Original Article

Patient allocation based on preoperative assessment of pancreatic fibrosis to secure pancreatic anastomosis performed by trainee surgeons: A prospective study

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Abstract

Background: A fragile or non-fibrotic pancreas increases the risk of postoperative pancreatic fistula (POPF) after pancreatic head resection, whereas pancreatic fibrosis decreases the risk. The degree of pancreatic fibrosis can be estimated using the time-signal intensity curve (TIC) of the pancreas, obtained from dynamic magnetic resonance imaging (MRI). We investigate whether trainee surgeons can perform pancreatic anastomosis safely, without POPF, when patients are selected carefully by the preoperative assessment of pancreatic fibrosis.

Methods: Seventy-two consecutive patients who underwent pancreatic head resection were enrolled in this prospective trial. Dynamic contrast-enhanced MRI of the pancreas was done preoperatively in all patients, who were allocated to one of two groups based on their pancreatic TIC profile: Group A comprised patients with type I pancreatic TIC, indicating a normal pancreas without fibrosis (n=46); and Group B comprised patients with type II or III pancreatic TIC, signifying a fibrotic pancreas (n=26). An end-to-side duct-to-mucosa pancreaticojejunostomy was performed in all patients; by two experienced surgeons in Group A and by one of eight trainee surgeons at various stages of training in Group B.

Results: There was no operative mortality. POPF developed in 19 patients; as grade A in 12 and grade B in 7. All except one of the POPFs occurred in Group A, with a grade A POPF recognized in one patient from Group B (p<0.001).

Conclusions: Even a trainee surgeon can perform a secure pancreatic anastomosis without subsequent POPF in patients with a pancreas displaying a fibrotic pancreatic TIC on dynamic MRI.

Introduction

Pancreaticoduodenectomy is the treatment of choice for many benign and malignant pancreatic and periampullary diseases. Recently, mortality after pancreatico-duodenectomy has decreased to below 2% in specialized units; however, morbidity remains as high as 40% to 50%.[1-4] Postoperative pancreatic fistula (POPF), which is often associated with subsequent abdominal abscess, sepsis, and erosive hemorrhage, is the most problematic complication and represents a leading cause of morbidity and mortality after pancreaticoduodenectomy.[1-7]

The most generally accepted determinants of POPF after pancreatico-duodenectomy are the anatomic features of the pancreatic remnant, such as a small pancreatic duct[3,8,9] and soft pancreatic texture.[2,9-12] In contrast, the risk of POPF decreases remarkably with the presence of pancreatic fibrosis at the resection margin.[10,12-14] We showed how the time-signal intensity curve (TIC) of the pancreas obtained from dynamic contrast-enhanced magnetic resonance imaging (MRI) reflects the histological degree of pancreatic fibrosis.[15,16] A pancreatic TIC with a rapid rise to a peak followed by a rapid decline (type I) was characteristic of a normal pancreas without fibrosis and pancreatic TICs with a slow rise to a peak followed by a slow decline or a plateau (types II and III) indicated a fibrotic pancreas. Fibrosis ratios of pancreases with types I, II, or III TICs were 4.1% (range, 1.8-8.2), 13.3% (range, 7.5-20.2), and 21.2% (range, 17.8-25.5), respectively.[16] Therefore, the pancreatic TIC provides reliable information for predicting the risk of POPF after a pancreatic head resection.[17] In addition, the pancreatic TIC profile reflects the anatomic condition of the pancreatic remnant related to POPF more precisely than the surgeon's palpation at the time of the operation.[17]

Thus, we hypothesized that appropriate patient selection by means of a pancreatic fibrosis assessment could result in performing a secure pancreatic anastomosis. We prospectively investigated whether a preoperative assessment of pancreatic fibrosis using pancreatic TIC analysis from dynamic MRI allows the young trainee surgeon to perform a successful pancreatic anastomosis without POPF after pancreatic head resection.

Patients and Methods

The subjects of this prospective study were 72 consecutive patients who underwent an elective pancreatic head resection at our institute between February, 2006 and August, 2009, for benign or malignant pathologies of the pancreatic or periampullary region. The study protocol was approved by the Institutional Review Board of Nagasaki University Hospital (IRB 07050266). Informed consent was obtained preoperatively from all participating patients, comprising 38 men and 34 women with a mean age of 70 years (range 38 to 86 years). Pancreatic head resection was achieved with a pylorus- preserving pancreaticoduodenectomy (PPPD, n=52), pancreas head resection with segmental duodenectomy (PHRSD, n=10), classic pancreaticoduodenectomy (PD, n=6), or duodenum-preserving total pancreas head resection (DPPHR, n=4).

Preoperative assessment of pancreatic fibrosis and patient registration

All 72 patients underwent dynamic contrast-enhanced MRI of the pancreas prior to surgery. The pancreatic MRI was conducted using the 1.5-T superconducting system (SIGNA Horizon LXTM; GE Medical Systems, Milwaukee, WI). We used a fat-suppressed three-dimensional fast spoiled gradient re-called echo sequence with the following imaging parameters: TR/TE, 6.0-6.1/1.3-1.4 msec; flip angle, 20°; section thickness, 6-8 mm; no intersection gap; matrix, 256 × 160; 1 excitation; field of view, 32-36 cm. The dynamic series comprised five individual dynamic images, obtained before, and then 25 s and 1, 2, and 3 min after a rapid bolus injection of 0.1 mmol meglumine gadopentetate (Magnevist®; Schering, Berlin, Germany)/kg body weight. The contrast medium was administered intravenously at 3 ml/s using an automated injector, and followed by flushing with 20 ml saline solution. The original MRI data were then loaded onto a workstation and radiologists positioned the region of interest (ROI) at the pancreatic parenchyma, anterior to the superior mesenteric artery, as for the presumed transection line of the pancreas, in each patient. The pancreatic TIC was then generated as a percentage increase in the signal intensity (SI), according to the following enhancement formula: (SIpost-SIpre)/SIpre × 100, where SIpre and SIpost represent the pre- and post-contrast SIs, respectively.[16] The patterns of pancreatic TIC were classified into three types (**Fig. 1**): type-I, characterized by a rapid rise to a peak, 25 s after the injection of contrast material, followed by a rapid decline; type-II, characterized by a slow rise to a peak, 1 min after the administration of contrast material, followed by a slow decline; and type-III, characterized by an even slower rise to a peak, 2 min after the administration of contrast material, followed by a slow decline or plateau.

In strict accordance with the pancreatic TIC profile, the patients were allocated to one of the following two groups: Group A, patients with type I pancreatic TIC, thus indicating a normal pancreas without fibrosis; and Group B, patients with type II or III pancreatic TIC, signifying fibrotic pancreas.[16,17]

Surgical techniques

All operations were performed by a team of surgeons who specialized in hepatobiliary and pancreatic surgery. The operative procedures for pancreatic resection; namely, PD, PPPD, PHRSD, and DPPHR, were selected according to the nature of the diseases. Patients with malignancy also underwent regional lymph node dissection, which included clearance of the soft tissue and nodes around the head of the pancreas and along the common hepatic artery and the hepatoduodenal ligament.

Pancreaticoenteric anastomosis was done using the same technique in all patients after completing the pancreatic head resection. An end-to-side, duct-to-mucosa, two-layer pancreaticojejunostomy was performed in the Roux-en Y fashion with interrupted sutures using 5-0 or 6-0 polydioxanone (PDSII; Ethicon, inc, Somerville, NJ) for a duct-to-mucosa anastomosis and 4-0 polypropylene (Prolene; Ethicon, Inc, Somerville, NJ) for an approximation between the pancreatic stump and the jejunal wall. In Group A, pancreaticojejunostomy was performed by two senior surgeons with more than 15 years of surgical experience, whereas in Group B, the pancreatic anastomosis was carried out by one of eight trainee surgeons at various stages of training with 4 to 6 years of experience in gastroenterological surgery. One trainee had performed two pancreatic anastomoses, two had performed one, and the other five had not performed any pancreaticoenteric anastomoses before the study began. First, the trainees scrubbed on the patients in Group A at least 3 cases, and they were encouraged to watch video tutorials on pancreatic head resection and to simulate the anastomotic procedure prior to performing a pancreatic anastomosis as an operating surgeon. Then, the trainees initiated pancreatic anastomosis under the supervision of a senior surgeon (Y.T.). No pancreatic duct stent was used in Group B. No sealants were used in either group. Two closed suction drains were routinely placed near the biliary and pancreatic anastomoses and a nasogastric tube was placed in each patient.

Perioperative management

All patients received intravenous broad-spectrum antibiotics for the first 2 postoperative days (PODs) and an H2 blocker during the entire postoperative hospital course. No prophylactic somatostatin or Octreotide was given. The nasogastric tube was removed when the bowel sounds returned, usually on POD 1 or 2. Patients fasted for the first 2 PODs, after which oral intake was gradually resumed if there was no evidence of POPF, delayed gastric emptying, or other intra-abdominal complications. The peribiliary and peripancreatic drains were removed on POD3 and POD5, respectively, in both groups as long as the recovery was uneventful. If there was evidence of POPF or any sign of an infective complication, the drains were left in place until the problem resolved.

Pre-, intra- and post-operative data

Preoperative data included age, gender, concentrations of serum albumin, total bilirubin and hemoglobin, lymphocyte counts, creatinine clearance, oral glucose tolerance test (OGTT) results, hemoglobin A1c (HbA1c) levels, *N*-benzoyl-L-tyrosyl-*p*-aminobenzoic acid (BT-PABA) test results, and biliary drainage. An abnormal glycemic response to the OGTT was defined according to the criteria proposed by the American Diabetes Association.[18]

Intraoperative data included the texture of the remnant pancreas, the diameter of the pancreatic duct (>3mm or ≦3mm), the type of pancreatic resection (PPPD, PD, PHRSD, or DPPHR), the type of lymphadenectomy (non or regional), the presence or absence of a pancreatic duct stent, operative time, intraoperative blood loss, blood transfusion, and the pathology of pancreatic and periampullary diseases. The texture of the pancreatic remnant at the site of transection was classified by the operating surgeon as soft (normal, friable), intermediate, or hard (fibrotic, sclerotic). The diameter of the main pancreatic duct was measured at the cut surface of the pancreatic remnant.

Data on the postoperative course and complications were collected. The drainage fluid amylase levels were measured on PODs1, 3, and 5. The occurrence of POPF, overall morbidity, hospital mortality, number of days until oral intake was resumed, number of days on total parenteral nutrition (TPN), duration of peripancreatic drain placement, and length of postoperative hospital stay were also evaluated.

Study end point

The end point of the primary study was POPF. Based on the International Study Group for Pancreatic Fistula (ISGPF) clinical criteria,[19] POPF was defined as the output via a peripancreatic drain of any measurable volume of drainage fluid, on or after POD3, associated with an elevated amylase content greater than three times the upper limit of the normal serum amylase value (>390 IU/L). The severity of POPF was classified into three grades as follows: grade A, transient, asymptomatic fistulas with elevated amylase levels only in the drainage fluid, for which treatments or deviation in clinical management are not required; grade B, clinically apparent, symptomatic fistulas requiring diagnostic evaluation and therapeutic management; and grade C, severe fistulas requiring major deviations in clinical management and aggressive therapeutic intervention.[19]

Statistical analyses

Continuous data are expressed as means ± SD. Comparisons of categorical and continuous variables between the two study groups were performed using standard univariate statistical tests: the chi-square test, two-tailed Fisher's exact test, and Mann-Whitney's *U*-test, where appropriate. Values of $p<0.05$ were considered significant. All confidence intervals were at the 95% level.

Results

The pancreatic TIC profiles were type I in 46 patients, type II in 24, and type III in 2. Therefore, 46 patients were assigned to Group A and 26 to Group B. The baseline demographics of the two study groups are compared in **Table 1**. Group A comprised 27 men and 19 women, with a mean age of 69 years, and Group B comprised 11 men and 15 women, with a mean age of 70 years. There were no significant differences between the groups. The groups were also similar in preoperative laboratory parameters and the need for preoperative biliary drainage. The glycemic response to OGTT was significantly worse in Group B than in Group A (p<0.001) and the serum concentration of HbA1c was higher in Group B than in Group A (6.7% vs. 5.7%, p=0.003). Furthermore, the mean value of the BT-PABA test results was significantly lower in Group B than in Group A (55% vs. 67%, p=0.008).

Intraoperative data and pathological diagnoses are shown in **Table 2**. The two study groups were comparable in the proportion of specific surgical techniques used for pancreatic resection, the extent of lymphadenectomy, operative time, intraoperative blood loss, and blood transfusion requirements. In Group A, the main indications for surgery were intraductal papillary mucinous neoplasm (IPMN) of the pancreas (mainly the branch-duct type), carcinoma of the bile duct, and carcinoma of the papilla of Vater, whereas in Group B, they were pancreatic ductal carcinoma, IPMN of the pancreas (mainly the main-duct type), and alcoholic chronic pancreatitis. There was a significant difference in pathology between the two groups. The texture of the remnant pancreas was soft in 38 of the 46 Group A patients, while 16 Group B patients had a hard pancreas and 10 had a pancreatic gland intermediate in texture. This difference was also significant (p<0.001). A small pancreatic duct ≦ 3mm in diameter was recognized in

35 of the 46 Group A patients, whereas a dilated pancreatic duct > 3 mm in diameter was identified in 17 of the 26 patients in Group B ($p<0.001$).

Table 3 summarizes the postoperative outcomes. POPF was identified in 19 (26.4%) patients overall. The POPF was classified as grade A, being transient and asymptomatic with only elevated drain amylase values in 12 patients, and as grade B in 7 patients, who required percutaneous drainage of an amylase-rich or infected peripancreatic intra-abdominal collection followed by conservative treatment with TPN, antibiotics, and/or Octreotide. There was no case of grade C POPF. Thus, the incidence of clinically relevant POPF (grade B or C) was 9.7% in this study. All except one of the POPFs developed in Group A. The only exception was a grade A POPF recognized in a patient in Group B, who had a slightly elevated drain fluid amylase value of 548 IU/L on POD3. The incidence of POPF of any extent was 39.1% in Group A and 3.8% in Group B, which was significant ($p<0.001$). The occurrence of clinically relevant POPF was also significantly higher in Group A than in Group B (15.2% vs. 0%, $p=0.044$). All POPFs developed in patients with a pancreas of soft (n=15) or intermediate (n=4) texture. The pancreatic TICs of 18 patients with a pancreas of intermediate consistency were type-I in 8 cases and type-II in 10. Among them, 3 patients with type-I TIC developed POPF (Grade A in 2 and Grade B in 1) and, contrarily, only one patient with type-II TIC showed POPF (Grade A). The median values of amylase in the drainage fluid on PODs 1, 3, and 5 were 3,549 IU/L, 1,025 IU/L, and 389 IU/L, respectively, in Group A and 439 IU/L, 80 IU/L, and 25 IU/L, respectively in Group B, being significantly different at each point. Other major postoperative complications included pulmonary complications (21%), delayed gastric emptying (11%), wound infection (7%), ascending cholangitis (6%), and biliary leakage (3%). Although there was a trend toward higher overall morbidity in Group A, no significant difference was found between the groups. No fatal complications, such as erosive hemorrhage caused by rupture of a pseudoaneurysm, were observed, and there was no operative mortality. None of the patients required relaparotomy. The duration of peripancreatic drain placement, total number of days on TPN, and postoperative hospital stay were significantly longer in Group A than in Group B.

Discussion

Factors contributing to the dramatic decline in mortality after pancreatico-duodenectomy include a better understanding of pancreatic disease, better patient selection, and the development of subspecialization or centralization of this complex operation,[20-24] as well as advances in operative techniques and perioperative critical care management. However, morbidity remains high and POPF is still the most common and potentially lethal postoperative complication after pancreaticoduodenectomy. Leakage of a pancreatic anastomosis can lead not only to a variety of clinical sequelae in the early postoperative course, but also to the development and progression of fibrosis in the pancreatic remnant associated with pancreatic functional deficiency as a late postoperative complication.[17]

The anatomic condition of the pancreatic remnant is known to be closely associated with the occurrence of POPF after pancreaticoduodenectomy and a non-fibrotic fragile pancreas is likely to predispose to the development of POPF.[2,9-12,16,17] Conversely, the risk of POPF decreases with the presence of pancreatic fibrosis.[10,12-14,16,17] Pancreatic TIC analysis based on dynamic contrast-enhanced MRI is a reliable and non-invasive technique of evaluating the histological degree of pancreatic fibrosis and can predict the risk of POPF after pancreatic head resection.[15-17] In our previous study,[15] POPF occurred in 25% of 52 patients with type I pancreatic TIC, but in only 1 (3%) of 37 patients with type II or type III TIC, after pancreatic head resection.

A pancreas displaying a fibrotic TIC is unlikely to be predisposed to the development of a POPF even after distal pancreatectomy.[25] Thus, we tested the hypothesis that appropriate patient selection based on a preoperative assessment of pancreatic fibrosis could result in complication-free pancreatic anastomoses, and our prospective trial clearly demonstrated evidence that after pancreatic head resection, POPF rarely developed in patients with a type II or III pancreatic TIC, even when the pancreatic anastomosis was performed by young trainee surgeons. In contrast, patients with type I pancreatic TIC had a high incidence of POPF even in the hands of experienced surgeons.

The indications for pancreatic resection differed between the two groups, being bile duct carcinoma, branch-duct IPMN of the pancreas, and ampullary carcinoma in Group A, and pancreatic ductal carcinoma, main-duct IPMN of the pancreas, and chronic pancreatitis in Group B. Carcinomas and main-duct IPMNs of the head of the pancreas, as well as chronic pancreatitis, are characterized by degrees of fibrosis in the distal pancreas caused by obstructive chronic pancreatitis[26-28] or by the stimulation of pancreatic stellate cells.[29,30] The pancreatic TIC should reflect these fibrous changes clearly. The grouping based on pancreatic TIC analysis also reflected well the anatomic condition of the pancreatic remnant. The harder texture of the remnant pancreatic gland and the larger pancreatic duct, associated with exocrine pancreatic dysfunction, were identified significantly more often in the Group B patients. This was thought to allow a more robust anastomosis and a lower output of pancreatic enzymes, reducing the risk or effect of POPF after pancreatic head resection.

To perform effective, safe pancreatic anastomosis requires knowledge and skill. On the other hand, trainee motivation is essential for learning because it fuels participation and ensures persistent efforts to improve performance.[31,32] Without trainee motivation, any educational curriculum will have limited success. Although pancreaticoduodenectomy is a complex procedure and surgical training should cover the entire process in every subset of patients, the performance of a secure pancreatic anastomosis without POPF greatly promoted trainee interest, motivated trainees to work harder on their skills, and ensured their satisfaction and participation in training in this study. To train young surgeons is always crucial, but trainees often have inadequate operative experience in pancreatic surgery due to its technical complexity and the risk of hazardous postoperative complications along with the limited number of available cases. The pancreatic TIC analysis showed that more than one-third of the patients (26/72) who underwent pancreatic head resection in this series had a fibrotic pancreas, indicating that they were the most suitable candidates for a safe pancreatic anastomosis performed by the unexperienced surgeons.

The reconstruction of pancreaticoenteric anastomosis after pancreatic head resection remains a contentious issue for the pancreatic surgeon. Although various techniques of managing the pancreatic remnant have been studied in relation to anastomotic leak, at present there is no consensus about how best to perform a safe pancreatic anastomosis.[33] However, the careful selection of patients allows even trainee surgeons to perform pancreatic anastomosis safely without resulting POPF. A surgical training system using pancreatic TIC analysis would promote trainee interest, ensure their satisfaction and participation in training, and lead to an effective and efficient way of acquiring advanced skills for pancreatic surgery.

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Figure Legend

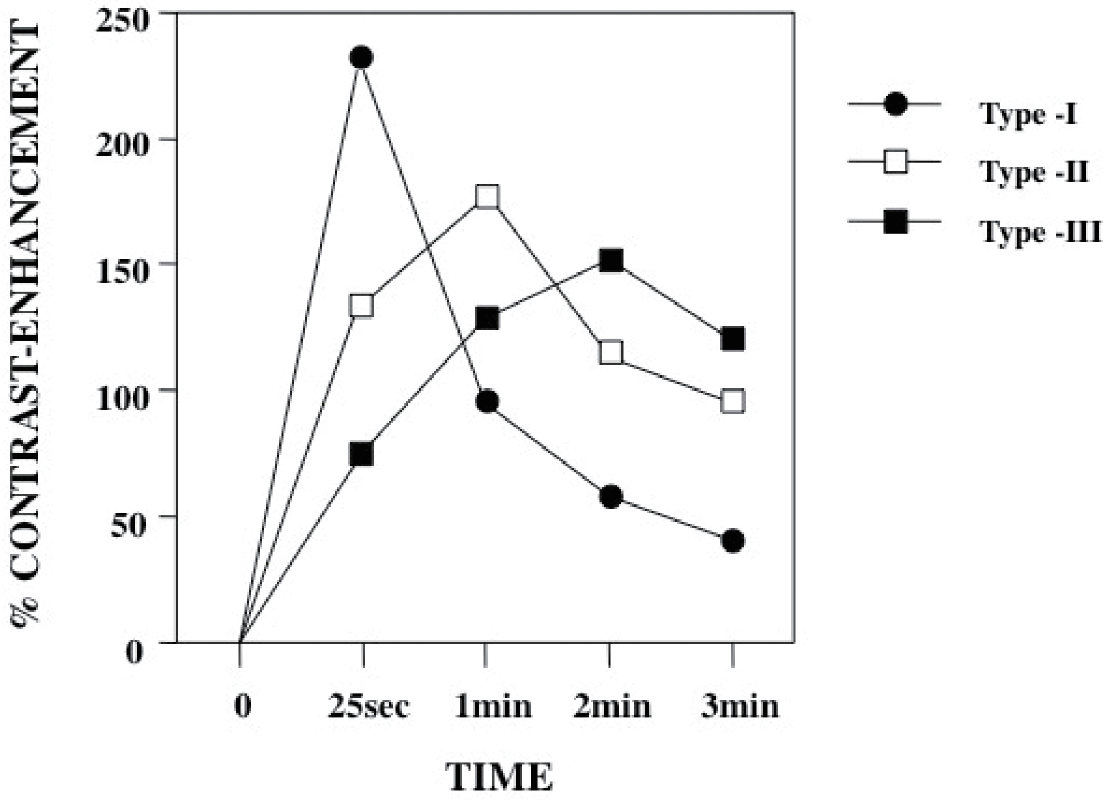

Fig. 1. Patterns of the time-signal intensity curve (TIC) from dynamic contrast-enhanced magnetic resonance images of the pancreas. A type I TIC exhibits a rapid rise to a peak, 25 s after the injection of meglumine gadopentetate, followed by a rapid decline. Type II and type III TICs exhibit a slow rise to a peak, 1 and 2 min after the administration of meglumine gadopentetate, followed by a slow decline or plateau, respectively.

Table 1. Baseline demographics

	Overall (n = 72)	Group A; type I TIC (n = 46)	Group B; type II or III TIC (n = 26)	*P* value
Age (years) (mean ± SD)	69.8±9.7	69.2±9.7	70.4±10.9	0.713
Gender				0.181
Male	38	27 (71)	11 (29)	
Female	34	19 (56)	15 (44)	
Preoperative laboratory values				
Lymphocyte (1000/mm^3)	2.0±0.7	1.9±0.4	2.0±0.5	0.285
Hemoglobin (g/dl)	12.6±0.8	12.7±0.8	12.4±0.9	0.581
Albumin (g/dl)	3.8±0.9	3.9±0.7	3.7±0.6	0.288
Total bilirubin (mg/dl)	3.1±4.1	2.8±3.9	3.5±4.3	0.555
Creatinine clearance (ml/min)	68±20	69±19	67±18	0.392
Preoperative OGTT				<0.001
Normal	42	34 (81)	8 (19)	
Impaired, Diabetic	30	12 (40)	18 (60)	
Preoperative hemoglobin A1c (%)	6.1±1.6	5.7±1.1	6.7±2.1	0.003
Preoperative BT-PABA test (%)	61.8±16.1	67.4±15.6	55.0±14.8	0.008
Preoperative biliary drainage				0.934
Yes	30	19 (63)	11 (37)	
No	42	27 (64)	15 (36)	

Values in parentheses represent the percentages of the row totals.

TIC: time-signal intensity curve of the pancreas obtained from dynamic contrast-enhanced magnetic resonance imaging (MRI)

OGTT: oral glucose tolerance test

BT-PABA: *N*-benzoyl-L-tyrosyl-*p*-aminobenzoic acid

Table 2. Intraoperative data and pathological diagnoses

	Overall (n = 72)	Group A; type I TIC (n = 46)	Group B; type II or III TIC (n = 26)	*P* value
Type of pancreatic resection				0.949
PPPD	52	32 (62)	20 (38)	
PHRSD	10	7 (70)	3 (30)	
PD	6	4 (67)	2 (33)	
DPPHR	4	3 (75)	1 (25)	
Texture of the pancreas				<0.001
Soft	38	38(100)	0 (0)	
Intermediate	18	8 (44)	10 (56)	
Hard	16	0 (0)	16(100)	
Pancreatic duct size (mm)				<0.001
≦3	44	35 (80)	9 (20)	
>3	28	11 (39)	17 (61)	
Lymphadenectomy				0.286
Non	5	3 (60)	2 (40)	
Regional	67	43 (64)	24 (36)	
Use of a pancreatic duct stent				<0.001
Yes	24	24(100)	0 (0)	
No	48	22 (46)	26 (54)	
Operative time (hours) (mean ± SD)	8.3±1.6	8.4±1.5	8.1±1.4	0.626
Blood loss (ml)	1228±927	1287±1066	1030±608	0.177
Blood transfusion				0.623
With	28	19 (68)	9 (32)	
Without	44	27 (61)	17 (39)	
Pathology				0.001
IPMN of the pancreas	22	16 (73)	6 (27)	
Bile duct carcinoma	18	15 (83)	3 (17)	
Pancreatic ductal carcinoma	17	4 (24)	13 (76)	
Ampullary carcinoma	6	6 (100)	0 (0)	
Chronic pancreatitis	4	0 (0)	4 (100)	
Others	5	5 (100)	0 (0)	

Values in parentheses represent percentages of the row totals.

TIC: time-signal intensity curve of the pancreas obtained from dynamic contrast-enhanced magnetic resonance imaging (MRI)

PPPD: pylorus-preserving pancreaticoduodenectomy

PHRSD :pancreatic head resection with segmental duodenectomy

PD: pancreaticoduodenectomy

DPPHR: duodenum-preserving total pancreatic head resection

IPMN: Intraductal papillary mucinous neoplasm

Table 3. Postoperative outcomes

	Overall (n = 72)	Group A; type I TIC (n = 46)	Group B; type II or III TIC (n = 26)	*P* value
Pancreatic fistula*				<0.001
Grade A	12	11 (92)	1 (8)	
Grade B	7	7 (100)	0 (0)	
Grade C	0	0	0	
No fistula	53	28 (53)	25 (47)	
Clinically relevant pancreatic fistula*, **				0.044
Yes	7	7 (100)	0 (0)	
No	65	39 (60)	26 (40)	
Drain fluid amylase levels (IU/L) (mean ± SD) on;				
POD1	2,549±2,457	3,549±2,474	439±283	<0.001
POD3	668±1,962	1,025±2,193	80±131	0.033
POD5	283±756	389±940	25±28	0.042
Overall morbidity (%)	43.1	47.8	34.6	0.426
Hospital mortality (%)	0	0	0	-
Days to resuming oral intake	4.2±4.3	4.6±5.2	3.2±1.4	0.082
Duration of peripancreatic drain placement (days)	9.9±11.2	12.6±12.5	5.6±1.2	0.014
Days on total parenteral nutrition	6.0±7.2	7.1±7.5	3.6±2.1	0.046
Postoperative hospital stay (days)	26.1±14.6	28.8±15.8	21.1±10.9	0.045

Values in parentheses represent the percentages of the row totals.

*; pancreatic fistula was defined and graded based on the International Study Group for Pancreatic Fistula (ISGPF) clinical criteria

**; clinically relevant pancreatic fistula includes grade B and grade C pancreatic fistula.

TIC: time-signal intensity curve of the pancreas obtained from dynamic contrast-enhanced magnetic resonance imaging (MRI)

POD: postoperative day