

# A new simple and safe technique of end-to-end invaginated pancreaticojejunostomy with transpancreatic U-sutures—early postoperative outcomes in consecutive 88 cases

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## Abstract

**Background** Postoperative pancreatic fistula (POPF) remains a leading cause of morbidity and mortality after pancreaticoduodenectomy (PD). Thus, a number of technical modifications regarding the pancreato-enteric anastomosis after PD have been proposed to reduce POPF rate. Until now, there is no consensus on which is the best. This study presents a new technique of the end-to-end invaginated pancreaticojejunostomy with two to three transpancreatic U-sutures and evaluates its safety and reliability. **Material and methods** From 2002 to 2007, 88 patients (54 men and 34 women) underwent an invaginated end-to-end pancreaticojejunostomy with two to three transpancreatic U-sutures after PD. The mean age was 52.4 years (range, 26–74 years). The diseases of the all patients were malignant. **Results** In all patients of this study, two transpancreatic U-sutures were performed in 59 and three U-sutures in 29. The median duration of surgery was 3.8 h (range 3–6.5) and the median time to perform pancreaticojejunostomy was 13.3 min (range 8–25). The median blood loss was 750 ml (range 300–1,800), 36 patients needed transfusion and the median blood transfusion was 380 mL (range 200–1,200). Overall morbidity occurred in 15 patients (17.0%). Only two patients (2.2%) had grade A of POPF and no patient had grade B and grade C of POPF. No operative death occurred. **Conclusions** An invaginated end-to-end pancreaticojejunostomy with two to three transpancreatic U-sutures is

simple, rapid, safe, and reliable technique, even in some patients with soft pancreas and small pancreatic duct.

**Keywords** End-to-end pancreaticojejunostomy · Transpancreatic U-suture · Pancreatic fistula · Pancreatic cancer

## Abbreviations

POPF postoperative pancreatic fistula  
PD pancreaticoduodenectomy

## Introduction

Advances in medical and surgical care have made pancreatoduodenectomy or pancreaticoduodenectomy (PD) a relatively safe operation, but it is still associated with significant morbidity, even in the most experienced hands [1, 2]. Postoperative pancreatic fistula (POPF) remains the most problematic and feared common complication. To reduce the incidence of POPF, a number of methods, including pancreaticogastrostomy, duct-to-mucosa anastomosis, pancreatic duct occlusion, the use of biologic adhesive, intraoperative transanastomotic stents, and PD with or without external pancreatic duct drainage, have been proposed and tested [3–14]. Nevertheless, there is no consensus on which is the best way for reducing POPF after PD.

Several years ago, we designed a new technique of end-to-end invaginated pancreaticojejunostomy with transpancreatic U-sutures after PD, and the preliminary result is encouraging [15]. The aim of this study is to report on early postoperative outcomes of consecutive 88 patients

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who underwent our new procedure and evaluates the safety and reliability of the technique.

## Materials and methods

From January 2002 to December 2007, 88 patients underwent PD at Institute of Hepato-Pancreato-Biliary Surgery, Tongji Medical College, Huazhong Scientific and Technological University, China. Among 88 patients, there were 54 men and 34 women. The mean age was 52.4 years (range, 26–74 years). The diseases of all the patients were malignant, including pancreatic head carcinoma in 46, cancer of the lower common bile duct in 30, and adenocarcinoma of the duodenum in 12. Fifteen of 88 patients were associated with diabetes mellitus. The presence of nondilated pancreatic duct and soft pancreas was in 23 of 88 patients.

To compare objectively our experience with other techniques, we accepted the definition of international criteria of POPF [1]. According to the international diagnostic criteria, POPF was defined as follows: output via an operatively placed drain (or a subsequently placed, percutaneous drain) of any measurable volume of drain fluid on or after postoperative day 3, with an amylase content greater than three times the upper normal serum value. Drain fluid have a “sinister appearance” that may vary from a dark brown to greenish bilious fluid to milky water to clear “spring water” that looks like pancreatic juice. Associated clinical findings include abdominal pain and distention with impaired bowel function, delayed gastric emptying, fever (higher than 38°C), serum leukocyte count greater than 10,000 cells/mm<sup>3</sup>. An international clinical grading system for POPF (grades A, B, C) was also accepted in this study (Table 1) [1].

## Surgical techniques

All operations were performed by one group of surgeons. We did not perform pylorus-preserving procedures in this

study. Lymph nodes around the head of the pancreas, the common hepatic artery, and the hepatoduodenal ligament were dissected. Wedge or segmental resection of the portal vein or superior mesenteric vein was performed when a pancreatic head mass was inseparable from the vein. The pancreas was transected at least 2-cm surgical margin from the tumor using an electro-tome or ultrasound knife. After the surgical specimen was delivered, an invaginated end-to-end pancreaticojejunostomy with two to three transpancreatic U-sutures would be prepared.

1. To facilitate the end-to-end invagination of the jejunum loop, the remnant pancreatic stump was dissected about 2 cm in length. After careful hemostasis, a plastic catheter in 2–3 mm in diameter as a stent was inserted into the remnant pancreatic duct, preventing stenosis of the pancreatic duct after ligating the U-sutures (Fig. 1a-1).
2. Preparing for Roux-en-Y jejunum loop. An approximate 45 cm in length of proximal jejunum loop was selected and the demucosation of the jejunum loop 1 cm in length was performed with electrical coagulation.
3. Placed two to three transpancreatic U-sutures with 4-0 PDS suture (Fig. 1a-2 to a-4). The surgical steps of the first transpancreatic U-suture: (1) needling from the mesenteric side of the anterior wall of the jejunum loop about 1 cm distal to the cut edge, then withdrawing the needle from the inside of the jejunum loop lumen; (2) with the same needle, bites into pancreatic parenchyma in full thickness at the inferior edge of the remnant pancreas from the front to back, giving approximately 1.5–2 cm in distance from the cut surface of the pancreas; (3) then the needle went inside-to-outside at the mesenteric side of the posterior wall of jejunum loop, then withdrawing the needle out approximately 1 cm from cut edge of the jejunum; (4) after that, the needle moved outside-to-inside at the middle point of the posterior wall of the jejunum loop with the same suture interval as step (1); (5) then the needle penetrated the pancreatic parenchyma in full thickness from the back to front at the midpoint of the line

**Table 1** Main parameters for POPF grading

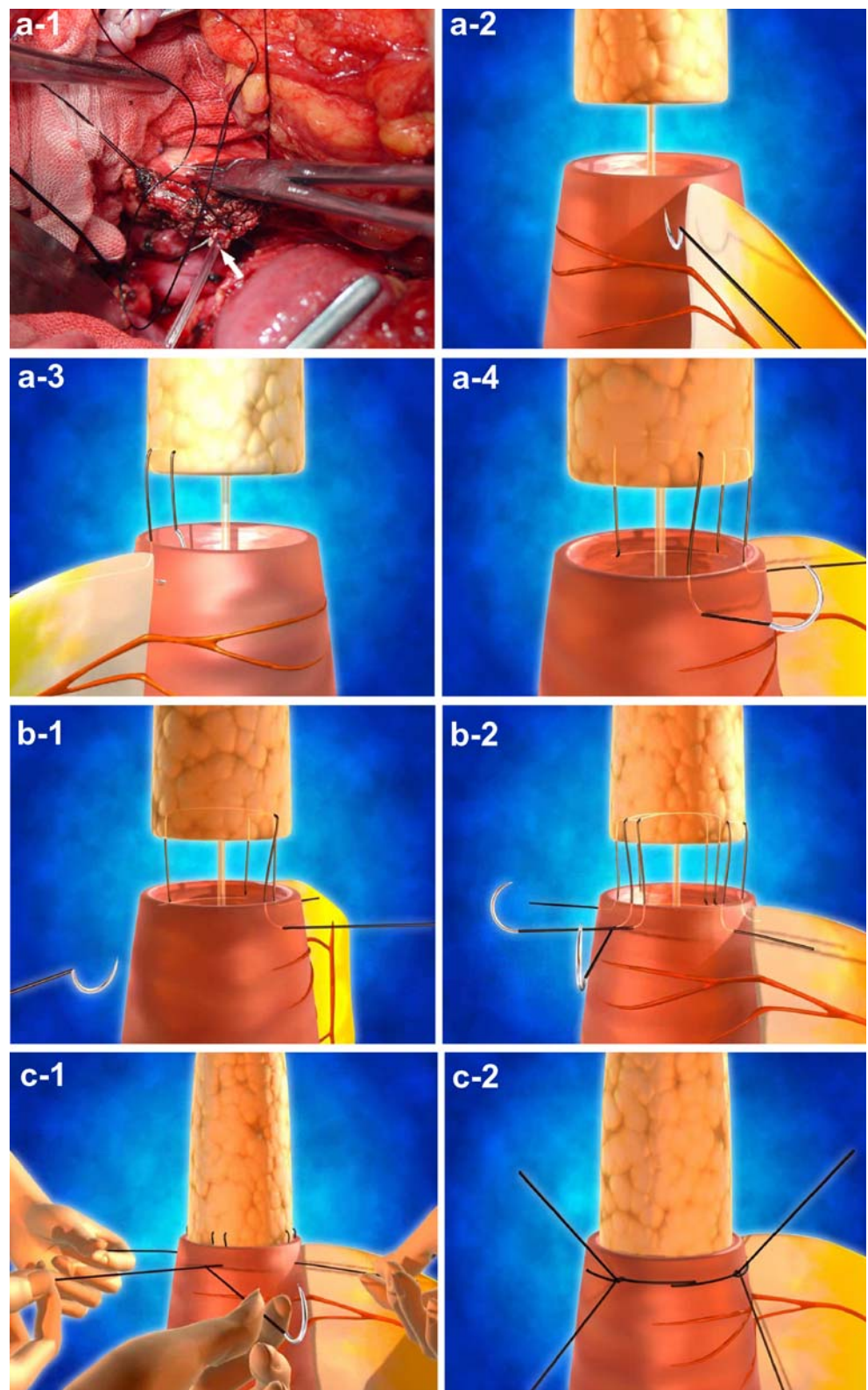
Grade	A	B	C
Clinical conditions	Well	Often well	Ill appearing/bad
Specific treatment <sup>a</sup>	No	Yes/no	Yes
US/CT (if obtained)	Negative	Negative/positive	Positive
Persistent drainage (after 3 weeks) <sup>b</sup>	No	Usually yes	Yes
Reoperation	No	No	Yes
Death related to POPF	No	No	Possibly yes
Signs of infections	No	Yes	Yes
Sepsis	No	No	Yes
Readmission	No	Yes/no	Yes/no

US Ultrasonography, CT computed tomographic scan, POPF postoperative pancreatic fistula

<sup>a</sup> Partial(peripheral) or total parenteral nutrition, antibiotics, enteral nutrition, somatostatin analogue and/or minimal invasive drainage

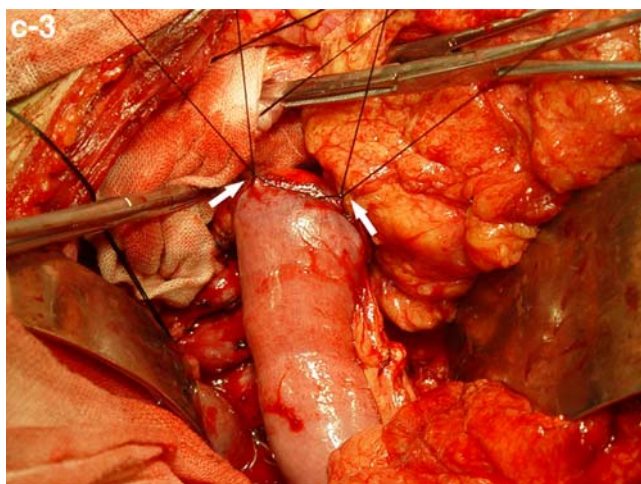
<sup>b</sup> With or without a drain in situ

**Fig. 1** **a-1** The plastic catheter that was inserted into the pancreatic duct (shown by *arrow*), **a-2** to **4** placing the first transpancreatic U-suture. **b-1** to **2** Placing the second transpancreatic U-suture. **c-1** Straining of the transpancreatic U-sutures, the pancreatic stump automatically invaginated into the jejunum, **c-2** and **3** ligating the U-sutures (shown by *arrows*)



between the superior and inferior edge of the pancreatic stump, giving approximately 1.5–2 cm in distance from the cut edge of the pancreas; (6) then the needle went inside-to-outside at the midpoint of the anterior wall of

the jejunum loop with the same suture interval as step (3), and thus finished the first U-suture. This first U-suture is not tied until the remaining one to two U-sutures have been placed. The surgical steps of the



**Fig. 1** (continued)

second U-suture: (7) abutting the first U-suture, another suture needle went outside-to-inside at the midpoint of the jejunum loop with the same suture interval as step (1); (8) then closing to the first U-suture, the needle transfixes the remnant pancreatic parenchyma in full thickness from the front to back at the midpoint of the line between the superior and inferior edge of the pancreatic stump; (9) and then the needle went inside-to-outside at the midpoint of the posterior wall of jejunum loop with the same suture interval as step (3); (10) then inserted the needle to the enteric cavity at the superior edge of the posterior wall of jejunum loop with the same demand of the suture interval as step (1); (11) then the same needle penetrated the superior edge of the remnant pancreatic parenchyma from the front to back, giving approximately 1.5–2 cm in distance from the cut surface of the pancreas; and (12) finally, the needle sutured inside-to-outside at the superior edge of the anterior wall of the jejunum loop with the same suture interval as step (3), and thus finished the second U-suture (Fig. 1b-1 and b-2). After that, through slowly straining the double U-sutures by the assistant surgeons at the same time, the pancreatic stump would be facilitatively invaginated into the jejunum loop without any difficulties (Fig. 1c-1). Then the double U-sutures were tied separately (Fig. 1c-2 and c-3). If the remnant pancreas was large in diameter, the third U-sutures should be placed. After four to six additional interrupted sutures being placed between the seromuscular layers of the anterior and posterior walls of jejunum loop and the pancreatic capsular parenchyma of the stump, the pancreas-enteric anastomosis was achieved.

After surgical reconstruction during PD, we always placed two drains. One was placed near the pancreaticojejunosomy and another one placed near the hepaticojejunosomy.

## Results

In all patients of this study, two transpancreatic U-sutures were placed in 59 cases and three U-sutures in 29. The median duration of surgery of 88 patients was 3.8 h (range 3–6.5) and the median time to perform pancreaticojejunosomy was 13.3 min (range 8–25). The median blood loss was 750 ml (range 300–1,800), 36 of 88 patients needed transfusion and the median blood transfusion for 56 patients was 380 mL (range 200–1,200). The median hospital stay of the 88 patients was 28 days (range 15–37).

Overall morbidity occurred in 15 patients (17.0%) in this study. Upper gastrointestinal bleed from severe erosive gastritis occurred in two patients and was successfully treated with conservative management. Delayed gastric emptying occurred in three patients and needed gastric decompression by nasogastric tube for 20, 27, and 41 days, respectively. Other complications included respiratory tract infection in four, urinary tract infection in two, and wound infection in four. According to the international clinical grading system, grade A of POPF was found in only two patients (2.2%). The grade A of POPF, called “transient fistula”, has no clinical impact and is not associated with a delay in hospital discharge [1] No patient had grade B and grade C of POPF and no patient died within 30 days after operation (Table 2).

## Discussion

Currently, PD is the standard treatment for malignant diseases of the pancreatic head and peri-ampullary region.

**Table 2** Outcome of pancreaticojejunosomy

Days of hospital stay, days	28 (15–37)
Operation time, h	3.8 (3–6.5)
Operative blood loss, ml	750 (300–1,800)
Need transfusion, <i>n</i>	36
Blood transfusion, ml	380 (200–1,200)
Morbidity rate, <i>n</i>	15 (17%)
Upper GI bleeding	2
Delayed gastric emptying	3
Respiratory tract infection	4
Urinary tract infection	2
Wound infection	2
POPF	–
Grade A	3
Grade B	0
Grade C	0
Death within 30 days after operation	0

GI gastrointestinal, POPF postoperative pancreatic fistula

In the last two decades, mortality from PD has significantly been reduced by improvement in surgical technique and pre- and postoperative care. The operative mortality rates reported for many high-volume pancreatic surgical centers are less than 4% [11, 12, 16–18]. However, the postoperative morbidity rate is still 30% to 60% [3, 6, 9]. POPF is the most problematic common complication after PD and its reported incidence varies from 3.9% to 31% [3, 19, 20]. Because POPF after surgery may worsen the early and long-term outcomes, an uncomplicated course is particularly important for the patients who underwent PD.

As described in the literature [3], risk factors for POPF were: (1) general factors, including age, gender, jaundice, and malnutrition; (2) disease-related factors, including pancreatic duct size, pancreatic texture, and pancreatic pathology; (3) procedure-related factors, including intraoperative blood loss, operative time, resection type, and anastomotic technique. Among them, surgical technique is one of the most important factors. To reduce the pancreatic leakage rate, various techniques of managing the pancreatic remnant have been studied. However, no one of these techniques has demonstrated a clear advantage. Nevertheless, pancreaticojejunostomy and pancreaticogastrostomy are most commonly used [5, 13, 14, 18, 19]. Anastomosis type between remnant pancreas and jejunum includes end-to-side duct-to-mucosa anastomosis, end-to-side (dunking) or end-to-end invagination anastomosis [5, 7]. Greene et al. [21] found that end-to-side duct-to-mucosa anastomosis was superior to invagination in terms of long-term anastomotic patency and function in a canine model. In review of the literature, Bartoli et al. [22] reported incidence of pancreatic fistula with end-to-side invagination anastomosis (26%) was significantly higher than with duct-to-mucosa (16%) anastomosis. Matsumoto et al. [23], in a retrospective study of 100 patients, showed a pancreatic fistula rate of 4.2% after duct-to-mucosa anastomosis versus 26.4% after invagination anastomosis. In study on 133 patients who underwent PD, Lee et al. [5] showed that continuous duct-to-mucosa anastomosis was a safer method, with a significantly lower leakage rate. However, Marcus et al. [24] reported that duct-to-mucosa anastomosis had lower pancreatic fistula rate in low-risk patients with dilated pancreatic duct or firm fibrotic pancreas, whereas the end-to-end invagination technique was safer in high-risk patients with small ducts or soft friable pancreas. Peng et al. [25] considered that binding pancreaticojejunostomy was a safer and effective technique. It was suggested that pancreatic surgeons must have more than one technique for managing the pancreatic stump in their armamentarium [26].

In this study, we introduce a new technique of the invaginated end-to-end pancreaticojejunostomy with two to three transpancreatic U-sutures. Of particular interest in this

technique is that only two patients with grade A of POPF were found. No patient had grade B and grade C of POPF in consecutive 88 patients who underwent PD, and therefore, the fistula-related morbidity and mortality was avoided. This suggests a benefit to the use of our technique. When compared with other studies [27–33], we found that the results of present study were much better and very encouraging. Except of the above-mentioned, the advantages of our technique are: (1) simple, only two to three transpancreatic U-sutures are placed; (2) easy, no need of isolation of long segment of remnant pancreas as described by Peng et al. [25], pancreatic stump could be easily invaginated into the jejunum loop through straining the U-sutures; (3) rapid, the median time to perform pancreaticojejunostomy using this technique was only 13.3 min (range 8–25).

In conclusion, a novel technique of the end-to-end invaginated pancreaticojejunostomy after PD using two to three transpancreatic U-sutures we designed is safe, reliable, rapid, and favorable.

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