

# Application of an improved continuous single-layer pancreaticojejunostomy technique in laparoscopic pancreaticoduodenectomy

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## Abstract

Laparoscopic pancreaticoduodenectomy (LPD) is a minimally invasive approach for pancreatic head and ampullary tumours, with pancreaticojejunostomy (PJ) critically influencing post-operative outcomes. This study aimed to compare a modified continuous single-layer PJ technique with the conventional two-layer method in LPD. A retrospective cohort study of 22 patients undergoing LPD compared the surgical outcomes between the modified group ( $n = 12$ ) and the conventional group ( $n = 10$ ). Baseline characteristics were well-matched between the two groups. The modified group demonstrated significantly shorter anastomosis time (19.08 vs. 23.1 min,  $P < 0.001$ ) and lower abdominal infection rates (0 vs. 3 cases,  $P = 0.041$ ). No significant differences were observed in clinically relevant post-operative pancreatic fistula or bleeding. Conclusively, the modified continuous single-layer PJ technique appears safe and feasible, offering efficiency advantages without compromising short-term outcomes. However, large-scale randomised controlled trials are warranted to validate safety, efficacy and long-term prognostic implications.

**Keywords:** Anastomotic safety, laparoscopic pancreaticoduodenectomy, pancreaticojejunostomy, post-operative complications, surgical technique

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## INTRODUCTION

Pancreaticoduodenectomy (PD) stands as the gold-standard treatment for pancreatic head and periampullary malignancies.<sup>[1]</sup> Pancreaticojejunostomy (PJ) critically affects post-operative complications like pancreatic fistula (PF),<sup>[2]</sup> and the quest for a universally recognised PJ technique continues consequently. However, no PJ technique has conclusively reduced PF incidence.<sup>[3]</sup> Laparoscopic pancreaticoduodenectomy (LPD) is a minimally invasive surgical approach, amplifying the technical challenges for conventional PJ due to procedural complexity. Our

institution has recently adopted a modified continuous single-layer PJ technique in LPD, yielding favourable surgical outcomes, which was shared through this retrospective analysis.

## GENERAL INFORMATION

A total of 22 patients who underwent LPD in our institution from August 2021 to November 2023 were included in this study. All patients signed informed consent forms preoperatively, approved by the ethics committee.

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The patients were categorised into two groups based on the different PJ techniques: the modified continuous single-layer PJ group ( $n = 12$ ) and the conventional duct-to-mucosa double-layer anastomosis group ( $n = 10$ ). The two groups were matched for demographic and pre-operative characteristics [Table 1]. Inclusive and exclusion criteria of the cases, pre-operative preparation, anaesthesia, specimen resection, hepatico-jejunostomy, gastrojejunostomy, drain placement and post-operative management were conducted comparably between the two groups.

## SURGICAL TECHNIQUE

### Conventional technique

The conventional PJ approach involves a two-layer anastomosis: an inner layer (pancreatic duct to jejunal mucosa) and an outer layer (parenchyma to seromuscular jejunum), which requires meticulous suturing and poses challenges in laparoscopic settings.

### Modified continuous single-layer anastomosis technique

The modified PJ technique comprises four key steps [Figures 1-4].

#### Posterior wall anastomosis

Following pancreatic stump mobilisation (1.5 cm along the splenic vein) and haemostasis, an end-to-side anastomosis is initiated using a 4-0 Prolene (double-needle) suture. The suture begins 0.5 cm from the superior pancreatic edge, traversing ventrodorsally through the pancreas and dorsoventrally through the jejunal seromuscular layer (4 cm from the jejunal stump). Continuous suturing proceeds downwards along the posterior walls of the pancreas and jejunum, maintaining 2 mm intervals without tension [Figure 1].

#### Pancreatic duct integration

A jejunal enterotomy is created opposite the pancreatic duct using the ultrasonic scalpel. Three sutures anchor the duct to the jejunal mucosa: the needle passes through the ductus posterior wall, exits the jejunal incision, and secures the ductal-jejunal interface [Figure 2a-c]. A non-fixed

pancreatic duct stent is then positioned to bridge the anastomosis [Figure 2d].

#### Posterior wall completion

Suturing resumes from the duct towards the pancreatic inferior edge [Figure 3a]. Upon reaching this landmark, 1-2 full-thickness sutures reinforce the pancreatic parenchyma and jejunal seromuscular layer. Sequential suture tightening finalises posterior wall [Figure 3b].

#### Anterior wall anastomosis [Figure 4a-d]

From the superior pancreatic edge, continuous suturing progresses upwards along the anterior walls [Figure 4a]. At pancreatic duct level, the needle penetrates the duct ventrally, exits the jejunal enterotomy anteriorly and secures the ductal closure with 1–2 additional stitches [Figure 4b and c]. The remaining anterior sutures are completed and tied to the posterior suture line [Figure 4d].

### Statistical analysis

Data were analysed using SPSS 25.0 (IBM Corporation, Armonk, New York, USA). Categorical variables were presented as frequencies, and continuous variables were presented as mean  $\pm$  standard deviation. Shapiro–Wilk test was used to test the normality of data distribution. Parametric continuous variables were compared with Student's  $t$ -test, while non-parametric variables were analysed with the Mann–Whitney  $U$ -test. Categorical variables were evaluated using the  $\chi^2$  test. A two-tailed  $P < 0.05$  indicated statistical significance.

## RESULTS

All perioperative statistical data are shown in Table 2. No mortality or Grade C post-operative PF (POPF) occurred in either group. Grade B POPF (16.7% in the modified group vs. 10% in the control group,  $P = 0.65$ ) and biochemical leaks (0% vs. 10%,  $P = 0.262$ ) showed no intergroup differences. The modified technique significantly reduced PJ time (19.08 vs. 23.1 min,  $P < 0.001$ ) and post-operative abdominal infections (0% vs. 30%,  $P = 0.041$ ). Intraoperative bleeding (118 vs. 90 mL,  $P = 0.474$ ), post-operative bleeding (1 vs. 0 cases,  $P = 0.35$ ), drainage tube removal time (16.25 vs. 18.10 days,  $P = 0.478$ )

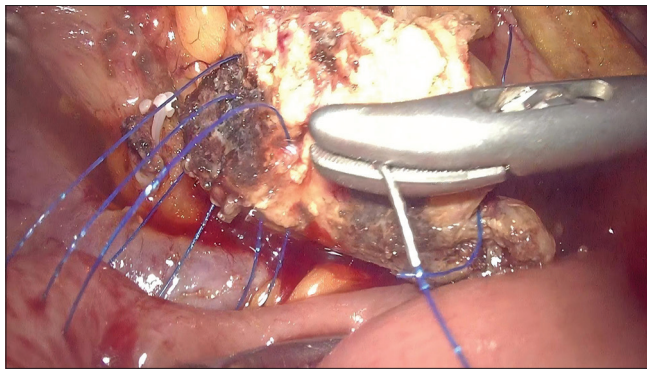
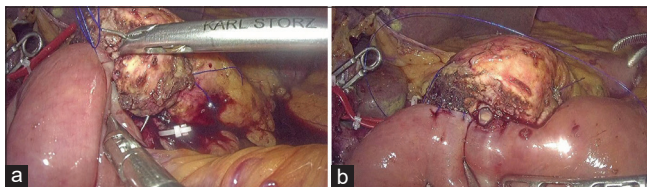
**Table 1: Demographic and pre-operative characteristics of the patients**

Variables	Modified group ( $n=12$ )	Conventional group ( $n=10$ )	$t, Z, \text{ or } \chi^2$	$P$
Gender				
Male	9	4	2.764	0.096
Female	3	6		
Age (years, $x \pm s$ )	66.25 $\pm$ 6.55	65.7 $\pm$ 8.63	0.17	0.867
Pre-operative diabetes status	6	4	0.22	0.691
Pre-operative total bilirubin ( $\mu\text{mol/L}$ )	61.17 $\pm$ 53.24	91.85 $\pm$ 69.32	-1.174	0.254
Pre-operative albumin (g/L)	36.66 $\pm$ 3.86	35.67 $\pm$ 2.18	0.719	0.481
Pre-operative haemoglobin (g/L)	118.92 $\pm$ 12.84	121.4 $\pm$ 13.78	-0.437	0.667

**Table 2: Intraoperative factors and post-operative data of the patients**

Variables	Modified group (n=12)	Conventional group (n=10)	t, Z, or $\chi^2$	P
<b>Intraoperative factors</b>				
Diameter of the main pancreatic duct (mm)	3.21±1.74	4.30±2.37	-1.245	0.227
Texture of the pancreas (soft)	8	5	0.627	0.429
PJ time (min)	19.08±2.11	23.10±2.42	-4.158	<0.001
Blood loss (mL)	118.33±91.63	90±65.84	0.73	0.474
<b>Post-operative data</b>				
<b>POPF</b>				
No leak	10	8	0.041	0.84
Biochemical leak	0	1	1.257	0.262
Grade B	2	1	0.206	0.65
<b>Post-operative bleeding</b>				
Gastrointestinal tract bleeding	1	0	0.873	0.35
Intra-abdominal bleeding	0	0	/	/
Abdominal infection	0	3	4.168	0.041
Intra-abdominal collections	4	5	0.627	0.429
Final drainage tube removal time (days)	16.25±5.41	18.10±6.59	-0.724	0.478
Post-operative hospital stay	18.75±5.43	21.50±6.15	-1.114	0.278

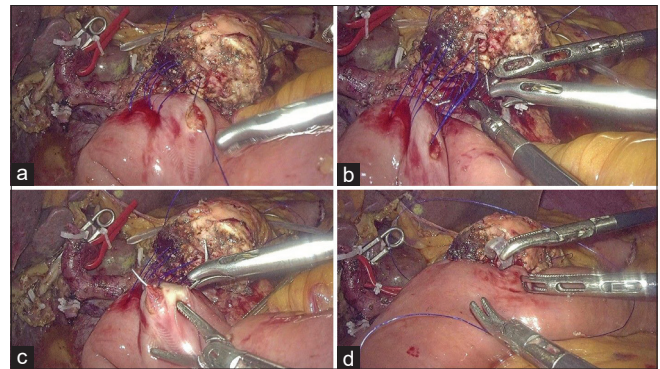
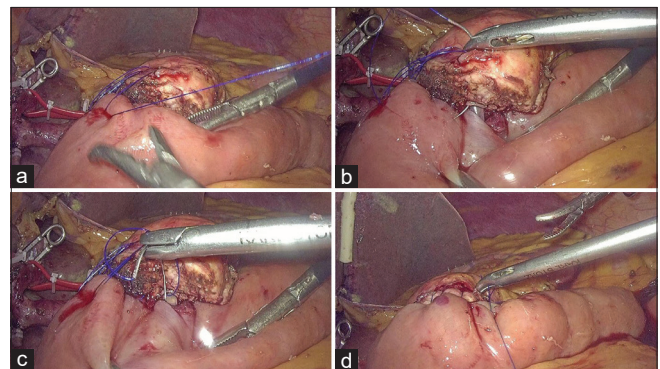
POPF: Post-operative pancreatic fistula, PJ: Pancreaticojejunostomy

**Figure 1:** Posterior wall anastomosis using continuous 4-0 Prolene suture**Figure 3:** (a) Posterior anastomotic suturing resumed from duct towards the pancreatic inferior edge. (b) Sequential suture tightening finalises posterior wall

and hospital stay (18.75 vs. 21.5 days,  $P = 0.278$ ) were comparable. Delayed gastric emptying was absent in both the groups.

## DISCUSSION

PJ remains the most technically demanding step in PD, with its complexity magnified in laparoscopic procedures.<sup>[4]</sup> While open surgical techniques like the modified Blumgart method or invagination PJ have been adapted laparoscopically,<sup>[1-3,5]</sup> their inherent procedural intricacy prolongs anastomotic time and challenges novice surgeons. Our modified PJ technique in LPD addresses

**Figure 2:** (a-c) Pancreatic duct secured to jejunal mucosa via duct-to-mucosa sutures following enterotomy. (d) The placement of pancreatic duct stent**Figure 4:** (a) Anterior wall anastomosis via continuous suturing. (b and c) Ventral duct incorporation and closure at enterotomy. (d) Anterior suture line tied to posterior suture line

these limitations by streamlining traditional two-layer duct-to-mucosa anastomosis into a single-layer continuous suture, prioritising simplicity and reducing anastomotic time without compromising safety.

The modified PJ technique offers several key advantages. First, continuous suturing eliminates interrupted knots,



ensuring uniform tension distribution across the anastomosis, which reduces tissue cutting and leakage risks. In addition, the technique minimises the gap between the pancreatic cut surface and the jejunal seromuscular layer, preventing the accumulation of pancreatic fluid to reduce the potential for tissue erosion. Furthermore, the sutures penetrate both the pancreatic duct and jejunal mucosa, increasing tissue thickness at the PJ anastomotic site. This approach reduces the likelihood of suture cutting and facilitates closer apposition of the pancreatic duct and jejunal mucosa. Moreover, the application of a pancreatic duct stent prevents anastomotic stricture and directs most pancreatic juice into the jejunum, promoting the formation of fibrous tissue and adhesion between the pancreatic duct and jejunal mucosa, which aids in the rapid sealing of the anastomosis. Besides, full-thickness suturing of the upper and lower margins of the pancreatic remnant reinforces areas potentially weakened by anterior and posterior wall suturing, reducing the risk of pancreatic leakage.

However, the modified technique carries inherent risks. Continuous suturing may exacerbate tension during tissue oedema, increasing the dehiscence risk if sutures are mishandled. It is advisable to avoid using needle holders to grasp the sutures during anastomosis, thereby reducing suture damage. In addition, non-fixated pancreatic duct stents have a risk of dislodgement. Furthermore, our study retrospective design and small sample size limit statistical power, necessitating cautious interpretation.

In conclusion, this modified PJ technique represents a pragmatic adaptation to laparoscopic constraints, balancing efficiency and reliability. Larger randomised trials are imperative to validate its long-term outcomes and establish standardised guidelines for widespread adoption.

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### Conflicts of interest

There are no conflicts of interest.

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