diagnosed the intraabdominal abscess, we inserted a percutaneous drainage tube. If the patient had a drainage tube in place, we exchanged it to a new tube because the tubes are vulnerable to obstructions by plugs consisting of fibrin and other substances. If the intraabdominal abscess was located in center of the body where the puncture was considered hazardous, we turned to the remedial antibiotics before considering surgical drainage. Intra-abdominal infection was defined as pus-like fluid discharge from a drainage tube when abscess formation was not detected on the imaging study. The incidence of CR-POPF was partly overlapped with that of abscess formation or intra-abdominal infection.

Each day that a patient demonstrated clinical symptoms of SIRS was recorded. POPF, DGE, and post-pancreatectomy hemorrhage were defined according to ISGPS criteria.[22–24]

2.4. Data collection

Using a prospectively maintained database, we obtained preoperative demographic and clinical data, details of the operation, including information on the pancreatic texture and main pancreatic duct diameter, pathological diagnosis, postoperative course, and complications.

This retrospective study was ethically approved by the institutional review board in Kansai Medical University (H140408), and registered to researchregistry3408. The work has been reported in line with the STROCSS criteria.[25]

The risk identification of POPF was performed using two type of scoring systems which were confirmed to be effective for predicting POPF.[26–28] One scoring system[26] is calculated with the BMI and pancreatic duct width using the formula (available at http://www.uhb.nhs.uk/pre-operative-prediction-of-pancreatic-fistula-calculator.htm). The Fistula Risk Score[27,28] is a ten-point scale that relies on weighted influence of four variables including gland texture, pathology, pancreatic duct diameter, and intra-operative blood loss. The weighted aggregate of these risk factors was used to calculate individual FRS scores (0–10) for each patient. Calculated scores were used to assign patients to 1 of 4 fistula risk zones: (1) negligible—0 points; (2) low—1 to 2 points; (3) moderate—3 to 6 points; (4) high—7 to 10 points.

2.5. Statistical analysis

All numerical data are expressed as median values and ranges. The chi-square test or Fisher's exact test was used for comparison of categorical variables. The Mann–Whitney *U* test was used for comparison of continuous variables. Multivariate analysis using logistic regression analysis was carried out to determine independent significant risk factors for POPF following PD. P-values less than 0.05 were considered significant.

3. Results

There were no significant differences in clinical backgrounds between the two groups except in operative time as shown in Table 1. Operative time in the m-Blumgart group was significantly shorter than in the m-Kakita group ($p = 0.001$). No difference in the fistula risk score[28–30] was found between the two groups. Although the incidence of overall POPF did not differ between the two groups, a significantly lower rate of CR-POPF was found in the m-Blumgart group relative to the m-Kakita group as shown in Table 2 (10% vs. 19%, $p = 0.038$). When CR-POPF rate was recorded according to the fistula risk score,[29,30] CR-POPF in the m-Blumgart group was observed in the moderate and high risk groups only, and was half the

Table 1 Clinical backgrounds.

Parameters	m-Kakita (n = 128)	m-Blumgart (n = 118)	p value
Age (years old), median (range)	69 (33–87)	72 (32–86)	0.109
Gender, Male:female, n (%)	73 (57): 55 (43)	80 (68): 38 (32)	0.081
BMI≥25, n (%)	21 (16)	20 (17)	0.909
Pancreatic disease: non-pancreatic disease, n (%)	80 (63): 48 (38)	63 (53): 55 (47)	0.148
Benign:malignant, n (%)	8 (6): 120 (94)	15 (13): 103 (87)	0.085
Co-morbid disease (-:+), n (%)	40 (31): 88 (69)	45 (38): 73 (62)	0.256
Albumin (g/dl), median (range)	3.9 (2.3–5.3)	4.0 (2.8–4.8)	0.417
Diabetes Mellitus (-:+), n (%)	93 (73): 35 (27)	85 (72): 33 (28)	0.913
Pre-operative biliary drainage (-:+), n (%)	49 (38): 79 (62)	59 (50): 59 (50)	0.064
Neoadjuvant therapy; none: NAC: NACRT, n (%)	98 (77): 11 (8): 19 (15)	109 (92): 8 (7): 1 (1)	0.001
Operation time (min), median (range)	424 (259–711)	396 (269–648)	0.001
Blood loss (ml), median (range)	834 (110–3853)	778 (144–3489)	0.505
Pancreatic duct (mm), median (range)	4 (1–10)	4 (1–15)	0.240
Pancreatic duct ≦3 mm, n (%)	57 (45)	51 (43)	0.836
Texture of pancreas, soft: hard, n (%)	67 (52): 61 (48)	70 (59): 48 (41)	0.271
Risk Score,[28] median (range)	7.72 (0.42–29.09)	9.34 (0.06–32.71)	0.071
Fistula Risk Score,[29,30] median (range)	5 (0–10)	5 (1–10)	0.379
Fistula Risk Score,[29,30] Negligible: Low: Moderate: High, n (%)	1 (1): 20 (16): 69 (54): 38 (30)	0 (0): 21 (18): 59 (50): 38 (32)	0.618

Table 2 Post-operative outcomes.

Parameters	Kakita (n = 128)	Blumgart (n = 118)	p value
Overall complications, n (%)	69 (54)	55 (47)	0.253
Pancreatic fistula, n (%)	51 (40)	55 (47)	0.284
Grade B/C, n (%)	25 (19)	12 (10)	0.038
DGE, n (%)	8 (6)	17 (14)	0.034
Grade B/C, n (%)	4 (3)	11 (9)	0.039
Post-pancreatectomy hemorrhage, n (%)	1 (1)	2 (2)	0.511
In-hospital death, n (%)	3 (2.3)	2 (1.7)	0.718
In-hospital stay (POD), median (range)	14 (7–84)	13 (7–82)	0.153
Drain AMY level (POD3), median (range)	144 (3–57696)	375 (9–42821)	0.024
Re-operation, n (%)	2 (1.6)	1 (0.9)	0.606
Intra-abdominal abscess, n (%)	34 (27)	13 (11)	0.002
Surgical site infection, n (%)	42 (33)	21 (18)	0.007
Date of drain removal, median (range)	3 (3–57)	3 (3–31)	0.130
Clavien-Dindo classification ≥III, n (%)	26 (20)	31 (26)	0.269

POD, post-operative day.

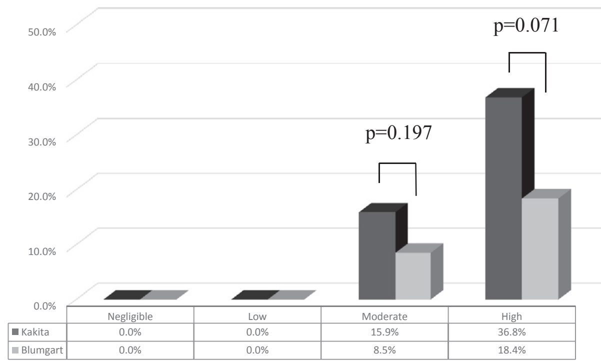
incidence of that in the m-Kakita group as shown in Fig. 2. As shown in Table 3, univariate analysis identified anastomotic type and fistula risk score[29,30] as risk factors for CR-POPF, and multivariate analyses revealed that the m-Blumgart anastomosis and fistula risk category (Negligible, Low) were independently protective against CR-POPF ($p < 0.05$). In a subgroup analysis of the patients with a main pancreatic duct diameter of 3 mm or less, CR-POPF rate in the m-Blumgart group was 16% relative to 28% in the m-Kakita group ($p = 0.119$).

Development of an intra-abdominal abscess and surgical site infection in the m-Blumgart group (11% and 18%, respectively) were significantly less frequent relative to the m-Kakita group (27% and 33%, respectively, $p < 0.01$). Overall and grade B/C DGE rates in the m-Blumgart group were significantly higher than those in the m-Kakita group (14% and 9% vs. 6% and 3%, respectively, $p < 0.05$). Grade B/C DGE occurred in 17 patients in the m-Blumgart group, and in 8 patients in the m-Kakita group. CR-POPF developed in 4 of 17 patients (24%) in the m-Blumgart group, and 2 of 8 patients (33%) in the m-Kakita group; this was not significant.

In-hospital death within 90 days after surgery was recorded in 3 of 128 patients (2.3%) in the m-Kakita group, and in 2 of 118 patients (1.7%) in the m-Blumgart group. Cause of death was aspiration pneumonia in one and post-pancreatectomy hemorrhage following CR-POPF in two patients in the m-Kakita group, and acute cardiac failure in one and severe sepsis following CR-POPF in one in the m-Blumgart group.

4. Discussion

The development of CR-POPF often results in severe complications including sepsis, intra-abdominal abscess, bleeding,



	Modified Kakita method	Modified Blumgart method
Fistula Risk Score Negligible: Low: Moderate: High, n (%)	1 (1):20 (16): 69 (54): 38 (30)	0 (0): 21 (18): 59 (50): 38 (32)

Figure 2 The rate of clinically-relevant post-operative pancreatic fistula according to "fistula risk score" risk zone. Incidence of CR-POPF increased with the fistula risk score. The rate of CR-POPF in the modified Blumgart group was 8.5% in the moderate risk zone, and 18.4% in the high-risk zone, lower than the 15.9% in the moderate risk zone and 36.8% in the high-risk zone of the modified Kakita method. There were no significant differences in the overall CR-POPF rate between the m-Blumgart and m-Kakita methods.

Table 3 Risk factors for clinically relevant post-operative pancreatic fistula.

Parameters	Univariate		Multivariate	
	Relative risk (95% CI)	p value	Relative risk (95% CI)	p-value
Age (<70 vs. ≧70)	1.83 (0.90–3.82)	0.096		
Male: female	1.70 (0.80–3.87)	0.171		
Body mass index (<25 vs. ≧25)	1.04 (0.43–2.93)	0.936		
Body mass index (<30 vs. ≧30)	1.40 (0.11–9.20)	0.418		
Benign: malignant	1.20 (0.38–5.28)	0.775		
Pre-operative biliary drainage (-:+)	1.10 (0.54–2.22)	0.786		
Operation time (min) (<408 vs. ≧408)	0.56 (0.27–1.13)	0.107		
Blood loss (ml) (<816 vs. ≧816)	1.38 (0.68–2.82)	0.372		
Resection of other organs (-:+)	1.19 (0.58–2.58)	0.644		
Co-morbid disease (-:+)	0.89 (0.41–1.85)	0.768		
Diabetes Mellitus (-:+)	1.77 (0.77–4.57)	0.184		
Albumin (g/dl) (<3.9 vs. ≧3.9)	1.83 (0.90–3.88)	0.098		
Modified Blumgart: modified Kakita	0.47 (0.22–0.96)	0.038	0.46 (0.21–0.97)	0.040
Fistula risk score (Negligible, Low vs Moderate, High)	5.61 (4.59–15.14)	0.001	5.69 (4.60–15.07)	0.001

CI, confidential interval.

and delayed gastric emptying. The safe reconstruction of pancreaticoenteric continuity during PD continues to be a challenge for the pancreatic surgeon. To date, many efforts have been made to reduce the occurrence of POPF PD in our institution, including the introduction of departmental policies,[21,29] use of the m-Kakita method,[5] reinforcement of the PJ using polyethylene glycolic acid mesh,[19] and use of a long internal stent.[18] Incidence of CR-POPF has ranged from 6% in to 19% in our series since 2004. In this study, the patients who were reconstructed using PJ without intra-pancreatic duct stenting were retrospectively divided into m-Blumgart ($n = 118$) and m-Kakita groups ($n = 128$). Consequently, patients who underwent m-Blumgart anastomoses had a significantly lower incidence of CR-POPF compared to the m-Kakita method (10% vs. 19%, $p = 0.038$). The incidence of CR-POPF in the m-Blumgart group was lower than that in the m-Kakita group at moderate and high-risk zones of the fistula risk score.[27,28] Moreover, multivariate analysis revealed that the m-Blumgart method and the fistula risk score were protective against CR-POPF development ($p < 0.05$). There were no differences in clinical background including fistula risk score between two groups. Although operative time in the m-Blumgart group was significantly shorter than that in the m-Kakita group, multivariate analysis did not reveal the association between operative time and CR-POPF. A significantly higher incidence of DGE in the m-Blumgart group may be due to a technical issue in the m-Blumgart group; specifically, gastrojejunostomy was performed by surgical trainees.

Grobmyer SR et al have suggested that an "ideal" pancreaticojejunal anastomosis would meet the following criteria from a technical standpoint: applicable to all patients, easy to teach, and associated with a low rate of pancreatic anastomotic failure-related complications.[14] The technique of the Blumgart method was first described by Blumgart LH et al[30,31] and subsequently modified and taught to a generation of his trainees. Recently, they reported the excellent results of 1.6% of mortality and 6.9% of CR-POPF after Blumgart anastomosis for PJ in 187 patients.[14] They proposed three benefits of this procedure: the use of full pancreatic thickness mattress sutures; the placement of the duct-to-mucosa sutures before securing the posterior seromuscular jejunum permits a tension-free approximation with excellent visualization of the pancreatic duct; and the mild compression provided by "sandwiching" the pancreas in between the jejunum. In the current study, the m-Kakita method did not fully cover the pancreatic stump but m-Blumgart method completely covered it with jejunal serosa after a U-suture between pancreatic parenchyma and seromuscular layer of the jejunum. The difference in the covering of the pancreatic stump might lead to a decrease in CR-POPF in the Blumgart group. The mattress sutures and "sandwiching" the pancreas seemed to make PJ anastomosis tighter in the m-Blumgart anastomosis relative to the m-Kakita method. Thereafter, implementation of the Blumgart anastomosis has spread to Asian[16,17] and European countries.[13] The use of the Blumgart method for PJ has reduced the incidence of CR-POPF to between 3 and 7%, relative to the 13–36% in the conventional method.[15–17] Fujii et al modified the original method by using fewer sutures (one to three) and completing coverage of the pancreatic stump with jejunal serosa, which resulted in zero mortality and 2.5% of CR-POPF in 120 patients.[16] Wang et al[17] also reported that the Blumgart PJ was superior to pancreaticogastrostomy in terms of pancreatic leakage and surgical mortality (CR-POPF; 7% in the Blumgart group vs. 20% in the pancreaticogastrostomy group, $p = 0.007$). Thus, Blumgart anastomosis is a simple, safe, and reproducible procedure even for young surgeons, and can be recommended as a standard method for PJ.

We are aware of some limitations of this study in terms of the retrospective nature of the analysis. The population analyzed was relatively homogeneous with regard to most of the clinical backgrounds, underlying diseases, clinical diagnosis, and type of operation. It should be noted that the same operative team performed standardized peri-operative management throughout the relatively short study period.

In conclusion, the modified Blumgart anastomosis without pancreatic duct stenting was associated with lower rate of CR-POPF.

Author contributions

SS and TY contributed to all aspects of this study and article. HY, SY, HK, SH, MK, HR, TM, KI and YM contributed to study conception, collection of the data and critical revision of the article. All authors approved the final draft of the article.

Conflict of interest

None declared.

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