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Original Article

Effect of modified Blumgart pancreaticojejunostomy on nutritional status in elderly patients after pancreaticoduodenectomy

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Abstract: Objective: To evaluate the effect of modified Blumgart pancreaticojejunostomy on the nutritional status in elderly patients after pancreaticoduodenectomy. Methods: Fifty-eight elderly patients who underwent pancreaticoduodenectomy in our hospital were evenly divided into the traditional group (receiving traditional Blumgart pancreaticojejunostomy) and the modified group (receiving modified Blumgart pancreaticojejunostomy). Results: In the modified group, intraoperative blood loss and 24-h VAS score were lower and time to off-bed activity and postoperative hospital stay were shorter than those in the traditional group ($P<0.05$). The levels of D-lactic acid, diamine oxidase, and endotoxin were increased after surgery and were higher in the modified group than those in the traditional group, while the digestive symptoms and cancer pain scores at 6 months after surgery and postoperative complication rate were lower than those of the traditional group (all $P<0.05$). The nursing satisfaction was higher in the modified group than that in the traditional group ($P<0.05$). The nutritional status, pancreatic endocrine function and pancreatic exocrine function showed no significant differences between the two groups. Conclusion: The modified Blumgart pancreaticojejunostomy can reduce the pain level, expedite postoperative rehabilitation, and improve the intestinal mucosal barrier function and quality of life of patients while not significantly affecting postoperative nutritional status and pancreatic function.

Keywords: Pancreaticoduodenectomy, elderly, modified Blumgart pancreaticojejunostomy, nutritional status, intestinal mucosal barrier function, quality of life

Introduction

Pancreaticoduodenectomy is a common surgical treatment for malignant tumors such as ampullary cancer, pancreatic cancer, distal cholangiocarcinoma, and duodenal papillary cancer as well as benign tumors of the pancreatic head. In recent years, minimally invasive technologies have been developed. The surgical mortality rate has been decreased to less than 5%, and its safety has been greatly improved [1, 2]. However, among all abdominal surgeries, pancreaticoduodenectomy is complicated and characterized by a large number of involved tissues and organs, wide range of resection, and complex anatomical structure. Postoperative complications such as pancreatic fistula, biliary fistula, and delayed gastric emptying are prone to occur, which is not conducive to the prognosis of patients. Related studies [3] have reported that pancreatic fistula is the most serious postoperative complication after pancreaticoduodenectomy, with an incidence of about 40%, and can cause secondary abdominal infection and massive bleeding, which is not conducive to postoperative rehabilitation and has certain mortality. Pancreaticoduodenectomy has complicated procedures for reconstruction of the digestive tract and long operation time. In addition, most patients have certain degree of malnutrition before operation, so it is of great significance to effectively reduce the impact of surgery on nutritional status. In recent years, a growing number of studies have found that appropriate anastomosis during pancreaticoduodenectomy can

reduce the risk of postoperative pancreatic fistula and other complications and improve the quality of life of patients [4, 5]. Blumgart-type technique, binding technique, and duct-to-mucosa anastomosis are commonly used in clinical pancreaticojejunostomy; however, there is still debate about which surgical technique can eliminate the risk of pancreatic fistula, and there are few reports about the effects of surgical methods on the nutritional status of patients [6]. In view of this, 58 elderly patients with pancreaticoduodenectomy in our hospital were enrolled in this study to investigate the feasibility and safety of traditional and modified Blumgart pancreaticojejunostomy, so as to provide a better choice for clinical anastomosis.

Materials and methods

Baseline data

This study complied with the Declaration of the World Medical Association Helsinki. Fifty-eight elderly patients who underwent pancreaticoduodenectomy in our hospital from February 2017 to March 2019 were enrolled and divided into the traditional group (n=29) and the modified group (n=29) according to the method of intraoperative pancreaticojejunostomy. This study was approved by the Ethics Committee of Ganzhou People's Hospital (No. KY002-08). The enrolled subjects and their families were informed and signed a consent form.

Inclusion criteria

The inclusion criteria: patients with age ≥60 years; patients met the Expert Consensus for Laparoscopic Pancreaticoduodenectomy surgical indications [7]; patients whose preoperative imaging examinations such as magnetic resonance cholangiopancreatography and/or B-ultrasound confirmed the diameter of the main pancreatic duct >3 mm in the body of the pancreas, and the patients were diagnosed with space-occupying diseases in the duodenum, ampullary and surrounding areas, and head of the pancreas; patient with no distant metastases to the abdominal cavity or liver; patients with no history of gastrointestinal reconstruction or upper abdominal surgery; and patients with complete clinical data. The exclusion criteria: patients with distant metastasis; patients with other digestive tract diseases; patients with insufficiency of vital organs (heart, liver, kidneys, *etc*.); patients with coagulation dysfunction or severe infection; and patients with a history of emergency surgery.

Methods

All patients underwent laparoscopic pancreaticoduodenectomy. In the modified group, the modified Blumgart pancreaticojejunostomy was used [8]. The measures were as follows: During the uncinate process of the superior mesenteric artery (SMA) and vein cross, the main pancreatic duct (MPD) and pancreatic stump were fully freed using forceps. The MPD was exposed and an incision was made in the side wall of the MPD with scissors to insert a pancreatic stent tube. Next, 5-0 Prolene was fixed on the section of the pancreatic parenchymal stump and the MPD was closed by wrapping in 2-4 circles and knotting. The MPD and the stent tube were fixed. The distal jejunum was passed through the right mesentery of the middle colon artery and placed under the hepatic hilum near the pancreatic stump. The mesenteric edge was opened at 5-10 cm from the jejunum stump. U-suture was performed on the jejunal seromuscular layer and pancreatic layers. The stent tube was inserted into the jejunum through the opening of the jejunal mucosa. The U-suture was tightened to complete the anastomosis.

In the traditional group, the traditional Blumgart pancreaticojejunostomy was used. The SMA was hooked around the uncinate process of the pancreas, and the duodenum, distal stomach, common bile duct, gallbladder, pancreatic head, and tumor were completely cut off to fully free the pancreatic stump. The distal jejunum was passed through the right mesentery of the middle colon artery and placed under the hepatic hilum close to the pancreatic stump. The suture started at the anterior side of the pancreatic stump about 1 cm away from the cut end: the pancreatic gland was traversed by 3-0 Prolene suture from anterior to posterior, after which a seromuscular bite of the posterior jejunal wall was taken. Each 3-0 Prolene suture was run from posterior to anterior, once again through the full thickness of the pancreatic parenchyma. Herein the U-suture was completed. The same suture was performed at 5-mm intervals using 5-8 stitches. An opening was made at the mesentery margin about 5-10 cm

from the jejunal stump. The pancreatic stent was inserted into the jejunum through the opening. Interrupted suture anastomoses using 6-0 Prolene were performed between the MPD and the jejunal mucosa. The previously held U-sutures were tied on the anterior capsule of the pancreas and placed through the seromuscular coat of the jejunum at the anterior edge of the seromuscular jejunal incision. The anastomosis was completed by tying the U-sutures on the anterior capsule of the pancreatic stump. The two groups were completed by the same chief physician and the team.

Observation indicators

Perioperative indicators: Intraoperative blood loss, operation duration, pancreaticojejunostomy duration, time to off-bed activity, defecation, time to removal of gastric tube and abdominal lead, length of hospital stay, and 24-h postoperative pain level, were recorded. The degree of pain was evaluated using the visual analog scale (VAS), with a total score of 0-10 points, representing painless to severe pain.

Nutritional status: 3 mL of fasting venous blood was collected before surgery and at 1 month after surgery, left to stand for 10 min, and centrifuged for 10 min (<4°C; speed: 3000 r/min; radius: 6 cm). The supernatant was aspirated and stored at -80°C. The levels of albumin, total protein, and transferrin were determined using a bromocresol green albumin assay (Shanghai Jingkang Bioengineering Co., Ltd.).

Intestinal mucosal barrier function: 3 mL of fasting venous blood was collected before and 72 h after surgery, left to stand for 10 min, and centrifuged for 10 min (temperature: <4°C; speed: 3000 r/min; radius: 6 cm). The supernatant was aspirated and stored at -80°C. The D-lactic acid, diamine oxidase (DAO) and endotoxin levels were determined using enzyme-linked immunosorbent assay (Shanghai Xinle Biotechnology Co., Ltd.).

Endocrine and exocrine function of the pancreas: At 6 months after surgery, 3 mL of venous blood was collected before and 2 h after the meal, left to stand for 10 min, and centrifuged for 10 min (temperature: <4°C; speed: 3000 r/min; radius: 6 cm). The supernatant was aspirated and stored at -80°C. Glucagon (GLC) and somatostatin (SS) levels were determined using enzyme-linked immunosorbent assay. Fecal samples were collected to measure human fecal elastase (FE-1) level using enzyme-linked immunosorbent assay (Shanghai Yansheng Industrial Co., Ltd.). An FE-1 level of ≥200 μg/g was considered normal, 100-200 μg/g indicated mild to moderate pancreatic insufficiency, and <100 μg/g indicated severe exocrine pancreatic insufficiency.

Quality of life: Quality of life of patients was evaluated in three dimensions of dietary digestive symptoms, cancer pain, and health care satisfaction before and 6 months after surgery using the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Pancreatic Cancer module (EORTC QLQ-PAN26) [9], with a total of 26 items. The higher scores in the first two dimensions indicated more severe symptoms and the lower quality of life; a high score in the latter dimension indicated a high quality of life.

Postoperative complications

At 6 months after surgery, pancreatic fistula, biliary fistula, biliary tract infection, postoperative jaundice, gastric emptying disorder and other complications were evaluated.

Statistical analysis

SPSS 22.0 was used to process the data. Measurement data ($\overline{x}\pm sd$) were compared using the independent *t*-test for intergroup comparisons, while the paired *t*-test was used for intragroup comparisons. Count data (%) were compared using the χ^2 test. Categorized data were examined using the rank sum test. Values of $P<0.05$ were considered statistically significant.

Results

Intergroup comparison of clinical data

Gender, age, preoperative total bilirubin, American Society of Anesthesiologists grade, disease type, and pancreas texture were compared between the groups, which showed no significant difference and were comparable ($P>0.05$) (**Table 1**).

Intraoperative related indices

The duration of operation and anastomosis was not statistically different between the

Table 1. The general characteristics of patients

Group	Male/ Female	Age (year)	Total bilirubin before operation (μmol/L)	ASA grade	Type of disease	Pancreas texture	TNM staging	Chemo-therapy	Smoking and drinking	BMI (kg/m^2)
				Grade I/II	A/B/C/D/E	Hard/ soft	Stage I/ II/III	Yes/no	Yes/no	
Traditional group (n=29)	18/11	68.28±5.16	79.65±21.75	13/16	11/6/6/4/2	12/17	6/13/10	16/13	20/9	23.15±3.26
Modified group (n=29)	17/12	69.94±6.01	81.32±20.89	12/17	12/7/5/4/1	11/18	5/12/12	18/11	18/11	22.09±3.15
t/χ^2	0.072	1.129	0.834	0.070	0.986	0.072	0.313	0.516	2.370	1.259
P	0.788	0.264	0.408	0.791	0.879	0.788	0.855	0.473	0.124	0.213

ASA, American Society of Anesthesiologists; BMI, body mass index; A, pancreatic cancer; B, distal bile duct cancer; C, duodenal cancer; D, ampullary cancer; E, other cancer.

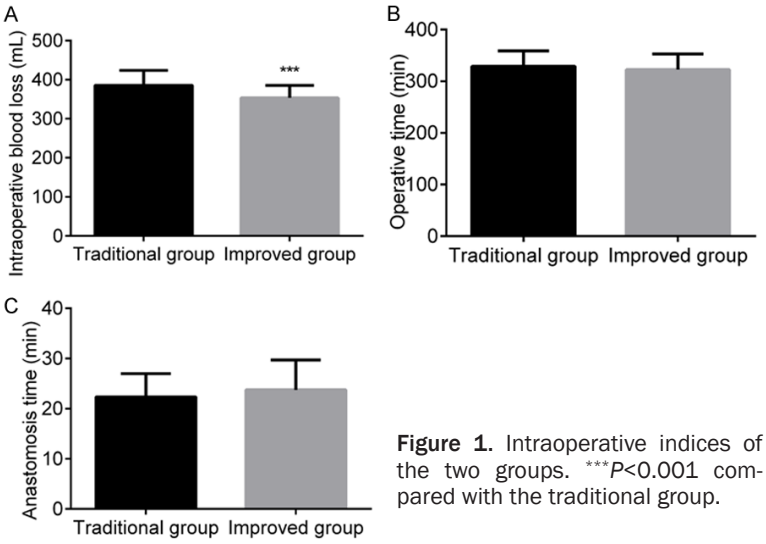

Figure 1. Intraoperative indices of the two groups. ***P<0.001 compared with the traditional group.

Nutritional status

The levels of preoperative albumin, total protein, and transferrin showed no significant differences between the two groups before operation (all P>0.05). In addition, there was no significant difference before or after surgery in the modified group (all P>0.05), suggesting that the modified Blumgart pancreaticojejunostomy did not adversely affect patient nutritional status (**Table 2**).

Intestinal mucosal barrier function

groups (P>0.05). Intraoperative blood loss was significantly lower in the modified group than that in the traditional group (P<0.05), suggesting that the use of the modified Blumgart pancreaticojejunostomy could reduce the amount of blood loss (**Figure 1**).

Postoperative recovery-related indicators

No significant intergroup difference was observed in defecation frequency and timing and time to removal of the gastric tube and abdominal drainage tube (P>0.05) between the two groups. The modified group showed a shorter postoperative hospital stay and time to off-bed activity as well as lower VAS scores at 24 h after surgery than the traditional group (P< 0.05), suggesting that the modified Blumgart pancreaticojejunostomy could reduce the pain level and accelerate the postoperative recovery (**Figure 2**).

No significant difference was found in the levels of D-lactic acid, DAO, and endotoxin between the two groups before surgery (all P>0.05). All the measurement indices improved after surgery and were higher in the modified group than those in the traditional group (P<0.05), suggesting that modified Blumgart pancreaticojejunostomy could reduce damage to intestinal mucosal barrier function (**Table 3**).

Pancreatic endocrine dysfunction

The levels of pre-meal GLC and SS exhibited no difference between the two groups before surgery (all P>0.05). However, the levels of GLC and SS at 2 h after the meal in both groups were higher than those before the meal (all P<0.05), but no significant difference was found between the two groups (P>0.05). In addition, there was no statistically significant difference in levels of pre-meal GLC and SS and levels of GLC and SS at 2 h after the meal between

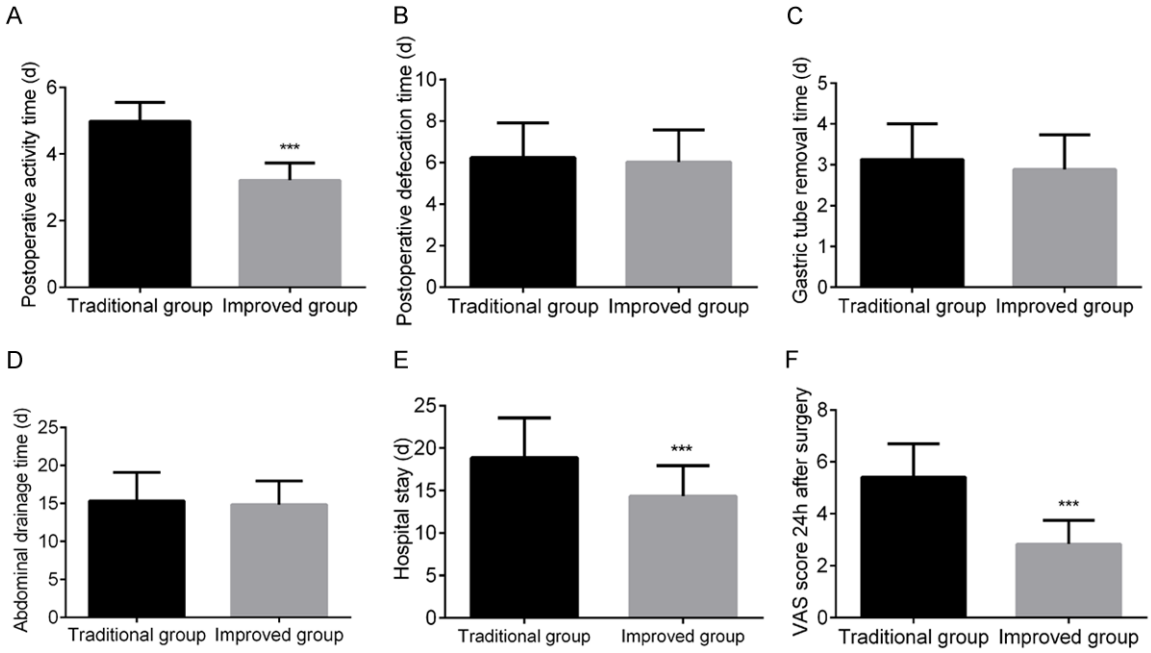

Figure 2. Postoperative recovery indices of the two groups. ***P<0.001 compared with the traditional group.

Table 2. Nutritional status indicators before and after surgery of the two groups ($\bar{x}$±sd, g/L)

Time	Group	Albumin	Total protein	Transferrin
Preoperative	Traditional group (n=29)	32.16±3.48	65.13±7.21	2.45±0.46
	Modified group (n=29)	33.25±3.16	65.88±7.45	2.51±0.48
	t	1.249	0.390	0.486
	P	0.217	0.698	0.629
1 month after surgery	Traditional group (n=29)	27.24±2.27###	60.34±5.75##	1.94±0.21###
	Modified group (n=29)	32.46±3.56	64.75±5.19	2.34±0.32
	t	6.658	3.066	5.628
	P	0.000	0.003	0.000

##P<0.01, ###P<0.001 compared to the preoperative indicators within the same group.

Table 3. Intestinal mucosal barrier function before and after surgery of the two groups ($\bar{x}$±sd)

Time	Group	D-lactic acid (g/mL)	DAO (U/L)	Endotoxin (ng/L)
Preoperative	Traditional group (n=29)	0.46±0.11	1.67±0.32	1.74±0.46
	Modified group (n=29)	0.48±0.12	1.64±0.35	1.75±0.51
	t	0.662	0.341	0.078
	P	0.511	0.735	0.938
72 h after surgery	Traditional group (n=29)	6.57±1.75###	3.67±0.98###	7.67±1.67###
	Modified group (n=29)	4.13±1.54###	2.19±0.46###	5.54±1.09###
	t	5.637	7.362	5.752
	P	0.000	0.000	0.000

###P<0.001 compared to those before surgery within the same group. DAO, diamine oxidase.

the two groups at 6 months after surgery, suggesting that the modified Blumgart pancreaticojejunostomy could prevent postoperative pancreatic endocrine dysfunction (**Table 4**).

Table 4. Pancreatic endocrine function at 6 months after operation of the two groups ($\bar{x}$±sd, ng/L)

Time	Group	GLC		SS	
		Before meal	2 h after meal	Before meal	2 h after meal
Before surgery	Traditional group (n=29)	69.86±13.25	92.58±15.27###	84.69±21.35	146.32±49.86###
	Modified group (n=29)	70.02±12.96	91.16±15.02###	85.96±20.15	148.85±50.03###
	t	0.046	0.357	0.233	0.193
	P	0.963	0.722	0.817	0.848
After surgery	Traditional group (n=29)	71.35±14.68	91.34±16.98###	85.69±22.64	148.64±52.31###
	Modified group (n=29)	70.69±13.47	92.68±17.64###	86.37±21.37	150.38±51.09###
	t	0.178	0.295	0.118	0.128
	P	0.859	0.769	0.907	0.899

###P<0.001 compared to before the meal within the same group. GLC, glucagon; SS, somatostatin.

Table 5. Pancreatic exocrine dysfunction 6 months after operation of the two groups [n (%)]

Group	Normal	Mild to moderate disorder	Severe disorder
Traditional group (n=29)	25 (86.21)	2 (6.90)	2 (6.90)
Modified group (n=29)	28 (96.55)	1 (3.45)	0
Z		1.422	
P		0.155	

Pancreatic exocrine dysfunction

No significant difference was found in pancreatic exocrine function at 6 months after surgery between the two groups (P>0.05), indicating that the modified Blumgart pancreaticojejunostomy could sustain pancreatic exocrine function (**Table 5**).

Quality of life

There was no significant difference in quality of life before surgery between the two groups (P>0.05). The digestive symptoms and cancer pain scores were lower in the modified group than those in the traditional group at 6 months after surgery. The modified group also exhibited higher nursing satisfaction scores (P<0.05), indicating that the modified Blumgart pancreaticojejunostomy could improve the quality of life of patients (**Table 6**).

Postoperative complications

The incidence of postoperative complications was lower in the modified group (6.90%) than that in the traditional group (27.59%) (P<0.05), indicating that the modified Blumgart pancreaticojejunostomy did not increase complications and had a high safety (**Table 7**).

Discussion

Pancreaticoduodenectomy is a common but relatively complex abdominal surgery, often involving organ resection, exploration of the abdominal cavity, and gastrointestinal tract reconstruction. It has the disadvantages of a high postoperative complication rate and technical difficulty [10]. Laparoscopic pancreaticoduodenectomy has less pain and trauma, and shorter incisions, but requires higher surgical skills than laparotomy. The anterior surface of the pancreas is covered by the peritoneum, the blood vessels around the pancreas and duodenum are dense, and the pancreas has an abundant blood supply with the vessels originating as branches of the celiac and superior mesenteric arteries. After the removal of lesion, hemostasis in the pancreatic section is challenging. Reasonable anastomosis is required for an uncomplicated operation [11].

In this study, the modified group showed lower intraoperative blood loss and VAS score at 24 h after surgery, shorter time to off-bed activity and postoperative hospital stay, and higher quality of life, whereas albumin, total protein, and transferrin levels at 1 month after surgery were not affected, indicating that the modified Blumgart pancreaticojejunostomy had the advantages of less blood loss, low pain level, rapid postoperative recovery, and high quality of life, with no significant effect on the nutritional status of the patients. The modified Blumgart pancreaticojejunostomy has the following advantages. First, the U-suture is not tightened temporarily after the anastomosis of

Table 6. EORTC QLQ-PAN26 scores before and after operation of the two groups ($\bar{x}$±sd, points)

Time	Group	Digestive symptoms	Cancer pain	Nursing satisfaction
Preoperative	Traditional group (n=29)	12.84±2.11	11.67±2.67	2.01±0.37
	Modified group (n=29)	12.76±2.03	11.92±2.75	2.05±0.41
	t	0.147	0.351	0.390
	P	0.884	0.727	0.698
6 month after surgery	Traditional group (n=29)	9.64±2.09###	8.59±1.75###	3.21±0.45###
	Modified group (n=29)	7.00±1.67###	6.01±1.03###	4.36±0.62###
	t	5.314	6.842	8.084
	P	0.000	0.000	0.000

###P<0.001 compared to before surgery within the same group.

Table 7. Incidence of postoperative complications of the two groups [n (%)]

Group	Pancreatic fistula	Biliary fistula	Biliary infection	Postoperative jaundice	Gastric emptying disorder	Total
Traditional group (n=29)	3 (10.34)	1 (3.45)	1 (3.45)	1 (3.45)	2 (6.90)	8 (27.59)
Modified group (n=29)	1 (3.45)	0	0	0	1 (3.45)	2 (6.90)
χ^2						4.350
P						0.037

the jejunum mucosa and the pancreatic duct with the support of jejunal mucosa, which can avoid the tear of the pancreatic tissue caused by excessively tight knots and simplify the operation procedure, shorten the operation duration, improve the operability, and ensure the safety of pancreaticojejunostomy [12]. Second, the MPD and stent are fixed only after complete separation of the pancreas, which expands the surgical space and reduces the surgery-related risks. Third, the MPD and stent are placed together in the jejunum. Under the protection of the mucosa of the anterior and posterior walls of the jejunum and pancreas, leakage of the pancreatic juice between the support tube and the MPD can be prevented and injury to the tissue around the anastomosis can be greatly reduced [13, 14].

The levels of D-lactic acid (a metabolite of intestinal bacterial fermentation) and DAO (an intracellular enzyme mainly expressed in the small intestinal mucosa) are generally low in healthy individuals. However, when the intestinal mucosal barrier function is damaged, its levels will be increased. When the body is traumatized or stressed, it releases large amounts of endotoxin, a lipopolysaccharide, which in turn aggravates the degree of damage to the intestinal mucosal barrier [15]. In this study, the levels of D-lactic acid, DAO, and endotoxin were higher at 72 h after surgery than those before surgery in both groups, but the levels were lower in the modified group than those in the traditional group, indicating that ischemia-reperfusion during pancreaticoduodenectomy easily damaged the intestinal mucosa and changed the integrity of the intestine, leading to a decrease in the intestinal mucosal defense capability. Endotoxin and D-lactic acid enter the blood circulation in large quantities, causing intestinal bacterial translocation and impairing intestinal mucosal barrier function, which in turn leads to higher levels of D-lactic acid, DAO, and endotoxin after surgery [16]. The modified Blumgart pancreaticojejunostomy eliminates the need for anastomosis of the pancreatic duct and jejunal mucosa, shortens the operation duration, and reduces the surgical risk, so as to reduce the surgical injury and the degree of damage to intestinal mucosal defense capability [5, 17]. FE-1 is a glycoprotein secreted by the pancreas with proteolytic ability, which can be used as an index to evaluate pancreatic exocrine function with high specificity and sensitivity [18]. In this study, no significant intergroup difference was noted in pancreatic exocrine dysfunction and GLC and SS levels at 2 h after the meal. Thus, there is no direct relationship between pancreatic and exocrine functions and

the choice of anastomotic scheme. Liu et al. [19] reported no significant difference in FE-1 level among patients who underwent treatment with different anastomosis methods, but the level was slightly lower than normal. The reason for this may be that there was a risk of pancreatic diabetes after pancreaticoduodenectomy, and diabetic autonomic dysfunction caused by diabetic microangiopathy or pancreatic microcirculation dysfunction may impair pancreatic exocrine function and weaken bowel-pancreatic reflex function. It is suggested that pancreatic diabetes should be prevented after pancreaticoduodenectomy to expedite the postoperative recovery process.

Pancreatic fistula is a serious complication after pancreaticoduodenectomy, which is affected by factors such as excessive secretion of bile and pancreatic juice, a thin pancreatic duct, a soft pancreatic texture, and limited space for anastomosis. There is a high risk of tear of the jejunal mucosa and pancreatic duct when sutures are tightened, and intermittent pinholes may lead to large amounts of the pancreatic juice to ooze when the pressure of the pancreatic duct is increased, thereby inducing pancreatic fistula [20-23]. In this study, the incidence of postoperative complications was lower in the modified group than that in the traditional group, implying that the modified Blumgart pancreaticojejunostomy had high safety and was conducive to patient prognosis. This may be because the modified Blumgart pancreaticojejunostomy can fully free the MPD and stent, and the MPD is firmly fixed by sutures, decreasing the risk of pancreatic fistula caused by rupture of the MPD and pinholes [18, 24]. Because of the poor physical condition of the elderly people, fewer people are eventually able to receive surgical treatment. Besides, in order to avoid the difference of surgical techniques caused by different techniques of surgeons, we chose the same surgeon to perform the surgery. Zhai et al. [25] showed that pancreatic duct dilation of <3 mm was an independent risk factor for pancreatic fistula after pancreaticoduodenectomy. Therefore, during selection of patients, we selected patients with pancreatic duct dilatation of >3 mm to reduce the occurrence of pancreatic fistula. However, due to the short study time and the reasons of surgeon, our sample size was relatively small, which may cause some bias in the results. This is the inadequacy of our study. In the next study, we will further accumulate cases and expand the sample size.

In summary, the modified Blumgart pancreaticojejunostomy can reduce the degree of pain, expedite the postoperative rehabilitation process, decrease damage to intestinal mucosal barrier function, and improve the quality of life of patients without affecting their postoperative nutritional status and pancreatic endocrine function, which is conducive to a good prognosis. In the follow-up studies, we followed up the postoperative complications for 6 months and collated the data; however, as some patients had not reached the one-year follow-up period, long-term follow-up was not conducted. Therefore, future prospective multi-center studies with larger sample sizes are needed. In addition, as this is a preliminary study, a complete schematic diagram of the two groups of surgery is not available to vividly show the differences between the two groups. In the future study, the surgical procedure will be recorded in detail and related schematic diagrams will be added.

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Disclosure of conflict of interest

None.

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References

[1] Hanna MM, Gadde R, Allen CJ, Meizoso JP, Sleeman D, Livingstone AS, Merchant N and Yakoub D. Delayed gastric emptying after pancreaticoduodenectomy. J Surg Res 2016; 202: 380-388.

[2] Bohara TP. A randomized prospective multicenter trial of pancreaticoduodenectomy with and without routine intraperitoneal drainage? Ann Surg 2016; 263: e20.

[3] Ricci C, Casadei R, Taffurelli G, Pacilio CA, Ricciardiello M and Minni F. Minimally invasive pancreaticoduodenectomy: what is the best

"choice"? A systematic review and network meta-analysis of non-randomized comparative studies. World J Surg 2018; 42: 788-805.
[4] Lyu Y, Li T, Cheng Y, Wang B, Chen L and Zhao S. Pancreaticojejunostomy versus pancreaticogastrostomy after pancreaticoduodenectomy: an up-to-date meta-analysis of RCTs applying the ISGPS (2016) criteria. Surg Laparosc Endosc Percutan Tech 2018; 28: 139-146.
[5] Bai X, Zhang Q, Gao S, Lou J, Li G, Zhang Y, Ma T, Zhang Y, Xu Y and Liang T. Duct-to-mucosa vs invagination for pancreaticojejunostomy after pancreaticoduodenectomy: a prospective, randomized controlled trial from a single surgeon. J Am Coll Surg 2016; 222: 10-18.
[6] Pugalenthi A, Protic M, Gonen M, Kingham TP, Angelica MI, Dematteo RP, Fong Y, Jarnagin WR and Allen PJ. Postoperative complications and overall survival after pancreaticoduodenectomy for pancreatic ductal adenocarcinoma. J Surg Oncol 2016; 113: 188-193.
[7] Study Group of Pancreatic Surgery in Chinese Society of Surgery of Chinese Medical Association, Pancreas of Minimally Invasive Treatment Group in Pancreatic Disease Branch of China International Exchange and Promotion Association for Medical and Healthcare, Pancreas Minimally Invasive Group in Pancreatic Diseases Committee of Chinese Research Hospital Association and Pancreas Minimally Invasive Group in Pancreatic Cancer Committee of Chinese Anti-Cancer Association. Expert consensus of laparoscopic pancreaticoduodenectomy (postscript of operation process and main steps). Zhonghua Wai Ke Za Zhi 2017; 55: 335-339.
[8] Bo ZY, Qiu YH, Shen NJ, Yang FC, Duan AQ, Zhu B, Yu LH, Liu YJ and Zhang YJ. Applicational value of modified pancreaticojejunostomy and risk factors of pancreatic fistula following pancreaticoduodenectomy. Zhonghua Wai Ke Za Zhi 2019; 57: 434-439.
[9] Wang SE, Shyr BU, Chen SC and Shyr YM. Comparison between robotic and open pancreaticoduodenectomy with modified Blumgart pancreaticojejunostomy: a propensity score-matched study. Surgery 2018; 164: 1162-1167.
[10] Perinel J, Mariette C, Dousset B, Sielezneff I, Gainant A, Mabrut JY, Bin-Dorel S, Bechwaty ME, Delaunay D, Bernard L, Sauvanet A, Pocard M, Buc E and Adham M. Early enteral versus total parenteral nutrition in patients undergoing pancreaticoduodenectomy: a randomized multicenter controlled trial (Nutri-DPC). Ann Surg 2016; 264: 731-737.
[11] Tung S, Davis LE, Hallet J, Mavros MN, Mahar AL, Bubis LD, Hammad A, Zhao H, Earle CC, Barbera L, Coburn NG, Siqqidui M, Li Q, Elmi M, Shin E, Hsieh E and Goyert N. Population-level symptom assessment following pancreaticoduodenectomy for adenocarcinoma. JAMA Surg 2019; 154: e193348.
[12] Sandini M, Ruscic KJ, Ferrone CR, Warshaw AL, Qadan M, Eikermann M, Lillemoe KD and Fernández-Del Castillo C. Intraoperative dexamethasone decreases infectious complications after pancreaticoduodenectomy and is associated with long-term survival in pancreatic cancer. Ann Surg Oncol 2018; 25: 4020-4026.
[13] Persaud A, Kakked G, Ahmed A, Shulik O and Ahlawat S. Hospitalization burden of biliary strictures and cholangitis after pancreaticoduodenectomy. J Surg Res 2019; 241: 95-102.
[14] Umetsu S, Wakiya T, Ishido K, Kudo D, Kimura N, Miura T, Toyoki Y and Hakamada K. Effect of sarcopenia on the outcomes after pancreaticoduodenectomy for distal cholangiocarcinoma. ANZ J Surg 2018; 88: E654-E658.
[15] Delpero JR, Jeune F, Bachellier P, Regenet N, Le Treut YP, Paye F, Carrere N, Sauvanet A, Adham M, Autret A, Poizat F, Turrini O and Boher JM. Prognostic value of resection margin involvement after pancreaticoduodenectomy for ductal adenocarcinoma: updates from a French prospective multicenter study. Ann Surg 2017; 266: 787-796.
[16] Adam MA, Choudhury K, Dinan MA, Reed SD, Scheri RP, Blazer DG 3rd, Roman SA and Sosa JA. Minimally invasive versus open pancreaticoduodenectomy for cancer: practice patterns and short-term outcomes among 7061 patients. Ann Surg 2015; 262: 372-377.
[17] Liao CH, Wu YT, Liu YY, Wang SY, Kang SC, Yeh CN and Yeh TS. Systemic review of the feasibility and advantage of minimally invasive pancreaticoduodenectomy. World J Surg 2016; 40: 1218-1225.
[18] Adam MA, Thomas S, Youngwirth L, Pappas T, Roman SA and Sosa JA. Defining a hospital volume threshold for minimally invasive pancreaticoduodenectomy in the United States. JAMA Surg 2017; 152: 336-342.
[19] Liu X and Xiong J. Re-discussion on the reasonable choice of pancreaticojejunostomy and pancreaticogastric anastomosis from the perspective of long-term quality of life. Chin J Pract Surg 2016; 36: 839-843.
[20] Wang X, Bai Y, Cui M, Zhang Q, Zhang W, Fang F and Song T. Modified Blumgart anastomosis without pancreatic duct-to-jejunum mucosa anastomosis for pancreatoduodenectomy: a feasible and safe novel technique. Cancer Biol Med 2018; 15: 79-87.
[21] Zureikat AH, Postlewait LM, Liu Y, Gillespie TW, Weber SM, Abbott DE, Ahmad SA, Maithel SK, Hogg ME, Zenati M, Cho CS, Salem A, Xia B, Steve J, Nguyen TK, Keshava HB, Chalikonda S, Walsh RM, Talamonti MS, Stocker SJ, Ben-

trem DJ, Lumpkin S, Kim HJ, Zeh HJ 3rd and Kooby DA. A multi-institutional comparison of perioperative outcomes of robotic and open pancreaticoduodenectomy. Ann Surg 2016; 264: 640-649.

[22] Kwon HE, Seo HI and Yun SP. Use of Neoveil or TachoSil to prevent pancreatic fistula following pancreaticoduodenectomy: a retrospective study. Medicine (Baltimore) 2019; 98: e15293.

[23] Jang JY, Chang YR, Kim SW, Choi SH, Park SJ, Lee SE, Lim CS, Kang MJ, Lee H and Heo JS. Randomized multicentre trial comparing external and internal pancreatic stenting during pancreaticoduodenectomy. Br J Surg 2016; 103: 668-675.

[24] Hirono S, Kawai M, Okada KI, Miyazawa M, Kitahata Y, Hayami S, Ueno M and Yamaue H. Modified Blumgart mattress suture versus conventional interrupted suture in pancreaticojejunostomy during pancreaticoduodenectomy: randomized controlled trial. Ann Surg 2019; 269: 243-251.

[25] Zhai ZL. Risk factors of pancreatic fistula after pancreaticoduodenectomy. Hangzhou: Zhejiang University; 2016.