Effect of Modified Blumgart Anastomosis on Surgical Outcomes After Pancreaticoduodenectomy

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Cite this article as: Özşay O, Aydın MC. Effect of modified blumgart anastomosis on surgical outcomes after pancreaticoduodenectomy. *Turk J Gastroenterol.* 2022;33(2):119-126.

ABSTRACT

Background: *Surgeons continue to be concerned about complications after pancreaticoduodenectomy, especially postoperative pancreatic fistula. Among the factors that cause postoperative pancreatic fistula, the pancreaticojejunostomy technique has stood out in recent studies. In this study, we aimed to compare the surgical outcomes, especially POPF, of the modified Blumgart and the traditional anastomosis techniques in patients who underwent pancreaticoduodenectomy.*

Methods: *A total of 144 patients who underwent pancreaticoduodenectomy were divided into 2 groups according to the performed pancreaticojejunostomy technique (modified Blumgart anastomosis, n = 91 and traditional anastomosis, n = 53). Preoperative clinicodemographic data, perioperative findings, and postoperative results were compared between the groups. Additionally, factors associated with clinically relevant postoperative pancreatic fistula were analyzed.*

Results: *The modified Blumgart anastomosis group had lower clinically relevant postoperative pancreatic fistula rate than traditional anastomosis group (n = 8 (8.8%) versus n = 14 (26.4%), P = .005). On the contrary, the biochemical leakage rate was higher in the modified Blumgart anastomosis group (n = 30 (33%) versus n = 9 (17%), P = .037). While postoperative pancreatic fistula-related reoperation rate was lower (n = 2 (2.2%) versus n = 7 (13.2%), P = .013), the length of hospital stay was also shorter (11 days (5-47 days) versus 21 days (6-46 days),*
P < .001) in the modified Blumgart anastomosis group. Univariate and multivariate analyses revealed that modified Blumgart anastomosis was an independent and negative predictive factor for clinically relevant postoperative pancreatic fistula (odds ratio = 0.274, 95% confidence interval = 0.103-0.728, P = .009).

Conclusion: *Compared to the traditional anastomosis, modified Blumgart anastomosis decreases the rate of transition from biochemical leakage to clinically relevant postoperative pancreatic fistula and postoperative pancreatic fistula-related reoperation and also shortens the length of hospital stay. In addition, modified Blumgart anastomosis is an independent and negative predictive factor for the development of clinically relevant postoperative pancreatic fistula.*

Keywords: *Fistula, leakage, pancreatic tumor, reconstruction, Whipple*

INTRODUCTION

Pancreaticoduodenectomy (PD) is still the only curative treatment option for periampullary tumors.[1] The surgical technique was first described by Whipple[2] in 1935. In the beginning, the mortality rate after PD was 25%, but it has decreased to 3% with increased surgical experience, developments in perioperative management, and radiological interventions.[3,4] However, the postoperative morbidity rate, mainly due to postoperative pancreatic fistula (POPF), is still between 30% and 50% even in high volume centers,[5,6] and these high rates concern the surgeons. The morbidities due to POPF, such as intra-abdominal bleeding, intra-abdominal abscess, delayed gastric emptying (DGE), and anastomotic leakage, may cause mortality,[7] prolong the length of hospital stay, and increase the cost of care.[8]

The anastomosis technique was considered one of the most effective factors for preventing POPF in the literature.[9] Many techniques have been developed over time, but a gold standard has not yet been defined. While some studies revealed that the anastomosis technique described by Blumgart[10] in 2010 and its modifications reduce the POPF rate,[11,12] some others stated the opposite.[13,14] In these studies, the operations were performed by more than one surgeon, and this reduces the reliability of the results. This study was conducted to investigate the effect of the modified Blumgart anastomosis

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Received: ***August 12, 2021*** *Accepted:* ***October 4, 2021*** *Available Online Date:* ***December 24, 2021***

DOI: ***10.5152/tjg.2021.21701***

(m-BA) technique on PD outcomes by comparing it with the traditional anastomosis (TA) technique.

MATERIALS AND METHODS

Patients

This study was approved by the local ethical committee (2021/174). A total of 144 patients who underwent PD due to benign or malignant indications between September 2013 and July 2020 were included in this study. The exclusion criteria were emergent surgery and total pancreatectomy. Patients were divided into 2 groups as m-BA (n = 91) and TA (n = 53) in terms of pancreaticojejunostomy (P-J) technique. The decision for surgery was made by the multidisciplinary council. Preoperative assessment was done by patient's symptoms, medical and surgical history, physical examination, hematological and biochemical laboratory findings, radiological imaging methods (computed tomography (CT), magnetic resonance imaging, endoscopic ultrasonography), and endoscopic findings. Informed consent was obtained before operation. Prospectively collected data of the patients were retrospectively reviewed. The patients' preoperative demographic data, body mass index (BMI), American Society of Anesthesiologists scores, medical history, previous upper abdominal surgical history, laboratory parameters (hemoglobin, albumin, aspartate aminotransferase, and alanine aminotransferase), preoperative biliary drainage, tumor location, operative time, blood transfusion, pancreatic texture, Wirsung diameter, postoperative complications, length of hospital stay, reoperation, mortality, and definitive pathological results were examined.

Preoperative biliary drainage was performed via endoscopic retrograde cholangiopancreatography and stent placement or percutaneous transhepatic cholangiography and biliary catheter placement. Patients were operated after reaching normal bilirubin levels. Perioperatively, Wirsung diameter was defined and analyzed as ≥3 mm and <3 mm, and the pancreatic texture was recorded as soft or hard, according to the surgeon's definition. Postoperative complications were graded according to Clavien–Dindo classification,[15] and complications Grade 3 or higher were accepted as severe complications.

Postoperative pancreatic fistula was defined and classified according to the International Study Group for Pancreatic Surgery-2016.[16] The diagnosis of POPF was made if the amylase level of the drain fluid was 3 times higher than the serum amylase level on the 3rd postoperative day. This was regarded as biochemical leakage (BL). Grade B fistula was defined as fistula requiring any changes in the treatment (need for antibiotics, enteral or parenteral nutrition, percutaneous, endoscopic, or angiographic interventions) or fistula with abdominal drainage lasting longer than 21 days. Fistula-related organ failure, reoperation, or death was accepted as Grade C fistula. Grade B and C fistulas were defined as clinically relevant POPF (CR-POPF). Delayed gastric emptying was defined as an inability to take a standard oral diet or need for nasogastric (NG) decompression, beyond the postoperative day 7.[17] Postpancreatectomy hemorrhage (PPH) was defined as blood loss via abdominal drains or NG tube, hematemesis, melena, decreased hemoglobin levels with unexplained hypotension and tachycardia.[18] In addition, hemorrhage detected during endoscopy, abdominal ultrasonography, CT angiography, or reoperation was also considered as PPH. Mortality was defined as death during the hospital stay.

Surgical Technique

Patients were operated on under general anesthesia in the supine position after NG and urinary catheters were placed. A central venous catheter was inserted into the right internal jugular vein. The standard antibiotic prophylaxis was third-generation cephalosporin. It was given at the beginning of the operation and was repeated every 6 hours. The standard PD as described in the literature was performed on all patients.[2] In addition, the lymph nodes between the coeliac trunk and the superior mesenteric artery (triangular area) were retrieved, and the proksimal jejunum was pulled up for P-J through the Treitz hole that occurred after duodenectomy. Pyloric preservation was not performed on any patients. An internal stent at the appropriate size was placed between the pancreatic duct and the jejunal opening in all patients, and external drainage was not performed. Two abdominal drains were placed around the P-J and hepaticojejunostomy. Traditional anastomosis was performed on all patients who underwent PD until February 2016, and m-BA was performed after this date.

Traditional Anastomosis

The P-J was created in 2 layers and end to side. A small enterotomy was performed on the antimesenteric border of the jejunum. The posterior outer row was created using 3-0 interrupted non-absorbable seromuscular sutures between the jejunum and the rear wall of the cut surface of the pancreatic remnant. An internal stent-guided ductomucosal anastomosis (the inner layer) was performed with 5-0 or 6-0 monofilament absorbable interrupted sutures between the enterostomy and pancreatic duct. Although the number of sutures varied due to the Wirsung diameter, it was at least 6. Finally, the anterior outer row was created using 3-0 interrupted non-absorbable sero-muscular sutures between the jejunum and the anterior border of the cut surface of the pancreatic remnant.

Modified Blumgart Anastomosis

A small enterotomy was performed on the antimesenteric border of the jejunum. A stent was used to localize the pancreatic duct on the cut surface of the remnant pancreas. Two transpancreatic (along the ventral–dorsal axis of the remnant pancreas) 3-0 non-absorbable sutures both on the superior and inferior of the pancreatic duct were performed 2 cm lateral to the cut surface of the remnant pancreas (Figure 1). These sutures were passed seromuscular transversely through the jejunum below the enterotomy. Then the sutures were passed through the pancreas along the dorsal–ventral axis, and the U shapes were completed. Ductomucosal anastomosis was created in the same way as in TA. After the posterior layer of the ductomucosal anastomosis was completed (Figure 2), the U-sutures were tied on the anterior surface of the remnant pancreas. Then the anterior layer of the ductomucosal anastomosis was completed (Figure 3). Two U-sutures were performed in the same way as described above, but this time, the sutures were passed along the ventral–dorsal axis and were tied on the remnant pancreas' posterior surface (Figure 4). The anastomosis included a total of 4 transpancreatic U-sutures, as 2 along the ventral–dorsal axis and 2 along the dorsal–ventral axis.

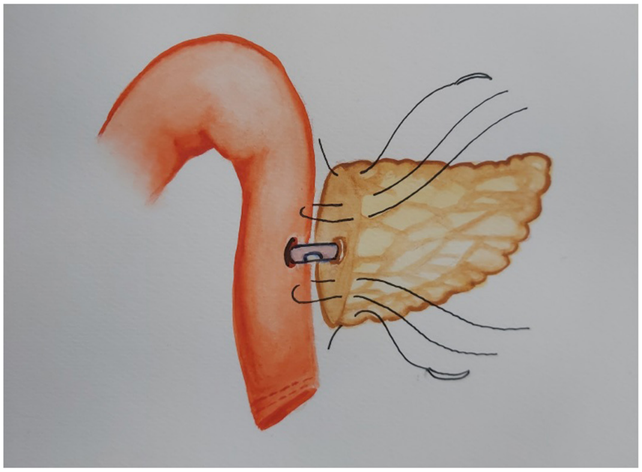

Figure 1. Transpancreatic U-sutures.

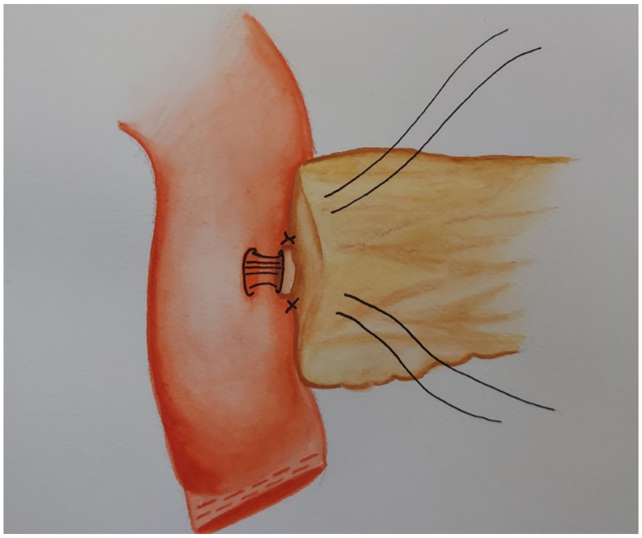

Figure 2. Posterior wall sutures of ductomucosal anastomosis.

Postoperative Period

Third-generation cephalosporin was administered to all patients during the first 3 days postoperatively, and it was prolonged when needed. Nasogastric and urinary catheters were removed in all patients on the 2nd postoperative day unless additional problems were encountered. Oral intake was started on the 3rd day under normal conditions. Drain amylase level was measured on the 3rd postoperative day. When a daily collection of drain fluid was less than 50 cc, the drains were removed. Octreotide was not used routinely.

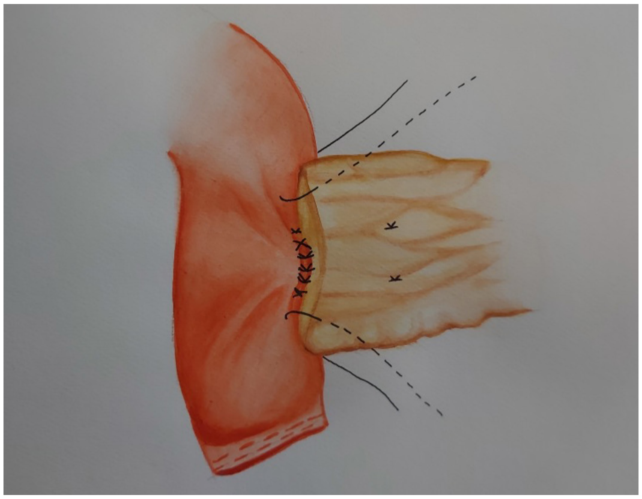

Figure 3. Completed first transpancreatic U-sutures and anterior wall sutures of ductomucosal anastomosis.

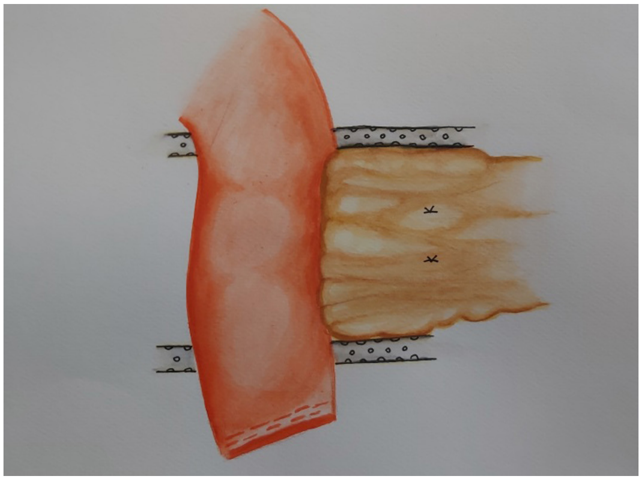

Figure 4. Completed second transpancreatic U-sutures.

Statistical Analysis

We used the Shapiro–Wilk test to determine the normality of the distribution of continuous variables. Normally distributed continuous variables were described as mean ± standard deviation and were analyzed with the Student's *t*-test. Non-normally distributed continuous variables were described as median with range and were analyzed with the Mann–Whitney *U* test. Chi-square or Fisher's exact test was used for analyzing the categorical data, which were described as frequencies with percentages. Variables with a *P* value <.1 in univariate analysis were included in a multivariate logistic regression analysis to identify independent predictive factors for CR-POPF. A *P* value <.05 was considered significant. The IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA) was used for data analysis.

RESULTS

The median age of the whole study group was 63 years (22-86 years), and 66 (45.1%) of them were female. There was no significant difference between the groups regarding preoperative clinicodemographic data, previous medical and surgical history, laboratory findings, preoperative biliary drainage, and tumor localization. The most common tumor localization was the pancreatic head (n = 84, 57.9%). The definitive pathological results revealed 121 (84%) malignancies, and there was no difference between the groups in terms of malignant/benign rate (Table 1).

Table 1. Preoperative Findings and Definitive Pathological Results

	Modified Blumgart (n = 91)	Traditional (n = 53)	*P*
Age (years)	63 (22-86)	62 (25-85)	.192
Gender (male), n (%)	45 (49.5)	34 (63.4)	.087
BMI (kg/m^2) (≥30), n (%)	24 (26.4)	19 (35.8)	.231
ASA score, n (%)			.092
ASA 1	32 (35.1)	5 (9.4)	
ASA 2	44 (48.4)	33 (62.3)	
ASA 3	15 (16.5)	15 (28.3)	
Previous medical history, n (%)			
Diabetes mellitus	35 (38.5)	14 (26.4)	.141
Hypertension	33 (36.3)	17 (32.1)	.611
Lung disease	10 (11)	10 (18.9)	.187
Cardiac disease	10 (11)	9 (17)	.306
Smoking	20 (22)	12 (22.6)	.926
Previous upper abdominal surgery, (yes), n (%)	10 (11)	5 (9.4)	.768
Laboratory findings			
Hemoglobin (g/dL)	11.97 ± 1.61	11.88 ± 1.14	.685
Albumin (g/dL)	3.85 ± 0.59	3.77 ± 0.53	.427
AST (U/L)	26 (8.5-284)	30 (11-220)	.082
ALT (U/L)	32 (5.8-266)	33 (9-478)	.063
Preoperative biliary drainage (yes), n (%)	50 (54.9)	31 (58.5)	.679
Location of lesion, n (%)			.436
Pancreatic head	52 (57.1)	32 (60.4)	
Ampulla	27 (29.7)	18 (34)	
Duodenum	3 (2.1)	9 (9.9)	
Distal choledochus	9 (9.9)	3 (5.7)	
Indication (malignant), n (%)	77 (84.6)	44 (83)	.801

ASA, American Society of Anesthesiologists; AST, Aspartate aminotransferase; ALT; alanine aminotransferase; BMI, body mass index.

Perioperative findings and postoperative outcomes of P-J groups were shown in Table 2. No significant difference was found between the groups regarding operation time, Wirsung diameter, and pancreatic texture. However, the rate of perioperative blood transfusion was higher in the m-BA group (n = 45 (49.5%) versus n = 14 (26.4%), p:0.007). Venous (superior mesenteric vein, vena porta) resection and vascular reconstruction were performed on 29 patients (20.1%) due to tumor invasion. Despite the absence of statistical difference between the groups, the vascular reconstruction rate was higher in the m-BA group (n = 22 (24.2%) versus n = 7 (13.2%), *P* = .113).

Table 2. Perioperative Findings and Postoperative Outcomes

	Modified Blumgart (n = 91)	Traditional (n = 53)	*P*
Operation time (min)	360 (120-720)	390 (200-700)	.183
Intraoperative blood transfusion, n (%)	45 (49.5)	14 (26.4)	**.007**
Pancreatic texture (soft), n (%)	68 (74.7)	40 (75.5)	.921
Diameter of Wirsung (≥3 mm), n (%)	48 (52.7)	25 (47.2)	.519
Venous reconstruction, n (%)	22 (24.2)	7 (13.2)	.113
CD ≥3 complications, n (%)	13 (14.3)	14 (26.4)	.072
Wound infection, n (%)	14 (15.4)	9 (17)	.801
Postoperative hemorrhage, n (%)	11 (12.1)	6 (11.3)	.891
POPF-related hemorrhage, n (%)	5 (5.5)	4 (7.5)	.725
Grade A POPF (biochemical leak), n (%)	30 (33)	9 (17)	**.037**
Grade B POPF, n (%)	6 (6.6)	10 (18.9)	**.024**
Grade C POPF, n (%)	2 (2.2)	4 (7.5)	.193
CR-POPF (Grade B + C), n (%)	8 (8.8)	14 (26.4)	**.005**
DGE, n (%)	16 (17.6)	10 (18.9)	.847
Chylous fistula, n (%)	2 (2.2)	-	.532
Length of hospital stay (days), n (%)	11 (5-47)	21 (6-46)	<**.001**
Reoperation, n (%)	4 (4.4)	7 (13.2)	.099
POPF-related reoperation, n (%)	2 (2.2)	7 (13.2)	**.013**
Hospital mortality, n (%)	6 (6.6)	6 (11.3)	.358
POPF-related hospital mortality, n (%)	-	2 (3.8)	.134

CD, Clavien–Dindo; CR, clinically relevant; DGE, delayed gastric emptying; POPF, postoperative pancreatic fistula.
Values shown in bold are statistically significant ($P < .05$).

Severe complications were observed in 27 patients (18.7%), and there was no significant difference between the groups. Furthermore, we found no significant difference between the groups regarding wound infection, postoperative hemorrhage, POPF-related hemorrhage, DGE, and chylous fistula. Any pancreatic stent-related complication was not observed. Clinically relevant postoperative pancreatic fistula developed in 22 patients (15.3%) and was significantly lower in the m-BA group (n = 8 (8.8%) versus n = 14 (26.4%), *P* = .005). On the contrary, BL rate was higher in the m-BA group (n = 30 (33%) versus n = 9 (17%), *P* = .037). While Grade C fistula did not significantly differ between groups, there was a significantly lower Grade B fistula in the m-BA group (n = 6 (6.6%) versus n = 10 (18.9%), *P* = .024).

The length of hospital stay was shorter in the m-BA group (11 days (5-47 days) versus 21 days (6-46 days), $P < .001$). A total of 11 (7.6%) patients were reoperated. The indications for reoperation were hemorrhage in 9 patients, gastroenterostomy stenosis in 1 patient, and mesenteric ischemia in 1 patient, without any significant difference between groups. Postoperative pancreatic fistula-related reoperation rate was lower in the m-BA group (n = 2 (2.2%) versus n = 7 (13.2%), *P* = .013). Mortality occurred in 12 patients (8.3%). The causes of death were severe cholangitis in 1 patient, massive intra-abdominal hemorrhage in 2 patients, chronic obstructive pulmonary disease exacerbation in 2 patients, pulmonary embolism in 1 patient, cerebrovascular event in 2 patients, myocardial infarction in 2 patients, mesenteric ischemia in 1 patient, and chronic renal failure in 1 patient. No significant difference was observed between the groups in terms of mortality. However, it was remarkable that POPF-related mortality occurred in 2 patients in the TA group, while there was not any in the m-BA group.

As a result of the univariate and multivariate analyses performed to evaluate the factors related to CR-POPF, it was found that m-BA was the single and negative predictive factor for CR-POPF (odds ratio = 0.274, 95% confidence interval = 0.103-0.728, *P* = .009) (Table 3).

Table 3. Logistic Regression Analysis of Predictive Factors for CR-POPF

	Univariate Analysis			Multivariate Analysis		
Variable	OR	95% CI	*P*	OR	95% CI	*P*
Operative time	1.004	1.000-1.008	.053	1.004	1.000-1.009	.063
Wirsung diameter < 3 mm	2.526	0.962-6.630	.060	2.454	0.902-6.682	.079
Modified Blumgart anastomosis (yes)	0.269	0.104-0.693	**.007**	0.274	0.103-0.728	**.009**

CR-POPF, clinically relevant postoperative pancreatic fistula; OR, odds ratio.
Values shown in bold are statistically significant ($P < .05$).

DISCUSSION

In the present study, we found a lower CR-POPF rate with m-BA compared to TA. Also, we observed that m-BA did not change the total fistula rate (biochemical leak + Grade B and C fistula), but reduced the transition from biochemical leak to CR-POPF. We think this result may be a different perspective for studies involving the m-BA technique in the literature.

In their study, Kalev et al[1] stated that the Grade C fistula rate was lower in the m-BA group compared to TA. Another study by Li et al[8] revealed that the CR-POPF rate was lower in the m-BA group compared to the TA group, and the BL rate was higher, although it was not significant. We found a lower CR-POPF rate and a higher BL rate in m-BA group similar to this study. We think that the transition from the BL to CR-POPF is decreased due to the technical property of m-BA (reducing the risk from minor ducts and strengthening the anastomosis, with transpancreatic U-sutures). Inflammation caused by BL (the initial stage of all pancreatic fistulas) and the parenchymal harming effect of the sutures performed in TA together cause the transition from this stage to CR-POPF. The main reason for us to think this way is that the CR-POPF rate was significantly lower in the m-BA group while there was no significant difference between the total fistula rates in both groups (m-BA: 41.8% versus TA: 43.4%, $P = .921$). Similar to our results, in the study by Lee et al[12] and Cao et al.[20] it was stated that m-BA did not change the total fistula rate compared to TA but decreased the rate of transition from BL to Grade B fistula. As far as we know, this is the first study evaluating the effect of m-BA on POPF from this perspective in the literature.

Clinically relevant postoperative pancreatic fistula and related complications continue to be the most important cause of morbidity and mortality after PD. These complications (such as intra-abdominal abscess, sepsis, and massive aneurysmatic bleeding) cause prolonged hospitalization and sometimes mortality.[7] In our study, we found that m-BA reduced the rate of POPF-related serious complications, primarily by reducing the rate of CR-POPF, and shortened the length of hospital stay, similar to the result of the study by Li et al.[8] While no mortality due to CR-POPF occurred in the m-BA group, it was seen in 2 patients in the TA group. We also found that, with the decrease in the CR-POPF rate, the POPF-related reoperation rate also decreased in the m-BA group. In our opinion, this result is one of the most important advantages provided by m-BA anastomosis, which reduces the transition from the BL stage to the Grade B fistula.

It was stated in previous studies that many unchangeable factors such as high BMI, soft pancreas texture, small Wirsung diameter, and excessive blood loss were the predictive factors for POPF.[21,22] In addition, the surgeon's experience and the anastomosis technique were essential changeable factors.[9] In this study, the surgeon factor was eliminated as a single surgeon performed the operations. Because we think that in studies with more than one operator, the surgical outcomes may be affected depending on the surgeon factor. Thus, the only changeable factor of this study was the anastomosis technique.

The fact that the TA group was operated in the first 3 years and the m-BA group was operated in the next period may raise a question about whether the increased surgical experience affects the results. Surgical experience is very important in such a study where 2 anastomosis techniques are compared, and it is possible that it may affect the results. However, when the results were reviewed, we found that the operative time and the postoperative outcomes (complications, reoperation, and hospital mortality), which are the main parameters that show the effects of surgical experience, were similar between the groups. In addition, the decrease in the

CR-POPF ratio only in the m-BA group, while the total POPF ratios did not change between the groups, is the main reason why we consider this impressive outcome as a result of the anastomosis technique rather than the increase in surgical experience.

In addition, the rate of blood transfusion was higher in the m-BA group in the present study. We attributed this to the following reason: vascular resection and reconstruction rate was higher in the m-BA group; thus, the blood loss was heightened as expected.

In the univariate and multivariate analyses performed to determine the risk factors associated with CR-POPF, we found that the only independent and negative predictive factor was m-BA. This was similar to the study by Li et al.[23]

The study's strengths are that the same surgeon performed all operations; thus, the procedures could be standardized, and also the clinical and demographical data of the patients were homogenous. The retrospective design of the study is a limitation.

CONCLUSION

Compared to TA, m-BA decreases the rate of transition from BL to CR-POPF and POPF-related reoperation and also shortens the length of hospital stay. In addition, m-BA is an independent and negative predictive factor for the development of CR-POPF. Therefore, it is a valuable alternative P-J technique for PD with better postoperative outcomes.

Ethics Committee Approval: This study was approved by the medical ethics committee of Ondokuz Mayıs University School of Medicine (2021/174).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer Review: Externally peer-reviewed.

Author Contributions: Consept – O.Ö., M.C.A.; Design – O.Ö., M.C.A.; Supervision – O.Ö., M.C.A.; Resources – O.Ö., M.C.A.; Materials – O.Ö., M.C.A.; Data Collection and/or Processing – O.Ö., M.C.A.; Analysis and/or Interpretation – O.Ö., M.C.A.; Literature Search – O.Ö., M.C.A.; Writing Manuscript – O.Ö., M.C.A.; Critical Review – O.Ö., M.C.A.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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