

Retrospective Study

Application of single-layer mucosa-to-mucosa pancreaticojejunal anastomosis in pancreaticoduodenectomy

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Abstract

AIM: To investigate the simplicity, reliability, and

safety of the application of single-layer mucosa-to-mucosa pancreaticojejunal anastomosis in pancreaticoduodenectomy.

METHODS: A retrospective analysis was performed on the data of patients who received pancreaticoduodenectomy completed by the same surgical group between January 2011 and April 2014 in the General Hospital of the People's Liberation Army. In total, 51 cases received single-layer mucosa-to-mucosa pancreaticojejunal anastomosis and 51 cases received double-layer pancreaticojejunal anastomosis. The diagnoses of pancreatic fistula and clinically relevant pancreatic fistula after pancreaticoduodenectomy were judged strictly by the International Study Group on pancreatic fistula definition. The preoperative and intraoperative data of these two groups were compared. χ^2 test and Fisher's exact test were used to analyze the incidences of pancreatic fistula, peritoneal catheterization, abdominal infection and overall complications between the single-layer anastomosis group and double-layer anastomosis group. Rank sum test were used to analyze the difference in operation time, pancreaticojejunal anastomosis time, postoperative hospitalization time, total hospitalization time and hospitalization expenses between the single-layer anastomosis group and double-layer anastomosis group.

RESULTS: Patients with grade A pancreatic fistula accounted for 15.69% (8/51) vs 15.69% (8/51) ($P = 1.0000$), and patients with grades B and C pancreatic fistula accounted for 9.80% (5/51) vs 52.94% (27/51) ($P = 0.0000$) in the single-layer and double-layer anastomosis groups. Although there was no significant difference in the percentage of patients with grade A pancreatic fistula, there was a significant difference in the percentage of patients with grades B and C pancreatic fistula between the two groups. The

operation time (220.059 ± 60.602 min *vs* 379.412 ± 90.761 min, $P = 0.000$), pancreaticojejunal anastomosis time (17.922 ± 5.145 min *vs* 31.333 ± 7.776 min, $P = 0.000$), postoperative hospitalization time (18.588 ± 5.285 d *vs* 26.373 ± 15.815 d, $P = 0.003$), total hospitalization time (25.627 ± 6.551 d *vs* 33.706 ± 15.899 d, $P = 0.002$), hospitalization expenses (116787.667 ± 31900.927 yuan *vs* $162788.608 \pm 129732.500$ yuan, $P = 0.001$), as well as the incidences of pancreatic fistula [$13/51$ (25.49%) *vs* $35/51$ (68.63%), $P = 0.0000$], peritoneal catheterization [$0/51$ (0%) *vs* $6/51$ (11.76%), $P = 0.0354$], abdominal infection [$1/51$ (1.96%) *vs* $11/51$ (21.57%), $P = 0.0021$], and overall complications [$21/51$ (41.18%) *vs* $37/51$ (72.55%), $P = 0.0014$] in the single-layer anastomosis group were all lower than those in the double-layer anastomosis group.

CONCLUSION: Single-layer mucosa-to-mucosa pancreaticojejunal anastomosis appears to be a simple, reliable, and safe method. Use of this method could reduce the postoperative incidence of complications.

Key words: Pancreaticojejunal anastomosis; Pancreatic fistula; Pancreaticoduodenectomy

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Core tip: Pancreaticoduodenectomy is a complex surgical procedure with a high perioperative complication rate and a high mortality rate, therefore, pancreaticoduodenectomy is considered a dangerous surgery. Pancreaticojejunal anastomosis plays an important role in pancreaticoduodenectomy; its success determines the success of the surgery. In our study, there was a significant difference in the percentage of patients with grades B and C pancreatic fistula between the two groups. Single-layer anastomosis was better than double-layer anastomosis when the pancreatic texture was soft. The use of this method could reduce the rates of postoperative pancreatic fistula, abdominal infection and peritoneal catheterization.

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INTRODUCTION

Pancreaticoduodenectomy is the primary surgical method for the treatment of pancreatic head tumors, distal bile duct tumors, ampullary tumors, duodenal tumors, and duodenal papilla tumors. However, because it is a complex surgical procedure with a high

perioperative complication rate and a high mortality rate, pancreaticoduodenectomy is considered a dangerous surgery. In the literature, the reported incidence of postoperative pancreatic fistula associated with this procedure differs due to the use of different definitions of pancreatic fistula; overall, the incidence ranges from 10% to greater than 30%^[1-4]. Pancreatic fistula was associated with delayed gastric emptying, intra-abdominal abscess, local infection at the incision site, sepsis, and blood loss after pancreaticoduodenectomy^[5-8]. Although the complication and mortality rates associated with pancreatic fistula have decreased due to improvements in perioperative management, surgical techniques and timely and proper management of postoperative complications^[5,9,10], the incidence of postoperative complications during the perioperative period is still 30%-60%^[11-15].

Pancreaticojejunal anastomosis plays an important role in pancreaticoduodenectomy; its success determines the success of the surgery. Currently, pancreaticojejunal anastomosis is considered a weak link in pancreaticoduodenectomy^[16,17]. Although several advocated methods of pancreaticojejunal anastomosis are considered to be able to reduce the occurrence of pancreatic fistula, the question of which pancreaticojejunal anastomosis method is best is still debatable^[18-25]. This study describes a new, safe, simple, easy-to-suture, and reliable method for pancreaticojejunal anastomosis.

MATERIALS AND METHODS

General information

This study retrospectively analyzed data on pancreaticoduodenectomies completed by the same surgical group between January 2011 and April 2014 at our hospital. In these surgeries, a variety of pancreaticojejunal anastomosis methods were used, including single-layer mucosa-to-mucosa pancreaticojejunal anastomosis (referred to hereafter as single-layer anastomosis) and double-layer mucosa-to-mucosa pancreaticojejunal anastomosis (referred to hereafter as double-layer anastomosis). Patients whose surgery involved either of these two pancreaticojejunal anastomosis methods in pancreaticoduodenectomy were enrolled, and patients who did not meet the inclusion criteria for the study were excluded. There were 102 patients in the two groups, with 51 cases in each group. Of these patients, 19 had hypertension, 14 had a history of diabetes mellitus, 30 had a past history of drinking, 27 had a history of smoking, and 14 cases had a history of abdominal surgery. There were 62 males and 40 females. Other general information on these patients is presented in Tables 1 and 2. All 102 cases were confirmed by postoperative pathology (Table 3).

Double-layer anastomosis group

General information: There were 51 patients in

Table 1 General information on patients in the single-layer anastomosis group

Item	Mean value	Standard deviation	Minimum value	Maximum value
Age (yr)	58.804	9.466	38.000	79.000
BMI (kg/m ²)	22.866	2.755	17.900	29.400
Albumin (g/L)	38.039	3.891	26.100	45.000
Blood glucose (mol/L)	6.472	2.540	3.960	16.610
Total bilirubin (μmol/L)	122.618	122.204	6.400	412.600
Alkaline phosphatase (u/L)	359.631	258.629	39.900	1396.900
r-GT	620.853	522.464	7.000	2503.200
Operation time (min)	220.059	60.602	135.000	480.000
Pancreaticojejunal anastomosis time (min)	17.922	5.145	11.000	40.000
Amount of blood loss (mL)	292.549	146.940	100.000	800.000
Pancreatic duct diameter (mm)	4.863	2.322	1.000	12.000
Hospitalization time (d)	25.627	6.551	15.000	49.000
Postoperative hospitalization time (d)	18.588	5.285	7.000	33.000
Hospitalization expense (yuan)	116787.667	31900.927	64874.000	237762.000

BMI: Body mass index.

Table 2 General information on patients in the double-layer anastomosis group

Item	Mean value	Standard deviation	Minimum value	Maximum value
Age (yr)	58.020	12.820	18.000	78.000
BMI (kg/m ²)	23.858	3.272	13.360	32.690
Albumin (g/L)	39.480	4.182	29.600	50.000
Blood glucose (mol/L)	6.482	2.228	4.120	13.550
Total bilirubin (μmol/L)	73.510	78.244	3.500	313.000
Alkaline phosphatase (u/L)	303.245	268.287	42.000	1105.600
r-GT	533.655	631.956	5.800	2744.000
Operation time (min)	379.412	90.761	210.000	570.000
Pancreaticojejunal anastomosis time (min)	31.333	7.776	16.000	47.000
Amount of blood loss (mL)	482.353	293.909	50.000	1500.000
Pancreatic duct diameter (mm)	3.961	2.362	1.500	12.000
Hospitalization time (d)	33.706	15.899	16.000	105.000
Postoperative hospitalization time (d)	26.373	15.815	11.000	101.000
Hospitalization expense (yuan)	162788.608	129732.500	84497.000	968534.000

BMI: Body mass index.

the double-layer anastomosis group. Sixteen of these received pancreaticoduodenectomy (PD); of these, 3 also received combined portal vein resection and reconstruction. Thirty-five patients received pylorus-preserving pancreaticoduodenectomy (PPPD); of these, 2 also received combined portal vein resection and reconstruction.

Surgical method: The pancreas was transected at the left side of the portal vein using a surgical knife. The bleeding points on the pancreatic resection surface were sutured and ligated using 6-0 PDS II for complete hemostasis. An appropriate pancreatic duct supporting tube was placed in the pancreatic duct. The pancreatic head was resected, and the duodenum and lymph nodes were completely cleaned. Approximately 2-3 cm of the pancreatic stump was freed, and an incision approximately 0.5 cm in length was made on the jejunal wall 4-5 cm from the jejunal stump. The distal end of the pancreatic duct supporting drainage tube was placed into the jejunum loop. The pancreatic parenchyma and the jejunal seromuscular layer were intermittently

sutured using 4-0 Vicryl sutures; surgical knots were not made at this point. Next, 6-0 PDS II absorbable thread was used to intermittently penetrate the pancreatic duct and the jejunal opening to form the mucosa-to-mucosa pancreaticojejunal anastomosis using intermittent sutures for 6 stitches. One suture on the middle of the posterior wall was reserved to fix the pancreatic duct supporting tube. The intermittent suture between the pancreatic parenchyma and the jejunal seromuscular layer was ligated to complete the anastomosis. After the cholangioenteric anastomosis and gastrointestinal anastomosis were completed, two abdominal drainage tubes were inserted, one before and one after the pancreaticojejunal anastomotic site to facilitate postoperative observation and conventional monitoring of the quantity and properties of the drainage fluid and to provide samples for the measurement of indicators such as bilirubin and amylase.

Single-layer anastomosis group

General information: There were 51 patients in the single-layer anastomosis group. Twenty of these received

Table 3 Pathology data

Pathological type	Number of cases
Distal bile duct adenocarcinoma	29
Chronic inflammation at the end of the distal bile duct mucosa combined with moderate atypical dysplasia	3
Villous adenoma at the end of distal bile duct mucosa and moderate-severe atypical dysplasia of some glands	1
Ampullary adenocarcinoma	14
Duodenal stromal tumors	1
Adenocarcinoma of the descending duodenum	3
Duodenal papilla adenocarcinoma	20
Duodenal neuroendocrine tumors	2
Tubulovillous adenoma of duodenal papilla with severe atypical dysplasia of some epithelia	1
Duodenal papilla adenocarcinoma	1
Chronic pancreatitis	1
Pancreatic head adenocarcinoma	22
Solid-pseudopapillary tumor of pancreatic head	1
Neuroendocrine tumor of pancreatic head	2
Neuroendocrine carcinoma of pancreatic head	1

PD; of these, 1 also received combined portal vein resection and reconstruction. Thirty-one of the patients in this group received PPPD; 1 of these also received combined portal vein resection and reconstruction.

Surgical method: The pancreas was transected at the left side of the portal vein using a small knife. The bleeding points on the pancreatic resection surface were sutured and ligated using 5-0 prolene sutures for complete hemostasis. Appropriate pancreatic duct supporting tubes were placed in the pancreatic duct. The pancreatic head was resected, and the duodenum and lymph nodes were completely cleaned.

Step 1: The pancreatic stump was freed for approximately 3-4 cm of its length. At 1-2 cm from the pancreatic stump, the anterior wall of the pancreatic duct and the anterior wall of the pancreas were intermittently penetrated and sutured using 4-0 absorbable Vicryl sutures for 3-4 stitches; surgical knots were not made at this point, and the suture was reserved for suturing the anterior wall of the jejunal incision and for suspension of the anterior wall of the pancreatic duct. The needling direction was from the whole layer of the anterior wall of the pancreas to the inside of the anterior wall of the pancreatic duct (Figure 1A).

Step 2: The proximal jejunum was lifted, and a 0.5-0.8 cm incision was made at the jejunal wall 4-5 cm from the jejunal stump. A 4-0 absorbable Vicryl suture was used to intermittently penetrate and suture the whole layer of the posterior-lateral wall of the jejunum, the posterior-lateral wall of the pancreatic duct, and the whole layer of the posterior-lateral wall of the pancreas for a total of 5-7 stitches (3-5 stitches in the posterior wall and 1 stitch in each lateral wall). Surgical knots were not made at this point. The needling was conducted from outside the jejunum to the inside of the jejunal section for suturing; then, the posterior-lateral wall of the pancreatic duct and the whole layer of the

posterior-lateral wall of the pancreas were penetrated and sutured. The knot was tied at one side. It is important to ensure that this knot is tied properly; if it is too tight, the pancreas and the pancreatic duct may be cut; if it is too loose, the attachment will be insufficient (Figure 1B).

Step 3: A supporting tube was placed in the jejunum with its distal end projecting over the mouth of the choledochenteric anastomosis by approximately 5-8 cm. The anterior wall suspension suture was used to intermittently suture the whole layer of the anterior wall of the jejunum section; knots were then tied one by one to create an anastomosis between the pancreatic duct mucosa and the jejunal mucosa. After the pancreaticojejunal anastomosis was finished, the suture was ligated; at this point, an excellent attachment of the jejunum to the whole pancreatic stump could be observed (Figure 1C). After the choledochenteric anastomosis and gastrointestinal anastomosis were completed, abdominal drainage tubes were placed at the inferior-posterior and superior-anterior sides of the pancreaticojejunal anastomotic site to facilitate postoperative observation and conventional monitoring of the quantity and properties of the drainage fluid and to provide samples for the measurement of indicators such as bilirubin and amylase.

Postoperative treatment

After surgery, conventional infection prevention, nutrition, rehydration, and maintenance of water-electrolyte and acid-base balance were provided. All patients in both groups received total parenteral nutrition support. Conventional drugs for inhibition of pancreatic secretion were not administered after surgery. The amylase level in the drainage fluid at the pancreaticojejunal anastomotic site was measured 1, 3, 4, 5, 6, 7, and 10 d after surgery. On postoperative day 7, abdominal computed tomography (CT) was conventionally performed. If no pancreatic fistula was present 10 d after surgery, the peritoneal drainage tube at the pancreaticojejunal anastomotic site was removed. In patients with pancreatic fistula, the peritoneal drainage tube was removed after the pancreatic fistula had healed.

Observation indicators

Intraoperative blood loss, pancreaticojejunal anastomosis time, operation time, pancreatic fistula rate, abdominal infection rate, peritoneal catheterization rate, total complication rate, total hospitalization time, postoperative hospitalization time, and hospitalization expenses were recorded.

Diagnosis of pancreatic fistula

Pancreatic fistula was defined according to the ISGPF as output *via* operatively or postoperatively placed drains of any measurable volume of drainage fluid with amylase content greater than three times the upper

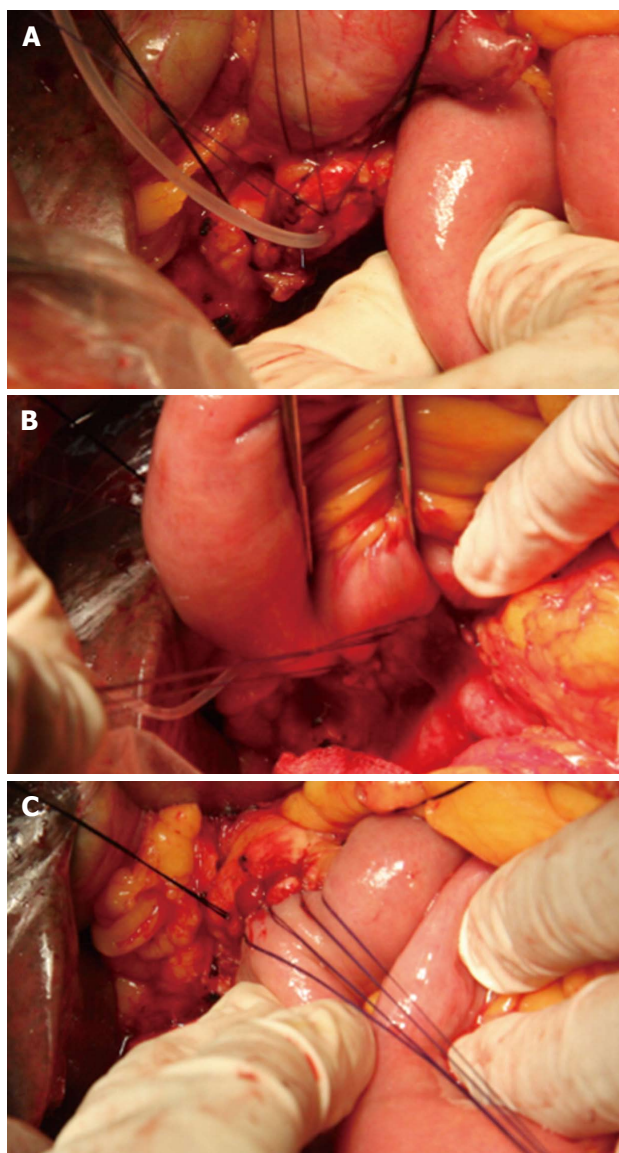


Figure 1 Surgical method using in single-layer anastomosis group. A: The pancreatic stump was freed for approximately 3-4 cm of its length; B: The proximal jejunum was lifted, and a 0.5-0.8 cm incision was made at the jejunal wall 4-5 cm from the jejunal stump; C: A supporting tube was placed in the jejunum with its distal end projecting over the mouth of the cholangioenteric anastomosis by approximately 5-8 cm.

normal serum value on or after postoperative day 3. Three grades of pancreatic fistula were determined according to the clinical severity of the individual cases. The grades were determined only after complete healing of the fistula had occurred^[26].

Statistical analysis

Statistical analyses of the data on the patients in the two groups were performed using SPSS 17.0 software. Quantitative data that did not conform to a normal distribution or that had heterogeneous variances were examined using the non-parametric rank sum test. Qualitative data were examined using the χ^2 test or the Fisher exact probability test. The examination level was $\alpha = 0.05$. $P < 0.05$ indicated that the difference was

statistically significant.

RESULTS

Comparison of preoperative and intraoperative patient data in the two groups

Gender, age, hypertension history, diabetes mellitus history, drinking history, smoking history, abdominal surgery history, preoperative biliary drainage, body mass index, total bilirubin, albumin, blood glucose, disease composition, surgical methods, jejunum-jejunum anastomosis (Braun anastomosis), pancreatic texture, and pancreatic duct diameter did not show significant differences in the two groups (Table 4).

Comparison of complications

Abdominal CT examination of 51 patients in the single-layer anastomosis group after surgery showed that the mouth of the pancreaticojejunal anastomosis and the surroundings did not have effusion. Abdominal CT examination of 51 patients in the double-layer anastomosis group after surgery showed that 6 cases had effusion surrounding the mouth of the pancreaticojejunal anastomosis. Table 5 shows the incidences of postoperative complications such as pancreatic fistula, peritoneal catheterization, abdominal infection, and total complications in the single-layer and double-layer anastomosis groups.

In the single-layer anastomosis group, patients with pancreatic fistula accounted for 25.49% (13/51), patients with grade A pancreatic fistula accounted for 15.69% (8/51), and patients with grade B pancreatic fistula accounted for 9.80% (5/51); there were no patients with grade C pancreatic fistula. In the double-layer anastomosis group, patients with pancreatic fistula accounted for 68.63% (35/51), patients with grade A pancreatic fistula accounted for 15.69% (8/51), patients with grade B accounted for 45.10% (23/51), and patients with grade C accounted for 7.84% (4/51). In the single-layer anastomosis group, 10 of the 27 patients with soft pancreas had pancreatic fistula, 2 of the 14 patients with normal pancreatic texture or mild fibrosis of the pancreas had pancreatic fistula, and 1 of the 10 patients with hard pancreas had pancreatic fistula. In the double-layer anastomosis group, 21 of the 24 patients with soft pancreas had pancreatic fistula, 10 of the 17 patients with normal pancreatic texture or mild fibrosis of the pancreas had pancreatic fistula, and 4 of the 10 patients with hard pancreas had pancreatic fistula. A comparison of the incidence of pancreatic fistula in patients with different pancreatic textures is presented in Table 6.

Comparison of intraoperative operation time, pancreaticojejunal anastomosis time, postoperative hospitalization time, total hospitalization time, and hospitalization expenses in the two groups

Because the intraoperative operation time, pancreatico-

Table 4 Comparison of patient data in the two groups, *n*

Item	Single-layer anastomosis group	Double-layer anastomosis group	P-value
Gender	Female: 21 Male: 30	Female: 19 Male: 32	0.6850
Age	> 60 yr: 24 ≤ 60 yr: 27	> 60 yr: 25 ≤ 60 yr: 26	0.8429
Hypertension	Yes: 6 No: 45	Yes: 13 No: 38	0.0750
Diabetes mellitus	Yes: 10 No: 41	Yes: 4 No: 47	0.0843
Drinking history	Yes: 14 No: 37	Yes: 16 No: 35	0.6638
Smoking history	Yes: 13 No: 38	Yes: 14 No: 37	0.8224
Abdominal surgery history	Yes: 5 No: 46	Yes: 8 No: 43	0.3731
Preoperative biliary drainage	Yes: 13 No: 38	Yes: 10 No: 41	0.4772
BMI	> 25: 13 ≤ 25: 38	> 25: 17 ≤ 25: 34	0.3847
Total bilirubin	> 171 μmol/L: 16 ≤ 171 μmol/L: 35	> 171 μmol/L: 10 ≤ 171 μmol/L: 41	0.1728
Serum albumin	≥ 35 g/L: 40 < 35 g/L: 11	≥ 35 g/L: 47 < 35 g/L: 4 cases	0.0503
Blood glucose	> 6.1 mmol/L: 19 ≤ 6.1 mmol/L: 32	> 6.1 mmol/L: 24 ≤ 6.1 mmol/L: 27	0.3161
Disease composition	Pancreatic head: 11 Duodenum and papilla: 16 Ampulla: 5 Distal bile duct: 19	Pancreatic head: 16 Duodenum and papilla: 14 Ampulla: 5 Distal bile duct: 14	0.5418
Surgical method	PD: 20 PPPD: 31	PD: 16 PPPD: 35	0.4072
Braun anastomosis	Yes: 5 No: 46	Yes: 2 No: 49	0.2400
Pancreatic texture	Soft: 27 Normal or mild fibrosis: 14 Hard: 10	Soft: 24 Normal or mild fibrosis: 17 Hard: 10	0.7918
Pancreatic duct diameter	> 3 mm: 30 ≤ 3 mm: 21	> 3 mm: 26 ≤ 3 mm: 25	0.4261
Intraoperative blood transfusion	Yes: 4 No: 47	Yes: 1 No: 50	0.3590

BMI: Body mass index; PD: Pancreaticoduodenectomy; PPPD: Pylorus-preserving pancreaticoduodenectomy.

Table 5 Comparison of postoperative complications, *n*

Complication	Single-layer anastomosis group	Double-layer anastomosis group	χ^2	P-value
Pancreatic fistula	Yes: 13 No: 38	Yes: 35 No: 16	19.0463	0.0000
Peritoneal catheterization	Yes: 0 No: 51	Yes: 6 No: 45	4.4271	0.0354
Abdominal infection	Yes: 1 No: 50	Yes: 11 No: 40	9.4444	0.0021
Total complications	Yes: 21 No: 30	Yes: 37 No: 14	10.2320	0.0014

jejunal anastomosis time, postoperative hospitalization time, total hospitalization time, and hospitalization expenses in the quantitative data of these two groups did not show normal distributions and/or exhibited heterogeneous variances, the data regarding these parameters were examined using the rank sum test to determine whether there were differences in these parameters between the two groups (Table 7).

DISCUSSION

The most important factor resulting in complications and deaths after pancreaticoduodenectomy was pancreatic fistula^[13,26-28]. The tightness of the pancreaticojejunal anastomosis to a large extent determines the success of pancreaticoduodenectomy. The modification of the pancreaticojejunal anastomosis method and the

Table 6 Comparison of the incidence of pancreatic fistula in patients with different pancreatic textures in the two groups

Pancreatic texture	Single-layer anastomosis group	Double-layer anastomosis group	χ^2	P-value
Soft	10/27	21/24	13.5737	0.0002
Normal or mild fibrosis	2/14	10/17		0.0245
Hard	1/10	4/10		0.3034

Table 7 Comparison of intraoperative and postoperative conditions in the single-layer anastomosis group and the double-layer anastomosis group

Item	Single-layer anastomosis group	Double-layer anastomosis group	Mann-Whitney	P-value
Operation time (min)	220.059 (\pm 60.602)	379.412 (\pm 90.761)	179.000	0.000
Pancreaticojejunal anastomosis time (min)	17.922 (\pm 5.145)	31.333 (\pm 7.776)	185.000	0.000
Postoperative hospitalization time (d)	18.588 (\pm 5.285)	26.373 (\pm 15.815)	854.500	0.003
Total hospitalization time (d)	25.627 (\pm 6.551)	33.706 (\pm 15.899)	841.000	0.002
Hospitalization expense (yuan)	116787.667 (\pm 31900.927)	162788.608 (\pm 129732.500)	800.000	0.001

improvement in surgical techniques described here can be used for pancreaticojejunal anastomotic leakage to reduce the incidence of pancreatic fistula. The single-layer pancreaticojejunal anastomosis method is a simple, reliable, and safe method for pancreaticojejunal anastomosis^[29,30].

The single-layer mucosa-to-mucosa pancreaticojejunal anastomosis elucidated in this study is associated with pancreatic duct diameters ranging from 1-12 mm and a mean pancreatic duct diameter of 4.863 mm. We considered that when the pancreatic duct diameter was greater than 2 mm, single-layer pancreaticojejunal anastomosis was a better choice.

Single-layer mucosa-to-mucosa pancreaticojejunal anastomosis is a simple and time-saving anastomosis method. It should be emphasized that during the process of pancreaticojejunal anastomosis, the suturing between the anterior wall of the pancreatic duct and the whole layer of the anterior wall of the pancreas, involving 3-4 stitches, should be conducted first, together with the suspension and opening of the pancreatic duct; this sequence is conducive to posterior wall suturing. During the suturing process, the distribution of needling should be even to prevent the formation of large spaces and the occurrence of non-strict pairing in some regions, which may cause pancreatic leakage. During the suturing of the anterior, lateral, and posterior walls of the duct, the needling site was approximately 1-2 cm from the pancreatic stump. To prevent damage to the pancreas and to small branches of the pancreatic ducts by multiple needling, which may cause pancreatic leakage, the needling for suturing the pancreas and the pancreatic duct should be conducted only once. The suturing method described here is simple and does not require sophisticated suturing techniques. The pancreaticojejunal anastomosis time in the single-layer mucosa-to-mucosa pancreaticojejunal anastomosis was 17.922 ± 5.145 min, and the pancreaticojejunal anastomosis time in the double-layer mucosa-to-

mucosa pancreaticojejunal anastomosis was 31.333 ± 7.776 min. The Mann-Whitney value for comparison of this parameter between the two groups was 185.000 ($P = 0.000$); thus, the difference in anastomosis time between the two groups was statistically significant, indicating that the single-layer anastomosis time was significantly lower than the double-layer anastomosis time.

Single-layer mucosa-to-mucosa pancreaticojejunal anastomosis is a reliable pancreaticojejunal anastomosis method. The 51 patients in the single-layer anastomosis group received conventional upper abdominal CT examination 1 wk after surgery to determine the condition of the mouth of the pancreaticojejunal anastomosis and its surroundings; the results showed that neither the mouth of the pancreaticojejunal anastomosis nor the surrounding area had effusion in any of the 51 patients. The 51 patients in the double-layer anastomosis group received conventional upper abdominal CT examination after 1 wk of surgery to display the condition of the mouth of the pancreaticojejunal anastomosis and its surroundings; the results showed that 6 patients had effusion at the mouth of pancreaticojejunal anastomosis and/or in the surrounding area. A χ^2 test of the data for the two groups yielded a χ^2 value of 4.4271 ($P = 0.0354$); thus, the difference in the incidence of effusion in the two groups was statistically significant. In the single-layer anastomosis patients, the suture used for the anastomosis was tight, and the mouth of the pancreaticojejunal anastomosis and its surroundings did not show effusion after surgery. In the single-layer mucosa-to-mucosa pancreaticojejunal anastomosis, the jejunum completely covered the pancreatic section, and the resulting pressure on the pancreatic section and on the small pancreatic ducts within the pancreatic section contributed to hemostasis and thus reduced the risk of postoperative pancreatic section bleeding and pancreatic fistula. These results indicate that the application of

single-layer mucosa-to-mucosa pancreaticojejunal anastomosis in pancreaticoduodenectomy is reliable.

The application of single-layer mucosa-to-mucosa pancreaticojejunal anastomosis in pancreaticoduodenectomy was shown to be safe. The pancreatic fistula rate in the single-layer anastomosis group was 25.45% (13/51), whereas the pancreatic fistula rate in the double-layer anastomosis group was 68.63% (35/51). A χ^2 test of the data regarding the incidence of pancreatic fistula in the two groups yielded a χ^2 value of 19.0464 ($P = 0.0000$). Thus, the difference between the two had statistical significance; the pancreatic fistula rate in the single-layer anastomosis group was lower than that in the double-layer anastomosis group.

Lin *et al.*^[31] summarized data from 1891 pancreaticoduodenectomy patients and concluded that soft pancreatic texture was the most important reason for the occurrence of pancreatic fistula. In our study, when the pancreatic texture was soft, the postoperative pancreatic fistula rate in the single-layer anastomosis group was 37.03% (10/27), whereas the rate of postoperative pancreatic fistula in the patients in the double-layer anastomosis group who displayed soft pancreatic texture was 87.50% (21/24). Comparison between the values obtained for the two groups yielded a χ^2 value of 13.5737 ($P = 0.0002$). The difference was statistically significant, indicating that single-layer anastomosis was better than double-layer anastomosis when the pancreatic texture was soft. The use of single-layer anastomosis reduced the time needed for suturing the pancreas, reduced the damage to the pancreas, and decreased the incidence of pancreatic fistula. When the pancreatic texture was normal or the pancreas displayed mild fibrosis, the incidence of postoperative pancreatic fistula was 14.28% (2/14) in the single-layer anastomosis group and 58.82% (10/17) in the double-layer anastomosis group. Comparison of the difference between the two groups using the χ^2 test and the Fisher exact probability test showed that the P -value was 0.0245, indicating that the difference between the two groups was statistically significant. For normal or mild fibrosis pancreatic texture, the pancreatic fistula rate in the single-layer anastomosis group was lower than that in the double-layer anastomosis group. In the single-layer anastomosis group, there were 5 cases of grade B pancreatic fistula, and the pancreatic fistula rate was 9.80%; there was no grade C pancreatic fistula in this group. In the double-layer anastomosis group, there were 23 cases of grade B pancreatic fistula, with a rate of 45.10%; in this group, there were 4 cases of grade C pancreatic fistula, with an incidence rate of grade C pancreatic fistula of 7.84%. Comparison of the incidences of grade B and grade C pancreatic fistula in the two groups yielded a χ^2 value of 22.0393 ($P = 0.0000$), indicating that the difference between the two groups was statistically significant. The incidence of grade B and grade C pancreatic fistula in the single-layer anastomosis group was significantly lower than that in the double-layer anastomosis group.

In the single-layer anastomosis group, the rate of postoperative peritoneal catheterization was 0/51, and that of abdominal infection was 1/51. In the double-layer anastomosis group, the rate of postoperative peritoneal catheterization was 6/51, and the rate of abdominal infection was 11/51; the differences in these two parameters in the two groups were statistically significant ($P < 0.05$). The rates of postoperative peritoneal catheterization and abdominal infection in the single-layer anastomosis group were significantly lower than those in the double-layer anastomosis group. The total postoperative complication rate in the single-layer anastomosis group was 41.17% (21/51) and the total postoperative complication rate in the double-layer anastomosis group was 72.55% (37/51). A χ^2 test comparing the data for the two groups yielded a χ^2 value of 10.232 ($P = 0.0014$); thus, the difference between the two groups was statistically significant. The postoperative complication rate in the single-layer anastomosis group was lower than that in the double-layer anastomosis group. In summary, the foregoing data show that the application of the single-layer mucosa-to-mucosa pancreaticojejunal anastomosis in pancreaticoduodenectomy is safe.

Patients who experienced pancreatic fistula after pancreaticoduodenectomy had prolonged hospitalization time and increased hospitalization expenses^[32]. The pancreatic fistula rate in the single-layer mucosa-to-mucosa pancreaticojejunal anastomosis group was lower than that in the double-layer mucosa-to-mucosa pancreaticojejunal anastomosis group. In addition, postoperative hospitalization time, total hospitalization time, and hospitalization expenses were all lower in the single-layer anastomosis group than in the double-layer anastomosis group. The rank sum test results showed that the P -values for all of these comparisons were < 0.05 ; thus, the differences were statistically significant. These results indicate that postoperative hospitalization time, total hospitalization time, and hospitalization expenses were all lower in the single-layer anastomosis group than in the double-layer anastomosis group.

In summary, the results of this study show that single-layer mucosa-to-mucosa pancreaticojejunal anastomosis is a simple, reliable, and safe anastomosis method. The use of this method could reduce the rates of postoperative pancreatic fistula, abdominal infection and peritoneal catheterization, overall complication rate, postoperative hospitalization time, total hospitalization time, and hospitalization expenses.

COMMENTS

Background

Pancreaticoduodenectomy is a standard treatment for various tumors of peri-ampullary region and pancreatic head. Pancreaticoduodenectomy is a difficult surgery with a high perioperative complication rate and a high mortality rate. Pancreatic fistula is associated with delayed gastric emptying, intra-abdominal abscess, local infection at the incision site, sepsis, and blood loss postoperation. Pancreaticojejunal anastomosis plays an important role in pancreaticoduodenectomy; its success determines the success of the surgery.

Research frontiers

Although the complication and mortality rates associated with pancreatic fistula have decreased due to improvements in surgical techniques, the incidence of postoperative complications during the perioperative period is still high. There are various pancreaticojejunal anastomosis procedures in pancreaticoduodenectomy, but so far none of the pancreaticojejunal anastomosis procedures is regarded as best. No matter what kind of way of pancreaticojejunal anastomosis use in pancreaticoduodenectomy, pancreatic fistula is still high.

Innovations and breakthroughs

In this study, single-layer anastomosis group applied single layer mucosa-to-mucosa pancreaticojejunal anastomosis to pancreaticoduodenectomy. It should be emphasized that during the process of pancreaticojejunal anastomosis, the suturing between the anterior wall of the pancreatic duct and the whole layer of the anterior wall of the pancreas, involving 3-4 stitches, should be conducted first, together with the suspension and opening of the pancreatic duct; this sequence is conducive to posterior wall suturing. There was no knots inside of pancreaticojejunal anastomosis. During the suturing process, the distribution of needling should be even to prevent the formation of large spaces and the occurrence of non-strict pairing in some regions, which may cause pancreatic leakage.

Applications

Single-layer mucosa-to-mucosa pancreaticojejunal anastomosis is a simple pancreaticojejunal anastomosis. Surgeons can apply it to pancreaticoduodenectomy, especially when the pancreatic texture is soft. It can reduce the incidence rate of grade B and C pancreatic fistula and may reduce the mortality.

Terminology

Pancreaticojejunal anastomosis is essential and crucial anastomosis in pancreaticoduodenectomy. It plays an important role in pancreaticoduodenectomy; its success determines the success of the surgery. Single-layer mucosa-to-mucosa pancreaticojejunal anastomosis could help the surgeon to enhance the reliability of pancreaticojejunal anastomosis.

Peer-review

The article is an helpful and original research paper. It provides a new way of pancreaticojejunal anastomosis to surgeon in pancreaticoduodenectomy. The study is well designed, and the retrospective study was carried out at a very high accuracy and quality.

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