

RESEARCH ARTICLE

Double loop reconstruction with isolated gastric limb after pancreaticoduodenectomy

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Publication history

Received: 31 May 2026
Accepted: 10 Aug 2026
Published online: 25 Aug 2026

Responsible editor

M Mostafa Zaman
0000-0002-1736-1342

Reviewers

A: Anonymous
E: Kazi Mahzabin Arin
0009-0004-0064-3847
F: Sonjoy Biswas
0009-0005-4077-2894

Keywords

pancreaticoduodenectomy,
single-loop reconstruction,
double-loop reconstruction,
delayed gastric emptying

Funding

Funded by Bangladesh Medical
University (Memo No. AI100-B-
1877704, date 2 June 2025).

Ethical approval

Approved by the Institutional
Review Board of Bangladesh
Medical University for (Memo No.
BSMMU/2024/10711(1), date 26
Nov 2024)

Trial registration number

Not available

Declaration

The article partially encompasses
MS theses of Dr. Md. Emaral Ali.

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Published by Bangladesh Medical
University (former Bangabandhu
Sheikh Mujib Medical University).

Abstract

Background: Delayed gastric emptying (DGE) and postoperative pancreatic fistula (POPF) remain the most frequent causes of morbidity after pancreaticoduodenectomy. Roux-en-Y double-loop reconstruction with an isolated gastric limb (RIGL) has been proposed to reduce these complications, but clinical evidence remains limited. The aim is to assess the effect of RIGL on the incidence of DGE and POPF following pancreaticoduodenectomy compared with conventional single-loop reconstruction (SLR).

Methods: This intervention study was conducted in the Department of Hepatobiliary, Pancreatic and Liver Transplant Surgery, Bangladesh Medical University, from December 2024 to November 2025. Adult patients undergoing elective pancreaticoduodenectomy were allocated to either conventional SLR or Roux-en-Y double-loop reconstruction with an isolated gastric limb (DLR) using a predefined alternating sequence. Thirty patients were included (SLR, 15; DLR, 15). Postoperative outcomes were compared between groups.

Results: Baseline demographic and clinical characteristics were comparable between groups. DGE occurred less frequently in the DLR group than in the SLR group (13.3% vs. 53.3%, $P=0.02$). Although POPF was less common following DLR (46.7% vs. 66.7%), the difference was not statistically significant ($P=0.27$). Rates of bile leakage, wound infection, pneumonia, and other postoperative complications were similar between groups. Mean hospital stay was shorter in the DLR group (16.2 vs. 19.5 days), but the difference was not statistically significant ($P=0.19$). No perioperative mortality or Grade C DGE/POPF was observed.

Conclusion: RIGL significantly reduced DGE after pancreaticoduodenectomy without increasing other postoperative complications. Larger prospective studies are warranted to confirm these findings and further evaluate its impact on POPF-related outcomes.

Key messages

This study demonstrates that Roux-en-Y double-loop reconstruction with an isolated gastric limb significantly reduces delayed gastric emptying after pancreaticoduodenectomy compared with conventional single-loop reconstruction. Beyond improving postoperative recovery, the technique facilitates continued enteral feeding in patients who develop pancreatic fistula, offering a practical advantage in postoperative management without increasing overall morbidity or hospital stay.

Introduction

Pancreaticoduodenectomy remains the standard curative procedure for malignant tumours of the pancreatic head, periampullary region, distal bile duct, and duodenum, and this pancreaticoduodenectomy is also performed for selected benign and premalignant condition. Advances in surgical techniques and perioperative care, have reduced postoperative mortality to less than 5% in high-volume centres, although morbidity remains high at 40–60% [1–3].

Delayed gastric emptying (DGE) and postoperative pancreatic fistula (POPF) are among the most clinically relevant procedure-specific complications [1]. DGE occurs in approximately 15–40% of patients and contributes to prolonged nasogastric tube use, delayed oral intake, extended hospitalization, increased healthcare costs, and reduced quality of life [1, 3]. POPF develops in up to 30% of patients and remains a major cause of severe morbidity, contributing to intra-abdominal sepsis, haemorrhage, reintervention, and mortality [1, 4].

The pathophysiology of DGE after pancreaticoduodenectomy is multifactorial and includes disruption of gastric and duodenal motility, antropyloric denervation, inflammation, ischaemia, intra-abdominal complications, and mechanical factors related to reconstruction [1]. Reconstruction configuration and route may influence gastric emptying through effects on gastrojejunostomy geometry, gastric-content transit, and exposure to local inflammation [5, 6]. Thus, antecolic and modified reconstructions may help reduce DGE by minimizing tension, angulation, and stasis [5, 6].

Roux-en-Y reconstruction with an isolated gastric limb (RIGL) separates the gastrojejunostomy from pancreaticobiliary anastomoses using independent jejunal limbs. This may reduce the effect of local inflammation, oedema, collections, and leakage on gastric emptying and may provide a less angulated alimentary route. Furthermore, during POPF or biliary leakage, the isolated gastric limb may permit enteral nutrition, potentially simplifying postoperative management. However, evidence supporting routine RIGL remains limited [7, 8]. Meta-analyses comparing single-loop and Roux-en-Y reconstructions have reported inconsistent effects on DGE and POPF [9]. Evidence specifically evaluating RIGL is scarce, particularly in South Asian populations, and no published study from Bangladesh was identified in our literature search up to study design. This study aimed to assess whether Roux-en-Y double-loop reconstruction with an isolated gastric limb reduces the incidence of DGE, and influences POPF-related outcomes compared with conventional single-loop reconstruction after pancreaticoduodenectomy.

Methods

Study design

This interventional study was conducted in the Department of Hepatobiliary, Pancreatic and Liver Transplant Surgery, Bangladesh Medical University,

Dhaka, Bangladesh, from December 2024 to November 2025. The study was designed to compare postoperative outcomes between conventional single-loop reconstruction (SLR) and Roux-en-Y double-loop reconstruction (DLR) with an isolated gastric limb following pancreaticoduodenectomy. As participants were allocated according to a predefined alternating sequence rather than a concealed randomization process, the study was considered a comparative study rather than a randomized controlled trial.

Participants

Adult patients (≥ 18 years) undergoing elective pancreaticoduodenectomy for benign or malignant diseases of the pancreatic head, periampullary region, distal common bile duct, or duodenum were screened for eligibility. Patients were included if pancreaticoduodenectomy was deemed feasible and written informed consent was obtained. Patients were excluded if resection could not be completed because of unresectable disease or distant metastasis identified intraoperatively, if total pancreatectomy was required, or if they had undergone previous major upper gastrointestinal reconstruction that could influence postoperative outcomes.

During the study period, 35 patients met the eligibility criteria and were enrolled. Five patients were subsequently excluded because pancreaticoduodenectomy could not be completed owing to unresectable disease identified during surgery. Finally included 30 patients, of whom 15 underwent conventional SLR and 15 underwent DLR. A participant flow diagram is presented in Figure 1. Following completion of the resection phase and confirmation that pancreaticoduodenectomy could be performed, patients were allocated to one of the two reconstruction techniques using a predefined alternating sequence. Patients were assigned consecutively to either SLR or DLR throughout the one year study period.

Preoperative assessment

All patients underwent a standardised preoperative evaluation according to departmental protocol. This included a detailed clinical assessment, complete blood count, liver function tests, renal function tests, coagulation profile, serum electrolytes, and radiological investigations. Contrast-enhanced computed tomography and magnetic resonance cholangiopancreatography (MRCP) were performed as indicated for diagnostic evaluation and surgical planning.

Preoperative biliary drainage by endoscopic retrograde cholangiopancreatography was performed selectively in patients with severe cholangitis or serum bilirubin levels exceeding 15 mg/dL. All cases were reviewed in the departmental multidisciplinary meeting before surgery.

Surgical techniques

All operations were performed by the same hepatopancreatobiliary surgical team using standardised operative principles. Roux-en-Y double-loop reconstruction with an isolated gastric limb in the DLR group, pancreaticojejunostomy and

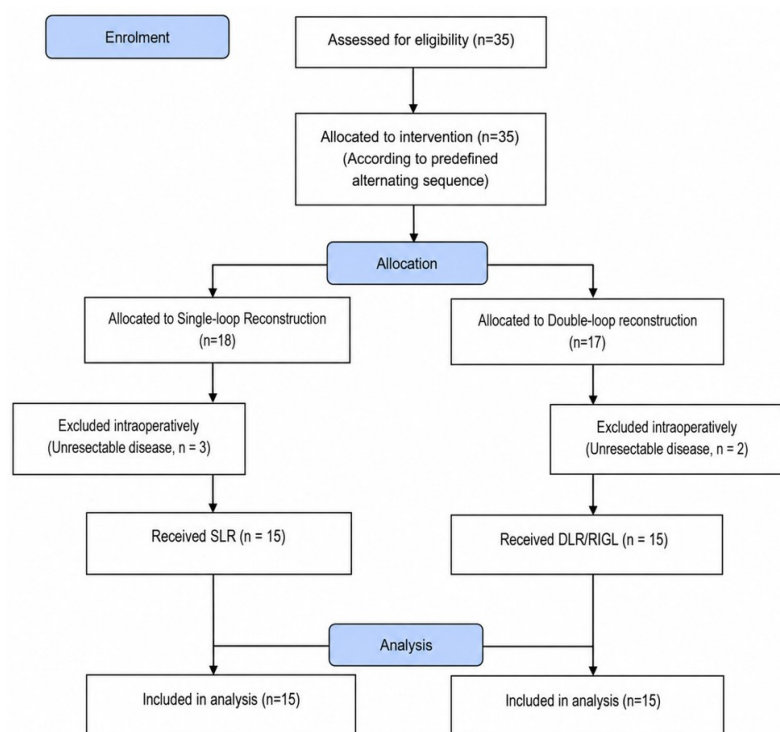


Figure 1 CONSORT flowchart for participant recruitment for pancreaticoduodenectomy in Bangladesh Medical University Hospital, Dec 2024 to Nov 2025

hepaticojejunostomy were constructed on a proximal jejunal limb brought retrocolically through the transverse mesocolon. Pancreaticojejunostomy was performed first, followed by an end-to-side hepaticojejunostomy approximately 10 to 15 cm distal to the pancreatic anastomosis.

The jejunum was subsequently divided approximately 35 to 40 cm distal to the hepaticojejunostomy using a linear stapling device. The distal jejunal limb was then brought to the stomach through an antecolic route, and a gastrojejunostomy was fashioned using a two-layer hand-sewn end-to-side or side-to-side technique. Intestinal continuity was restored by creating a jejunojejunostomy between the alimentary limb and the biliopancreatic limb, thereby completing the Roux-en-Y reconstruction with an isolated gastric limb.

Conventional single-loop reconstruction

In the conventional SLR group, all three anastomoses were created on a single jejunal limb. A pancreaticojejunostomy was constructed first, followed by a hepaticojejunostomy approximately 10 cm distal to the pancreatic anastomosis. An antecolic gastrojejunostomy was then performed approximately 50 cm distal to the hepaticojejunostomy using the same jejunal loop.

Drain placement

Three silicone drains were routinely placed at the end of the procedure: one adjacent to the pancreaticojejunostomy, one adjacent to the hepaticojejunostomy, and one in the left subhepatic region. Drains were removed when the output was

minimal and there was no evidence of clinically significant leakage. Patients with controlled low-output fistulae were discharged with drains in situ when appropriate and followed closely in the outpatient setting.

Postoperative management and follow-up

Postoperative care was standardised for all patients. Broad-spectrum antibiotics were administered according to institutional protocol. Total parenteral nutrition was initiated on the first postoperative day when required and gradually transitioned to enteral and oral feeding according to clinical recovery. Nasogastric tubes were removed once gastric output had decreased and gastrointestinal function had returned.

Patients who developed postoperative pancreatic fistula received octreotide (50 µg subcutaneously every 8 hours) according to departmental practice. Laboratory investigations, including complete blood count, liver function tests, serum creatinine, serum electrolytes, and drain fluid amylase levels, were performed on postoperative days 1, 3, and 5 and subsequently as clinically indicated.

All patients were followed for at least 30 days after surgery. Following discharge, patients attended weekly outpatient follow-up visits or were reviewed earlier if complications occurred.

Outcome measures and their ascertainment

The outcomes of the study were DGE, POPF, PPH, bile leakage, wound infection, pneumonia, length of hospital stay, and perioperative mortality.

DGE was defined according to the International Study Group of Pancreatic Surgery (ISGPS) criteria as impaired gastric emptying requiring prolonged nasogastric decompression or reinsertion of a nasogastric tube after surgery [10]. The severity of DGE was graded A, B, or C according to ISGPS recommendations.

POPF was defined according to the 2016 ISGPS criteria as any measurable drain output with an amylase concentration greater than three times the upper limit of normal serum amylase activity on or after postoperative day 3 and associated with a clinically relevant condition. Clinically relevant POPF was classified as Grades B or C [11].

Post-pancreatectomy haemorrhage was defined and graded according to ISGPS criteria based on the timing, location, and severity of bleeding. Surgical site infection was identified using the Centres for Disease Control and Prevention definitions [12]. Perioperative mortality was defined as any death occurring during the index hospital admission or within 30 days after surgery. Length of hospital stay was calculated from the date of surgery to the date of discharge.

Data collection

Data were collected using case record form developed before the commencement of the study. Information regarding demographic characteristics, comorbidities,

laboratory findings, radiological investigations, operative details, postoperative complications, management strategies, and hospital stay was recorded. To ensure data quality, all information was cross-checked against hospital records, operative notes, and discharge summaries.

Statistical analysis

Data were analysed using SPSS version 26.0. Continuous variables were tested for normality using the Shapiro–Wilk test. Normally distributed variables (e.g., age, body mass index, alkaline phosphatase, albumin, international normalised ratio and common bile duct diameter) were expressed as mean and standard deviation, whereas non-normally distributed variable (e.g., bilirubin) were presented as median and interquartile range. Categorical variables (e.g., sex, comorbidities, preoperative diagnosis, main pancreatic duct diameter and lymphatic enlargement) were summarised as frequencies and percentages.

Comparisons between the conventional SLR group and the Roux-en-Y DLR group were performed using the independent-samples *t* test or Mann–Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate. A two-sided *P* < 0.05 was considered statistically significant.

Table 1 Demographic, clinical and laboratory characteristics of two study groups for pancreaticoduodenectomy

Characteristics	Single loop reconstruction (n=15)	Double loop reconstruction (n=15)	<i>P</i>
Age in years ^a	52.7 (12.5)	50.5 (14.3)	0.67
Male sex	8 (53.3)	7 (46.7)	0.71
Body mass index (kg/m ²) ^a	20.4 (3.6)	20.4 (2.5)	0.96
Co-morbidities			
Diabetes mellitus	3 (20.0)	6 (40.0)	0.16
Hypertension	5 (33.3)	3 (20.0)	0.23
Hypothyroidism	3 (20.0)	–	0.11
Bronchial asthma	1 (6.7)	–	0.50
Preoperative diagnosis			
Periampullary carcinoma	9 (60.0)	7 (46.7)	0.63 ^b
Distal cholangiocarcinoma	3 (20.0)	4 (26.7)	
Carcinoma of the head of the pancreas	2 (13.3)	3 (20.0)	
Malignant duodenal GIST	1 (6.7)	–	
SPT of the head of pancreas	–	1 (6.7)	
Main pancreatic duct diameter			
2 – 4 mm	9 (60.0)	11 (73.3)	0.44
≥5 mm	6 (40)	4 (26.7)	
Lymphatic enlargement	11 (73.3)	10 (66.7)	0.69
Bilirubin (mg/dL), median (IQR)	2.4 (0.9 – 7.5)	7.8 (5.1 – 9.8)	0.09 ^c
Alkaline phosphatase (IU/L), median (IQR)	357.0 (251.0 – 537.5)	245.0 (190.5 – 300.5)	0.15
Albumin (gm/dL) ^a	38.3 (7.4)	37.9 (6.5)	0.87
International normalised ratio ^a	1.2 (0.3)	1.2 (0.2)	<0.99
Common bile duct diameter (mm) ^a	15.3 (4.0)	16.1 (4.4)	0.58

GIST indicate gastrointestinal stromal tumour; SPT, solid pseudopapillary tumour; IQR, interquartile range.

Results are number (%), unless otherwise indicated.

^aMean (standard deviation); ^bFisher's Exact test; ^cMann–Whitney U test; ^d*t* test for the rest

Results

Thirty patients were included in the final analysis, with 15 undergoing SLR and 15 undergoing DLR. The two groups were comparable with respect to baseline demographic and clinical characteristics. Mean age was 52.7 years in the SLR group and 50.5 years in the DLR group (Table 1). Mean body mass index was identical (20.4 kg/m²). The prevalence of comorbidities, including diabetes mellitus and hypertension, did not differ significantly between groups. Preoperative clinical, laboratory, radiological, and diagnostic characteristics were also comparable. Periampullary carcinoma was the most common indication for pancreaticoduodenectomy in both groups. Serum bilirubin, alkaline phosphatase, albumin, and international normalized ratio showed no significant between-group differences. Similarly, magnetic resonance cholangiopancreatography findings, including main pancreatic duct diameter, common bile duct diameter, and lymph node enlargement, were comparable.

Although POPF was more common in the SLR group (66.7% vs. 46.7%), the difference was not statistically significant (*P* = 0.27) (Table 2). Likewise, rates of bile leakage, wound infection, pneumonia, chyle leakage, and post-pancreatectomy haemorrhage were numerically higher in the SLR group but did not differ significantly between groups.

The proportion of patients having DGE was significantly lower (*P* = 0.02) in DLR group (13.3%) compared with SLR group (53.3%). Most DGE cases (75%) in the SLR group were in Grade A, whereas the two DGE cases observed in the DLR group were in Grade B. No Grade C was found in either group (Table 3). POPF was identical in both groups. Management strategies for POPF were broadly similar between groups. However, patients in the DLR group were more frequently able to continue enteral feeding, whereas nothing per oral management and combined octreotide-drainage therapy were used only in the SLR group. The mean length of postoperative hospital stay was 19.5 days in the SLR group and 16.2 days in the DLR group. Although hospitalization tended to be shorter following DLR, the difference was not statistically significant (*P* = 0.19). No perioperative deaths occurred in either group.

Discussion

The present study evaluated the impact of Roux-en-Y double-loop reconstruction with an isolated gastric limb (DLR/RIGL) on postoperative outcomes following pancreaticoduodenectomy. The principal finding was a significant reduction in DGE among patients undergoing DLR group compared with SLR group. In contrast, rates of POPF, bile leakage, wound infection, pneumonia, and length of hospital stay did not differ significantly between groups. These findings suggest that the primary advantage of DLR lies in reducing DGE rather than in preventing other postoperative complications.

Table 2 Comparison of postoperative complications between single-loop reconstruction and double loop reconstruction groups, number (%)

Complications	Single loop reconstruction (n=15)	Double loop reconstruction (n=15)	P ^a
Postoperative pancreatic fistula	10 (66.7)	7 (46.7)	0.16
Delayed gastric emptying and postoperative pancreatic fistula	6 (40.0)	2 (13.3)	0.09
Bile leakage	5 (33.3)	2 (13.3)	0.15
Chylous leak	2 (13.3)	3 (20.0)	0.33
Post-pancreatectomy haemorrhage	1 (6.7)	–	0.50
Wound infection	12 (80.0)	8 (53.3)	0.09
Pneumonia	3 (20.0)	–	0.11
Readmission within 30 days	–	1 (6.7)	0.50

^aFisher's Exact test

DGE remains one of the most common causes of prolonged recovery after pancreaticoduodenectomy. Although it is rarely life-threatening, DGE delays oral intake, prolongs nasogastric decompression, increases healthcare utilization, and negatively affects postoperative recovery [13]. The significantly lower incidence of DGE observed in the DLR group is consistent with previous studies evaluating isolated gastric limb reconstruction. Ben-Ishay et al. reported DGE rates of 15.4% following RIGL compared with 59.1% after conventional reconstruction and identified isolated gastric limb reconstruction as an independent protective factor against DGE [14]. Similar reductions in DGE have been reported in studies evaluating Roux-en-Y and other dual-loop configurations, particularly when an antecolic gastrojejunostomy is used [15–17]. Collectively, these findings support the concept that reconstruction geometry influences postoperative gastric function.

Table 3 Distribution of study participant according to delayed gastric emptying and postoperative pancreatic fistula, number (%)

Variables	Single loop reconstruction (n=15)	Double loop reconstruction (n=15)	P ^a
Delayed gastric emptying (DGE)	8 (53.3)	2 (13.3)	0.02
DGE according to International Study Group of Pancreatic Surgery grading ^b			
Grade A	6 (75.0)	–	0.13
Grade B	2 (25.0)	2 (100.0)	
Postoperative pancreatic fistula	10 (66.7)	7 (46.7)	0.16
POPF According to International Study Group of Pancreatic Surgery grading ^b			
Grade A	5 (50.0)	2 (28.6)	0.35
Grade B	5 (50.0)	5 (71.4)	
Postoperative supportive measure in patient with postoperative pancreatic fistula			
Nothing per oral	5 (33.4)	–	0.59
Enteral nutrition maintained	10 (66.7)	15 (100.0)	
Octreotide given	4 (26.7)	5 (33.3)	
Postoperative hospital stay, days	19.5 (6.0)	16.2 (3.5)	0.19

POPF indicates postoperative pancreatic fistula

^aFisher's Exact test or Chi-square test; ^bGrade C not found.

Several physiological mechanisms may explain the lower incidence of DGE observed with DLR. In conventional reconstruction, the gastrojejunostomy lies adjacent to the pancreaticojejunostomy and hepaticojejunostomy. Consequently, local inflammation, oedema, fluid collections, or low-grade leakage may impair gastric motility. By separating the gastric outlet from the pancreaticobiliary anastomoses, the isolated gastric limb may reduce exposure of the stomach and gastrojejunostomy to these local inflammatory effects. Furthermore, the antecolic orientation of the isolated gastric limb may minimize angulation, redundancy, and mechanical obstruction, thereby facilitating gastric emptying [15, 16]. Although these mechanisms remain partly theoretical, the present findings provide clinical support for their potential relevance.

The relationship between reconstruction technique and POPF remains less clear. In the present study, POPF occurred less frequently in the DLR group, but the difference was not statistically significant. This observation is consistent with previous systematic reviews and meta-analyses, which have generally failed to demonstrate a consistent reduction in POPF through reconstruction configuration alone [18–21]. The development of POPF is influenced by multiple factors, including pancreatic texture, duct diameter, pathology, gland consistency, and technical aspects of pancreaticojejunostomy, many of which may exert a greater influence than the arrangement of intestinal limbs [4, 19].

Although DLR did not significantly reduce POPF incidence, an interesting clinical observation was that patients with POPF in the DLR group were more often able to continue enteral feeding. Because the gastric limb is anatomically separated from the pancreaticobiliary limb, postoperative nutritional support may be less affected by pancreatic leakage. However, the present study did not evaluate fistula healing time, duration of drainage, nutritional outcomes, reintervention rates, or time to fistula closure. Therefore, this observation should be interpreted cautiously and considered hypothesis-generating rather than definitive evidence of improved POPF management [11].

Other postoperative complications, including bile leakage, wound infection, pneumonia, and post-pancreatectomy haemorrhage, were comparable between groups. These findings suggest that the benefits of DLR are specific to gastric emptying rather than a global reduction in postoperative morbidity. Similarly, although the mean hospital stay was approximately three days shorter in the DLR group, this difference was not statistically significant. The observed trend may be related to the lower incidence of DGE; however, larger studies are required to determine whether DLR translates into a meaningful reduction in hospitalization [19, 21].

An important strength of this study is that all procedures were performed within a single hepatopancreatobiliary unit using standardised

perioperative protocols and by the same surgical team, thereby minimizing technical variability. Nevertheless, several limitations should be acknowledged. First, the study employed an alternating allocation strategy rather than concealed randomization, introducing the possibility of selection bias. Second, the sample size was relatively small and the study was powered primarily to detect differences in DGE, limiting its ability to identify differences in less frequent outcomes such as clinically relevant POPF. However, a post hoc analysis indicated that the study had a 75% power to detect DGE differences between groups (53.3% vs 13.3% for a 5% alpha), which is fairly optimum. Finally, long-term nutritional outcomes, functional recovery, and quality-of-life measures were not assessed.

Despite some limitations, the findings provide preliminary evidence that Roux-en-Y DLR may reduce DGE after pancreaticoduodenectomy without increasing other postoperative complications. Given the substantial impact of DGE on patient recovery and healthcare utilization, this technique warrants further testing in multicentre studies with adequate power to assess both DGE and clinically relevant POPF.

Conclusion

Roux-en-Y DLR with an isolated gastric limb was associated with a significantly lower rate of DGE compared with conventional SLR after pancreaticoduodenectomy. No significant differences were observed in POPF, other postoperative complications, or length of hospital stay. These findings suggest that DLR may be a useful reconstructive option for reducing DGE, although larger studies are required to confirm its benefits and determine its effect on other clinically important outcomes.

Acknowledgements

We would like to express our sincere gratitude to colleagues of the Department of Hepatobiliary, Pancreatic & Liver Transplantation Surgery, Bangladesh Medical University, for their generous support.

Author contributions

Conception and design, or design of the research; or the acquisition, analysis, or interpretation of data: MEA, AMAAA, MSU, MS, KAH, BCD. *Drafting the manuscript or revising it critically for important intellectual content:* AMAAA, MSU, MEA. *Final approval of the version to be published:* AMAAA. *Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved:* AMAAA, MEA.

MEA and AMAAA are equal contributors.

Conflict of interest

We do not have any conflict of interest.

Data availability statement

We confirm that the data supporting the findings of the study will be shared upon reasonable request.

AI disclosure

We accept full responsibility for the content of this manuscript. We acknowledge that AI (Co-pilot) was used to

assist with English language editing: prompts were employed to refine sentence structure, grammar, and word choice. Every suggestion from the AI was reviewed and edited by the authors to ensure accuracy and preserve the integrity of our original expressions.

Supplementary file

None

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