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Conventional Reconstruction Versus Double Roux Reconstruction Procedure After Pancreaticoduodenectomy

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Abstract

Background: Pancreaticoduodenectomy (PD), or the Whipple procedure, is commonly associated with high morbidity. Traditional reconstruction using a single jejunal limb carries risks due to the interaction between pancreatic and biliary secretion. The double roux reconstruction procedure (DRRP) may mitigate these risks.

Objectives: We hypothesized that DRRP would reduce postoperative pancreatic fistula and related complications compared to the classic Whipple procedure.

Methods: This prospective study included 50 patients (31 classic, 19 DRRP). In DRRP, one Roux limb was used for pancreatic anastomosis, and another for gastrojejunostomy and hepaticojejunostomy. Two drains were placed near each anastomosis and removed once biliary and pancreatic secretions decreased to < 10 mL/day for two consecutive days.

Results: The DRRP group had a lower, though not statistically significant, rate of postoperative pancreatic fistula (POPF, 5.3% vs. 16.1%). Reoperation rates were higher in the DRRP group (26.3% vs. 9.7%).

Conclusions: The DRRP may reduce certain risks but is associated with specific challenges such as anastomotic leaks and port thrombosis, emphasizing the need for careful patient selection, and further investigations for establishing its benefits definitively.

Keywords: Whipple Procedure, Pancreaticoduodenectomy, Roux-en-Y

1. Background

Despite advances in surgical technique and perioperative care, pancreaticoduodenectomy (PD), or the Kausch-Whipple procedure, continues to carry a morbidity rate of 25 - 60%, although hospital mortality has dropped below 5% (1, 2). Common complications include delayed gastric emptying, anastomosis leakage, postoperative pancreatic fistula (POPF), and intra-abdominal infections (3). Numerous modifications have been developed to reduce these risks.

The conventional Whipple procedure reconstructs the pancreatic, biliary, and gastric systems on a single jejunal limb. While effective, this approach can lead to complications due to the interaction of pancreatic and biliary secretions. The double roux reconstruction procedure (DRRP), using two separate Roux limbs (a pancreatic limb and a gastric-biliary limb), offers a potential solution (4, 5). It aims to reduce leakage, reflux, and infection by preventing pancreatic enzyme activation via bile, enterokinase, and gastric secretions

2. Objectives

We aimed to compare the classic Whipple and DRRP in terms of surgical technique, postoperative complications, and clinical outcomes. We hypothesized that DRRP would reduce the incidence of POPF and

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related complications compared to the conventional Whipple procedure.

3. Methods

This prospective study was conducted at Firoozgar Hospital (Iran University of Medical Sciences, Tehran) between January 2021 and December 2023. Written informed consent was obtained from all patients. The study was approved by the Institutional Ethics Board (IR.IUMS.FMD.REC.1401.669). The study was conducted in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

The census method of sampling was employed. Patients eligible for PD were thoroughly informed about both techniques and selected their preferred approach in consultation with the surgical team.

Inclusion criteria consisted of adult patients diagnosed with malignancies or conditions requiring PD who were deemed operable based on preoperative imaging and clinical evaluations. Exclusion criteria included the presence of contraindications for PD, such as extensive metastases, unresectable tumors due to vascular invasion, or severe anatomical distortions (e.g., prior total gastrectomy), advanced cirrhosis, severe comorbidities, prior chemotherapy or radiotherapy, severe malnutrition, or hypoalbuminemia.

Data were collected from daily ICU nurse charts, which were scanned and monitored consistently, and included demographics (age and gender), clinical features, tumor characteristics (location and post-operative pathology), past medical history, pre-operative biliary drainage, complications, length of stay, and mortality.

In the DRRP group, one Roux limb was routed retrocolically for pancreaticojejunostomy. The second limb (45 - 65 cm) was used for 10 cm apart gastrojejunostomy and hepaticojejunostomy. Two drains were placed near the pancreatic and biliary anastomoses to monitor secretions and bleeding, and were removed once output dropped below 10 mL/day for two consecutive days. Biliary and pancreatic secretions were measured and recorded daily. Pancreatic leak was defined as fluid drainage beyond the third postoperative day with amylase > 3x serum levels. Biliary leak was defined as > 50 mL of bile-stained fluid within 24 hours. CT was performed when fever persisted to assess for abscesses or fluid collections.

Statistical analysis was performed using IBM SPSS Statistics (v. 27.0). Chi-square tests were used for categorical variables; Mann-Whitney U for continuous variables. Significance was set at P-value < 0.05.

4. Results

A total of 50 patients were recruited, with 19 (38%) undergoing the DRRP procedure and 31 (62%) undergoing the classic approach. In the DRRP group, 68.4% of patients were male, compared to 71.0% in the classic group, with no statistically significant difference between groups (P = 0.849). No significant differences were observed between groups regarding prior abdominal surgery or tumor location A higher rate of diabetes mellitus was observed in the classic group (32.3% vs. 5.3%; P = 0.025). There were no significant differences in tumor pathology, bilirubin levels, or need for preoperative biliary drainage. Median blood loss was 300 mL in both groups (P = 0.626); operation time was slightly longer in the DRRP group (7.0 vs. 6.25 hours; P = 0.301; Table 1).

Postoperative pathology varied slightly between the groups, though differences were not statistically significant (P = 0.339). Adenocarcinoma was the predominant diagnosis in both groups (87.1% in the classic vs. 68.4% in the DRRP group), followed by neuroendocrine tumors and solid pseudopapillary epithelial tumors. Preoperative bilirubin levels and biliary drainage requirements were similar, with no significant difference observed (P = 0.226 and P = 0.640, respectively; Table 1).

Blood loss and operation time were comparable between the groups, with median blood loss of 300 ml in each group (P = 0.626) and operation time of 6.25 hours for the classic approach and 7.0 hours for DRRP (P = 0.301). Rates of pancreatic anastomosis leakage were lower in the DRRP group (5.3%) compared to the classic group (16.1%), though this difference was not statistically significant (P = 0.251). Complication rates, including intraabdominal abscess, sepsis, pneumonia, pancreatitis, and thromboembolic events, did not significantly differ between groups (Table 2). None of the patients developed postoperative obstruction.

The DRRP group had a higher rate of reoperations (26.3%) compared to the classic group (9.7%), but this was not statistically significant (P = 0.119). Causes for reoperation included leaks at various anastomotic sites and abscess formation, with one in-hospital death occurring in the DRRP group (P = 0.197; Table 2).

ICU and hospital stays were similar between the groups, with a median ICU stay of 6 days and hospital stay of 10 days for the classic group and 13 days for DRRP (P = 0.984 and P = 0.142, respectively; Table 2).

5. Discussion

Table 1. Comparison of the Baseline Characteristics of the Patients [a]

Variables	Classic (N = 31)	DRRP (N = 19)	Value	P-Value
Gender			0.036 [b]	0.849
Male	22 (71.0)	13 (68.4)		
Female	9 (29.0)	6 (31.6)		
Age	59 (46 - 65)	64 (45 - 70)	276.5 [c]	0.719
Diabetes mellitus	10 (32.3)	1 (5.3)	5.003 [b]	0.025
Previous abdominal surgery	6 (19.3)	3 (15.8)	0.101 [b]	0.75
Location of tumor			2.675 [b]	0.614 [b]
Ampulla	4 (12.9)	5 (26.3)		
Body and tail	1 (3.2)	-		
CBD	7 (22.6)	3 (15.8)		
Pancreas head	18 (58.1)	11 (57.9)		
Periampullary	1 (3.2)	-		
Postoperative pathology			5.681 [b]	0.339
Cholangiocarcinoma	1 (3.2)	1 (5.3)		
Adenocarcinoma	27 (87.1)	13 (68.4)		
NET	2 (6.5)	2 (10.5)		
Solid pseudopapillary epithelial	1 (3.2)	2 (10.5)		
Giant cell tumor	-	1 (5.3)		
Preoperative bilirubin	0.9 (0.64 - 1.9)	1.2 (1.1 - 1.9)	234.0 [c]	0.226
Preop biliary drainage	20 (64.5)	11 (57.9)	0.219 [b]	0.640
Symptoms				
Abdominal pain	14 (45.2)	7 (36.8)	0.335 [b]	0.563
Icter	12 (38.7)	7 (36.8)	0.017 [b]	0.895
Weight loss	5 (16.1)	3 (15.8)	0.001 [b]	0.975

Abbreviation: DRRP, double roux reconstruction procedure.

[a] Values are expressed as No. (%) unless indicated.

[b] Pearson chi-square value.

[c] Mann-Whitney U value.

The findings of our study indicated that the benefits of DRRP did not translate into a significant difference in most postoperative outcomes.

Our findings reaffirm the existing literature regarding classic Whipple complications, with 16.1% of patients in the classic PD group experiencing pancreatic anastomotic leakage, alongside a 9.7% incidence of SSI and an intra-abdominal abscess rate of 19.4%. These findings suggest potential benefits for certain patient populations. The DRRP was developed to preserve the duodenum, pylorus, and surrounding vasculature, which can minimize complications related to gastrointestinal reconstruction and anastomotic leaks. In our study, DRRP showed promise in certain areas, with pancreatic anastomosis leakage rate of only 5.3%, though this difference was not statistically significant. These advantages, if validated in larger studies, could support the role of DRRP in carefully selected patients, particularly those at lower risk of reoperation. However, the higher reoperation rate observed in the DRRP group highlights notable challenges. In line with our results, Grobmyer et al. (as cited by Uzunoglu et al.) have reported that no significant difference was observed between the two techniques (6). However, in some previous studies, DRRP has been associated with shorter operation time (5, 7), reduced need for postoperative biliary drainage (3, 5) and better post-operative quality of life (8).

Our study found a 26.3% reoperation rate in the DRRP group compared to 9.7% in the classic group, which may suggest potential challenges in managing certain complications unique to DRRP, such as leaks at preserved gastrointestinal junctions and increased risk of port thrombosis or abscess formation, which highlights the importance of thorough preoperative planning and postoperative monitoring for DRRP

Table 2. Comparison of the Intraoperative and Postoperative Outcomes [a]

Variables	Classic (N = 31)	DRRP (N = 19)	Value	P-Value
Blood loss	300 (200 - 500)	300 (200 - 450)	270.5 [b]	0.626
Operation time	6.25 (6.00 - 7.00)	7.0 (6.0 - 7.50)	243.5 [b]	0.301
Complications				
POPF	5 (16.1)	1 (5.3)	1.317 [c]	0.251
POPF grade			2.732 [c]	0.255
Grade A	4 (12.9)	-		
Grade B/C	1 (3.2)	1 (5.3)		
Intraabdominal abscess	6 (19.4)	3 (15.8)	0.101 [c]	0.750
Intraabdominal bleeding	1 (3.2)	-	0.625 [c]	0.429
SSI	3 (9.7)	3 (15.8)	0.417 [c]	0.519
Sepsis	3 (9.7)	2 (10.5)	0.009 [c]	0.923
Pneumonia	4 (12.9)	1 (5.3)	0.764 [c]	0.382
Pancreatitis	-	2 (10.5)	3.399 [c]	0.065
PTE	2 (6.5)	-	1.277 [c]	0.258
DVT	1 (3.2)	-	0.625 [c]	0.429
Port thrombosis	-	1 (5.3)	1.665 [c]	0.197
Reoperation	3 (9.7)	5 (26.3)	2.426 [c]	0.119
Cause of reoperation			8.263 [c]	0.219
Hepaticojejunostomy leak	1 (3.2)	-		
Gastrojejunostomy leak	-	2 (10.5)		
Luschka duct leak	1 (3.2)	-		
POPF B/C	1 (3.2)	1 (5.3)		
Abscess	-	1 (5.3)		
Dehiscence	-	1 (5.3)		
ICU stay (d)	6 (5 - 7)	6 (5 - 9)	293.5 [b]	0.984
Hospital stay (d)	10 (9 - 14)	13 (9 - 19)	221.5 [b]	0.142
In-hospital death	-	1 (5.3)	1.665 [c]	0.197

Abbreviations: DRRP, double roux reconstruction procedure; POPF, postoperative pancreatic fistula.

[a] Values are expressed as No. (%) unless indicated.

[b] Mann-Whitney U value.

[c] Pearson chi-square value.

patients. This contrasts with theories suggesting a generally lower reoperation rate for DRRP, which may be attributable to smaller study sizes or different patient selection criteria in previous studies. This finding underscores the importance of meticulous preoperative imaging to identify patients who may be anatomically better suited for this approach and the need for enhanced postoperative monitoring protocols tailored to address the unique complications associated with DRRP. Our findings highlight the variability in outcomes between patient groups, such as the significantly lower prevalence of diabetes mellitus in the DRRP cohort. It is possible that certain subgroups of patients, such as those without diabetes or with favorable anatomical characteristics, may derive greater benefit from DRRP. Future studies should consider stratified analyses to explore outcomes based on patient-specific factors, as these findings could guide patient selection and optimize surgical outcomes.

Although not evaluated in this study, the anatomical preservation inherent to DRRP may have long-term benefits, such as reduced bile reflux, improved nutritional outcomes, and decreased incidence of dumping syndrome, compared to the classic Whipple procedure. Previous literature has suggested that such preservation may contribute to better postoperative quality of life, and this remains a critical area for future investigation. Exploring these quality-of-life outcomes

could help define the patient population most likely to benefit from DRRP.

This study had several limitations that should be considered when interpreting the results. First, our sample size was relatively small, which restricts the statistical power needed to detect subtle differences between the DRRP and classic Whipple procedures. Second, this was a single-center study in a tertiary care facility, meaning that surgical expertise, perioperative protocols, and infection control measures were uniform and may not reflect practices across different institutions, potentially impacting the incidence of complications, including surgical site infections, limiting the generalizability of our findings. Furthermore, patients were not randomly assigned to treatment groups; instead, eligible patients were thoroughly informed about both procedures and made the final decision in consultation with the surgical team. This self-selection introduces a risk of selection bias, as patients' choices and underlying characteristics may have influenced outcomes. In addition, the inclusion criteria may not fully capture the heterogeneity of patients undergoing PD, and the higher rate of complications observed may be influenced by patient selection and surgical complexity. Additionally, we did not control for all possible confounding factors, such as patient comorbidities (e.g., diabetes mellitus) and nutritional status, which may have affected re-operation rates and other complications. Finally, long-term outcomes, such as quality of life and survival, were not evaluated, limiting our understanding of the comparative effectiveness of DRRP.

5.1. Conclusions

In conclusion, the DRRP group showed a trend toward a lower pancreatic anastomosis leakage rate, suggesting potential benefits that may require further investigation in larger studies to confirm. Notably, the higher reoperation rate observed in the DRRP group highlights challenges associated with this technique, such as anastomotic leaks and port thrombosis, emphasizing the need for careful patient selection and thorough perioperative planning when considering DRRP.

Footnotes

Authors' Contribution: Study concept and design: M. M., A. N., and E. E.; Analysis and interpretation of data: H. M. and A. H.; Drafting of the manuscript: H. M. and A. H.; Critical revision of the manuscript for important intellectual content: M. M., A. N., and E. E.; Statistical analysis: H. M.

Conflict of Interests Statement: The authors declare no conflict of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after its publication. The data are not publicly available due to privacy reasons.

Ethical Approval: The current study was done after getting permission from Medical Ethics Committee of Iran University of Medical Sciences (registration No.: IR.IUMS.FMD.REC.1401.669).

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