Duct-to-mucosa versus invagination pancreaticogastrostomy reconstruction after pancreaticodudenectomy: a comparative study

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Background
Pancreaticoduodenectomy (PD) is the most used standard operation for both benign and malignant diseases in the pancreatic head. Panc. Fistula following pancreaticoduodenectomy is relatively common and remains a major cause of mortality and morbidity.
Aim
To evaluate the early outcome of the main two techniques of pancreatic duct anastomosis with the stomach (duct-to mucosa vs. invagination) in patients who undergo pancreaticodudenectomy.
Patients and methods
This is a prospective randomized study was conducted on 50 patients with elective PD with two schedule techniques of pancreatic anastomoses with the stomach divided in two groups: group A (duct-to mucosa technique) and group B (invagination technique) performed in the department of the Hepato-pancreaticobiliary surgery, National Liver Institute, Menoufia University form October 2019 to October 2021.
Results
This study showed that, postoperative pancreatic fistula (POPF) developed in 1 (4%) case in group A and 5 (20%) cases in group B. regarding Delayed Gastric Empting (DGE), 15 (60.00%) patients had no DGE, 5 (20.00%) patients had grade A, 4 (16.00%) had grade B,1 (4.00%) had grade C among group A while, among group B, 20 (80.00%) patients had no DGE, 5 (20.00%) patients had grade A, with no significant difference ($P = 0.126$). Also, there was no statistically significant difference between the two groups regarding diagnostic tools, preoperative drainage as well tumor size, type of tumor regarding histopathological examination as the majority of examined specimens were adenocarcinoma.
Conclusion
Our study concluded that were Duct-to-mucosa pancreaticogastrostry is safer anastomosis. Following pancreatico duodenectomy other than invagination technique.

Keywords:
Duct-to-mucosa, Hepatopancreaticobiliary, pancreatic fistula, pancreaticodudenectomy, pancreaticogastrostomy

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Introduction

Among all abdominal anastomoses, the pancreatic anastomosis still has the highest rate of surgical complications, making it the Achilles' heel of pancreatic surgery [1]. After a standard (PD) or pylorus-preserving pancreaticoduodenectomy (PPPD), pancreatic leakage is still a common and dangerous consequence [2].

A pancreatic fistula (PF) is usually followed by several additional potentially fatal complications, such as peritonitis, which is the most serious cause of morbidity and is responsible for up to 80% of postoperative deaths [3]. Pancreatic texture, resection technique, MPD size, blood supply of the cut edge of the gland, patient age, presence of jaundice, blood loss, and finally anastomotic technique are all risk factors for pancreatic leakage. The most important parameters, however, are pancreatic texture, MPD size, and anastomotic method [4].

(1) Dealing with pancreatic duct following. partial PD is still Controversy. Although, Advancement in

techniques of panc. duct anastomosis. following partial PD, pancreatic fistula still the Achilles' heel of pancreatic surgery.

(2) There are several techniques and technical aspects of the pancreatico-enteric anastomosis that can be used to prevent these issues, with the goal of lowering the risk of pancreatic fistula and, consequently, postoperative morbidity and mortality [5]. Pancreaticojejunostomy (PJ) and pancreaticogastrostomy (PG) are the two primary anastomotic procedures for repair following PD. It is still up for debate which pancreatic anastomosis method works best following PD. The surgeon or specific characteristics of each patient may influence the choice of anastomotic technique [6].

(3) A duct-to-mucosa or invagination PG is used to anastomose the pancreatic end to the stomach PG [7]. Waugh and Clagett performed the first PG clinical application in 1946, and numerous variations to the technique have been documented in the literature since then invagination or duct-to-mucosa anastomosis, the use of trans anastomotic tubes for internal and external drainage of pancreatic juice, the use of fibrin sealant, the use of several transfixing mattress sutures, or the use of two purse-string binding sutures are some of these alterations [6].

In high-risk patients with small ducts or soft, friable pancreas, some authors demonstrated that the invagination approach was safer; nevertheless, other authors showed that the duct-to-mucosa procedure offers a secure anastomosis [3].

Aim of this work is to evaluate the early outcome of the main two techniques of pancreatic anastomosis with the stomach (duct-to mucosa versus invagination) in patients who undergo pancreaticodudenectomy.

Patients and methods

This was a prospective randomized study of elective PD (either pylorus-preserving or classical Whipple's) with two schedule techniques of pancreatic anastomoses with the stomach performed in the department of HPB surgery, National Liver Institute, Menoufia University in the period between 1/10/2019:1/10/2021.

The study was approved by Ethical institutional review board (IRB)

The two types of anastomoses include: duct-to-mucosa PG and invagination PG.

Twenty five cases were done for each type of pancreatic anastomosis with total 50 patients studied. The cases randomized selected in two groups as odd number for group A (Duct-to-mucosa PG) and even number for group B (Invagination PG).

The inclusion criteria

(1) Any periampullary tumors (pancreatic head, lower common bile duct, ampulla of Vater, duodenum) diagnosed by multislice triphasic computed tomography (CT) scan, magnetic resonance image (MRI). Pancreatic cysts that need PD.

(2) The data will be collected and studied according to:

Preoperative data

Patients' demographics (age, sex, weight, body mass index); associated co-morbidities included diabetes mellitus hypertension (HTN); preoperative labs included LFT, RFT, CBC, tumor markers; Preoperative diagnostic tools included pelvic-abdominal ultrasound (US). Multislice triphasic CT, dynamic magnetic resonance image (MRI), endoscopic ultrasound (EUS) and biopsy were done if needed.

Operative data

The type of the pancreatic anastomosis chosen by rotation schedule for the two types, all procedures will be performed by the same team surgeons for each type in our department using the same technique, same approach, and same anastomotic fashion to avoid technical bias, all sutures will be interrupted sutures and internal pancreatic duct stent for all patients.

Operative technique

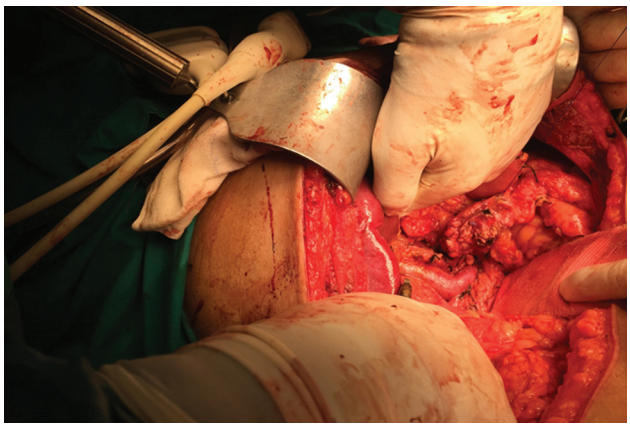
In order to minimize the size of the stomach and the distensions of the small bowel, a nasogastric tube was presented while the patient was under general anesthesia. When performing a diagnostic laparoscopy, a Foly's urethral catheter was injected to be detached in the recovery room. Chevron incisions, or two-sided subcostal incisions, were used in our technique. To rule out the presence of metastatic diseases, the liver and peritoneal superficial were thoroughly examined, and intraoperative US of the liver and pancreas was performed. Then, extensive Kocherization was carried out by the side duodenal ligament, partially exposing the Superior mesenteric Vein (SMV), Inferior vena cava (IVC), and aorta.

Invasions or encasements of these arteries prevent resections from progressing; only crucial bypass was required.

Dissections in this area were done carefully and sensibly because venous tears might cause torrential bleeding and it can take a long time to stop the bleeding. The duodenum was opened above the Winslow foramen. After separating the gastro-hepatic ligaments, the peritoneum was cut across the proper hepatic artery. Any identified lymph nodes were removed in the direction of the sample. After moving forward with the dissection medially, the frontal superficial of the portal vein was identified. The frontal surface, which is frequently avascular, was gently dissected between it and the neck of the pancreas downward. In addition, one more index finger was passed from below within the SMV and upward through the neck of the pancreas to sense the other finger from below. But this was not enough to sanction the incursions; To feel for the right gastric artery, which was also detached but much smaller than the gastro-duodenal artery, a finger had to be inserted under the second section of the Kocherized duodenum with the thumb in the anterior position. The lymph nodes in the porta hepatis could be removed thanks to peritoneal incisions made over the CBD.

Divisions of the pancreas performed now or afterward the mobilization of the duodenojejunal loop and transporting the loop to right under the major mesenteric vessels. The Pancreas body was mobilized and moved to the left of the portal vein and SMV and until the confluence of splenic vein and portal vein was exposed to get the pancreas to be more free for anastomosis of the stomach. (Fig. 1 pancreatic stump freely mobilized).

Figure 1



Pancreatic stump freely mobilized.

The greater curvature of the stomach was devascularized in its lower part to prepared for anastomosis of the pancreatic stump to the stomach.

PG was done by either duct to mucosa or invaginations methods: Duct-mucosa PG anastomosis group A:

The pancreatic stump was approximated to the posterior wall of the stomach and the site of the anastomosis was marked by diathermy then the posterior layer started with 3/0 polypropylene material about 5–6 stitched with whole thickness of the posterior wall of the stomach with whole thickness of the pancreas sparing the pancreatic duct, the pancreatic stent 6 French nelyton tube was inserted to the pancreatic duct and fixed loosely with 6/0 viryl stich. (Fig. 2 Internal stent in the pancreatic duct).

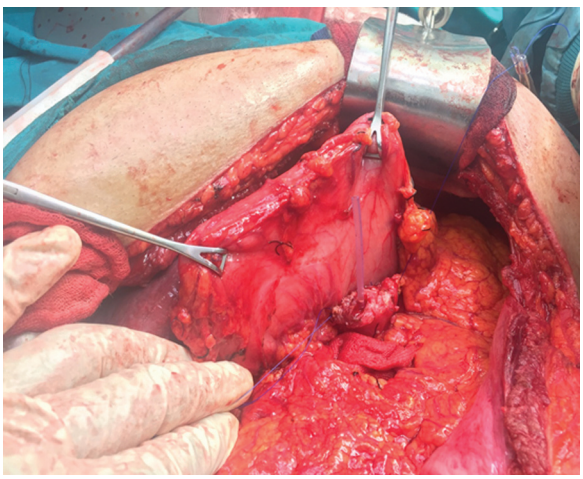
Opening in posterior wall of the stomach a hole equal and close to pancreatic duct then4/0 polypropylene material about 3–4 stiches were taken the posterior wall of the pancreatic duct with mucosa of the posterior wall of the stomach.

Then the anterior wall of the pancreatic duct anastomosed with mucosa of the stomach with same manner of the posterior wall then the last layer of the anterior wall of the whole thickness of the stomach anastomosed in the anterior wall of the whole thickness of the pancreas. (Fig. 3 duct to mucosa technique).

Invagination Pancreaticogastrostomy anastomosis Group B

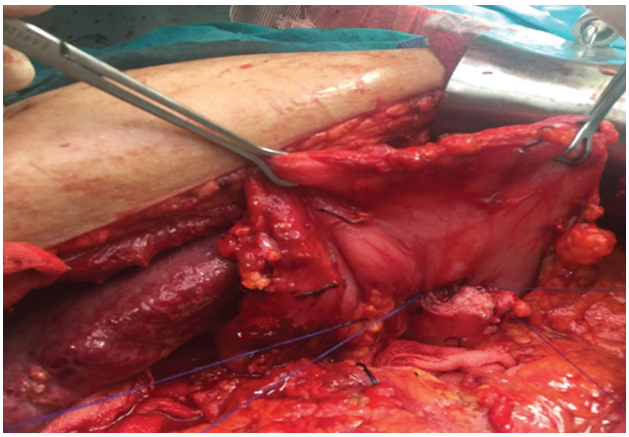
The pancreatic stump was approximated to the posterior wall of the stomach then the posterior wall of the stomach was opened equal to the diameter of the

Figure 2



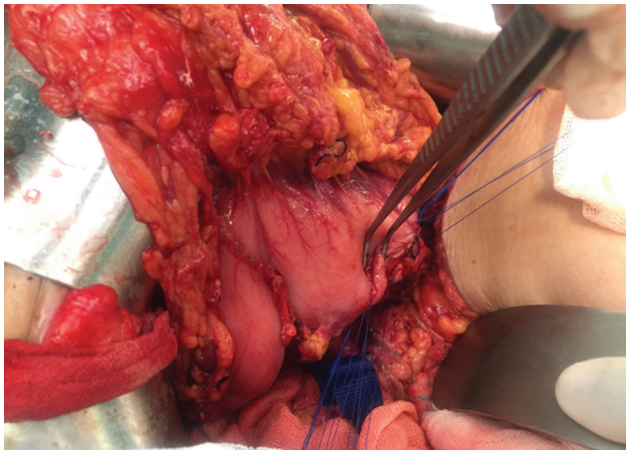
Internal stent in the pancreatic duct.

Figure 3



Duct to mucosa technique.

Figure 4



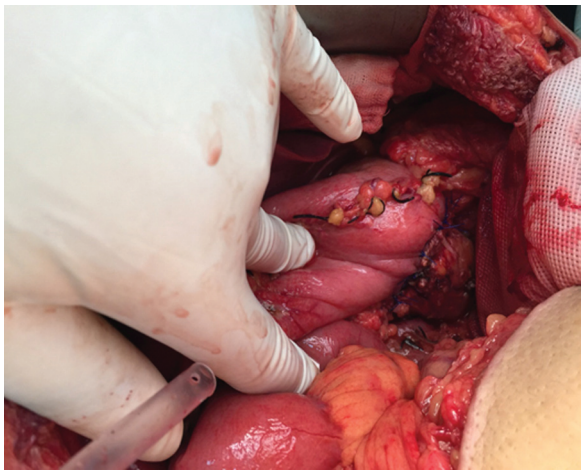
Invagination Pancreticogastrostomy technique.

pancreas the whole pancreas was invaginated to the posterior wall of the stomach and 5-6 stiches with 3/0 polypropylene material was taken of the whole thickness of the wall of the stomach and whole thickness of the pancreas with pancreatic duct the pancreatic stent was inserted to the pancreatic duct then the anterior layer was taken as the same manner of the posterior layer (Figs 4 and 5: Invagination PG technique).

The gastrojejunostomy was conducted using a linear stapling device just proximal and subsequently to the stapling line after the hepaticojejunal anastomosis was performed as the end-side of the jejunal loop on to its anti-mesenteric boundary to the end of the common hepatic ductas. One layer, three-layer vicryl anastomosis can also be hand stitched.

Following surgery, the nasogastric tube was removed after three days, at which point eating was resumed.

Figure 5



Pancreaticogastrostomy completed.

There were antibiotics taken. TPN might be desired. It was desired to monitor liver, kidney, hemogram (including platelet counts), and prothrombin time on a daily basis. Even though there was less bleeding on the table in the immediate postoperative period, the CVP line was better for all of these needs.

Postoperative data

Early postoperative perioperative (first 90 days) data was recorded as hospital stay, complications, postoperative interventional procedures or reoperations if needed, readmission: causes and managements and survival.

Whipple specimens: Specimens that require the pathologist and surgeon to communicate directly in order to be properly oriented and have the margins identified.

Statistical analysis

The collected data were tabulated using Microsoft Excel 2019, and statistically analyzed using SPSS program (Statistical Package for Social Sciences) software version 26.0. Descriptive statistics were done for numerical parametric data as mean±SD (standard deviation) and minimum and maximum of the range and for numerical non parametric data as median and first and third interquartile range, while they were done for categorical data as number and percentage and Inferential analyses were done for quantitative variables using independent *t*-test in cases of two independent groups with parametric data and Mann Whitney *U* in cases of two independent groups with non-parametric data. Inferential analyses were done for qualitative data using χ^2 test for independent groups. The level of

significance was taken at *P* value less than 0.05 is significant, otherwise is nonsignificant. The *P*-value is a statistical measure for the probability that the results observed in a study could have occurred by chance.

Results

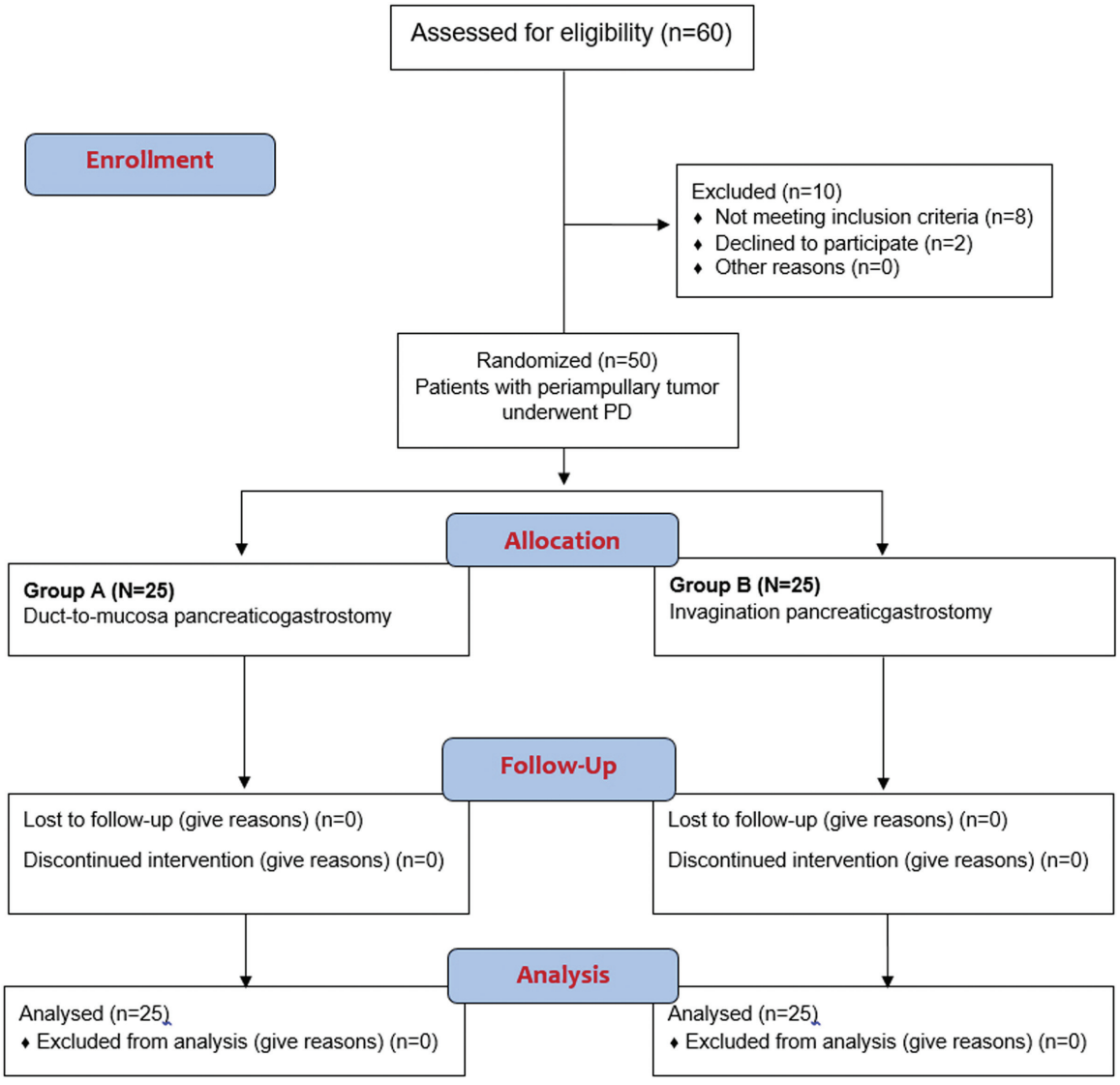
A CONSORT flow chart of the study population is shown in Fig. 6, of 50 consecutive patients with periampullary tumor seen during the study period underwent PD, 20 (40%) women and 30 (60%) men were eligible and included in the study. The mean age was 56.58±9.50 years.

The present study showed that there was no statistically significant difference between the two groups regarding age ($P=0.714$), sex ($P=1.00$), weight ($P=0.057$) and BMI ($P=0.383$). the most common comorbidities found was DM representing 68% patients in group A and 76% in group B with no statistically significant difference between the two studied groups regarding comorbidities ($P > 0.05$). (Table 1).

Jaundice was the most common presentation I patients of both studied groups current study showed that the most common diagnosis found that representing 92% patients in group A and 88% in group B with no statistically significant difference between the two studied groups ($P > 0.05$). (Table 2).

Our study noticed that the median level of hemoglobin level was significantly lower in patients of group A compared with group B ($P=0.015$). Meanwhile, there was no statistically significant difference between the

Figure 6



Flowchart of the study patients.

Table 1 Comparison between the studied groups regarding demographic characteristics and comorbidities

	Group (A) Duct-to-mucosa group (*n*=25) *N* (%)	Group (B) Invagination group (*n*=25) *N* (%)	Test value	*P*-value
Sex				
Male	10 (40.0%)	10 (40.0%)	χ^2= 0. 0	1.00
Female	15 (60.0%)	15 (60.0%)		
Age (years)				
Mean±SD	57.08±10.69	56.08±8.34		
Median	59.0	55.0	***T***= 0.369	0.714
Range	35.0- 75.0	42.0- 73.0		
Weight (Kg)				
Mean±SD	76.04±14.04	82.96±10.83		
Median	78.0	82.0	***T***= 1.95	0.057
Range	49.0- 112.0	55.0- 109.0		
BMI (Kg/m2)				
Mean±SD	29.40±3.64	30.18±3.53		
Median	29.0	30.0	$^{Z}_{MWU}$= 0.895	0.383
Range	20.0–35.0	20.0–35.0		
Comorbidities	***N* (%)**	***N* (%)**		
DM	17 (68.0%)	19 (76.0%)	χ^2= 0.397	0.529
Hypertension	9 (36.0%)	12 (48.0%)	χ^2= 0.739	1.00
Cardiovascular disease	2 (8.0%)	1 (4.0%)	χ^2= 0.355	1.00
Smoking	1 (4.0%)	5 (20.0%)	χ^2= 3.03	0.189
Pulmonary disease	1 (4.0%)	0	χ^2= 1.02	1.00

P value less than 0.05 is significant, *P* value less than 0.01 is highly significant. IQR, Interquartile range; SD, Standard deviation; χ^2, Chi-Square test; ^{Z}MWU, Mann- Whitney *U* test.

Table 2 Comparison between the studied groups regarding presentation and preoperative diagnosis

	Group (A) Duct-to-mucosa group (*n*=25) *N* (%)	Group (B) Invagination group (*n*=25) *N* (%)	X^2	*P*-value
Presentation				
Jaundice	23 (92.0%)	22 (88.0%)	0.0	1.00
Loss of weight	19 (76.0%)	19 (76.0%)	0.0	1.00
Preoperative diagnosis				
Distal CBD Stricture	1 (4.0%)	1 (4.0%)	0.0	1.0
Duodenal mass	1 (4.0%)	1 (4.0%)	0.0	1.0
Periampullary mass	6 (24.0%)	11 (44.0%)	1.34	0.232
PHM (pancreatic head mass)	17 (68.0%)	12 (48.0%)	1.31	0.252

P value less than 0.05 is significant, *P* value less than 0.01 is highly significant. IQR, Interquartile range; SD, Standard deviation; χ^2, Chi-Square test; ZMWU, Mann- Whitney *U* test.

two groups regarding other laboratory data ($P>0.05$). (Table 3).

In the current study as regards there was no statistically significant difference between the two groups regarding diagnostic tools, preoperative drainage as well tumor size ($P > 0.05$). (Table 4).

Preoperative biliary drainage is not recommended in such respectable peri-ampullary lesions, so few cases in the two groups underwent biliary drainage either by Percutaneous Transhepatic Drainage (PTD) or ERC.

In the present study as regards there was no statistically significant difference between the two groups regarding method of reconstruction, diameter of MPD, texture of pancreas, anastomosis time, intraoperative blood loss and blood transfusion ($P > 0.05$). Table 5

Pancreatic fistula has been recently defined by the International Study Group of Pancreatic Fistula (ISGPF) as 'drain output of any measurable volume of fluid on or after postoperative day 3 with amylase content greater than three times that of normal serum amylase.' Three grades were applied according to clinical impact, from grade A (none) to grade C (significant**)**.

The pancreatic leakage postoperatively was detected by monitor the amylase in the drains in postoperative day 3, 5, 7, and high outlet fistula.

Table 3 Comparison between the studied groups regarding preoperative laboratory data

	Group (A) Duct-to-mucosa group (*n*=25)				Group (B) Invagination group (*n*=25)					
	Mean±SD	median	Min.	Max.	Mean±SD	median	Min.	Max.	Test value (^{Z}MWU)	*P*-value
T. Bilirubin	11.08±10.10	9.50	0.20	53.00	13.05±10.93	10.00	0.90	39.00	0.282	0.778
D. Bilirubin	7.91±8.19	6.54	0.10	42.00	9.37±9.03	7.70	0.60	35.00	0.437	0.662
Alb	3.36±0.47	3.30	2.40	4.50	3.25±0.43	3.20	2.20	4.10	0.927	0.354
AST	42.72±64.63	28.00	15.00	345.00	35.92±32.64	25.00	11.00	153.00	0.399	0.690
ALT	47.28±28.61	38.00	12.00	145.00	40.12±24.75	31.00	12.00	104.00	1.26	0.207
ALP	232.60±207.75	185.00	14.00	1050.0	240.56±113.89	219.00	31.00	512.00	1.49	0.135
GGT	276.36±173.59	300.00	33.00	644.00	373.72±245.61	318.00	51.00	1056.0	1.79	0.073
INR	1.25±0.16	1.20	1.01	1.60	1.29±0.18	1.30	1.00	1.60	0.918	0.359
BUN	34.84±15.40	35.00	1.00	91.00	33.04±8.41	34.00	20.00	52.00	0.457	0.648
Creatinine	0.86±0.16	0.90	0.40	1.10	0.99±0.29	0.90	0.45	2.10	1.91	0.056
Hb	11.16±1.96	11.20	7.90	14.00	12.40±1.84	13.00	8.80	15.00	2.42	0.015
WBC	7.67±2.47	7.40	3.90	12.40	7.46±2.69	6.80	3.50	12.70	0.398	0.691
PLT	217.28±108.85	205.00	1.00	407.00	216.80±104.61	200.00	70.00	451.00	0.155	0.877
CRP	24.19±18.38	15.00	2.00	61.00	25.55±20.53	22.00	3.00	73.00	0.010	0.992
LDH	93.26±12.26	93.00	50.00	150.00	93.63±10.46	93.00	50.00	153.00	0.025	0.965
Lact.	30.29±30.58	16.15	4.00	87.00	9.95±9.08	7.00	3.00	34.00	1.79	0.073
Amylase	12.96±2.96	13.00	5.00	20.00	12.12±2.96	12.00	4.00	21.00	0.893	0.372
Lipase	18.26±3.26	18.00	18.00	40.00	17.12±4.26	17.00	5.00	40.00	0.815	0.415
AFP	16.91±25.31	9.30	1.30	126.00	10.30±11.23	3.60	0.30	34.00	0.282	0.778
CA19.9	407.06±396.75	345.00	12.40	1770.00	892.12±1292.61	380.00	1.00	5564.0	0.437	0.662
CEA	3.01±1.15	3.01	2.20	3.82	4.10±2.35	1.15	2.01	5.26	0.927	0.354

P less than or equal to 0.05 is considered statistically significant, *P* less than or equal to 0.01 is considered high statistically significant. LDH, Lactic Dehydrogenase; PLT, Platelet; SD, standard deviation, –comparison between groups done by Mann Whitney *U* Test.

The present study demonstrated that postoperative pancreatic fistula (POPF) developed in 1 (4%) case in group A and 5 (20%) cases in group B with significant differences (*P*=0.186). Regarding Delayed Gastric Empting (DGE), 15 patients (60%) had no DGE, while 10 (40%) cases developed postoperative DGE (5 patients (20%) had grade A, 4 (16%) had grade B,1 (4%) had grade C) among group A. While, among group B, 20 patients (80%) had no DGE, 5 patients (20%) had grade A, with no significant difference (*P*=0.126). Also, regarding post-PD Hy 3 Cases developed PPH in two groups, significant difference (*P*=1.00). 4% had bile leakage in group A and 20% in group B (*P*=0.055). (Table 6).

Our study shows no statistically significant difference between the two groups regarding postoperative interventional procedures ($P > 0.05$) as in group A,

Table 4 Comparison between the studied groups regarding other preoperative data

	Group (A) *Duct-to-mucosa group* (*n*=25) *n* (%)	Group (B) *Invagination group* (*n*=25) *n* (%)	χ^2	*P* value
Diagnostic tools				
CT	25 (100.0%)	25 (100%)	0.00	1.00
US	25 (100.0%)	25 (100.0%)	0.00	1.00
MRI	25 (100.0%)	25 (100.0%)	0.00	1.00
EUS	6 (24.0%)	4 (16.0%)	0.125	0.724
MRCP	25 (100.0%)	25 (100.0%)	0.00	1.00
ERCP	11 (44.0%)	14 (56.0%)	0.320	0.572
Biopsy	3 (12.0%)	2 (8.0%)	0.00	1.00
Pre-operative drainage				
No	17 (68.0%)	16 (64.0%)		
PTD	2 (8.0%)	2 (8.0%)	0.107	0.948
Stent	6 (24.0%)	7 (28.0%)		
Size of tumor (cm)				
Mean±SD	(3.30*3.10)±(1.36*1.02)	(3.08*2.13)±(2.54*1.66)		
Median	3.0*3.20	3.0*2.0	**^{Z}MWU**= 0.294	0.770
Range	(1.08*3.13)–(3.5*3.5)	(1.0*1.0)–(3.5*3)		

P value less than 0.05 is significant, *P* value less than 0.01 is highly significant. ERCP, Endoscopic Retrograde cholangiopancreatograph; MRCP, magnetic resonance cholangiopancreatography; SD, Standard deviation; χ^2, Chi- Square test; ^{Z}MWU, Mann- Whitney *U* test. * No significant.

Table 5 Comparison between the studied groups regarding operative data

	Group (A) Duct-to-mucosa group (*n*=25) *n* (%)	Group (B) Invagination group (*n*=25) *n* (%)	χ^2	*P*-value
Type of operation				
PD	5 (20.0%)	6 (24.0%)	0.117	0.733
PPPD	20 (80.0%)	19 (76.0%)		
Diameter of MPD				
>3 mm	20 (80.0%)	17 (68.0%)	0.936	0.333
3 mm	5 (20.0%)	8 (32.0%)		
Texture of pancreas				
Firm	1 (4.0%)	0 (0.0%)		
Hard	12 (48.0%)	6 (24.0%)	4.58	0.101
soft	12 (48.0%)	19 (76.0%)		
Blood transfusion				
No	6 (24.0%)	5 (20.0%)	0.117	0.733
Yes	19 (76.0%)	20 (80.0%)		
Amount of blood transfusion (L)				
Mean±SD	1.96±1.62	1.68±1.22		
Median	2.0	2.0	^{Z}MWU= 0.506	0.613
Range	0.0–6.0	0.0–4.0		
Blood loss (mL)				
Mean±SD	876.0±604.35	884.0±532.04		
Median	700.0	700.0	^{Z}MWU= 0.293	0.770
Range	200.0–2500.0	200.0–2000.0		
Anastomosis time (min.)				
Mean±SD	46.80±13.06	40.0±8.90		
Median	45.0	40.0	^{Z}MWU= 1.782	0.075
Range	30.0–70.0	30.0–60.0		
Operative time (hrs.)				
Mean±SD	6.89±1.06	6.17±1.45		
Median	7.0	6.0	^{Z}MWU= 2.221	**0.026**
Range	4.05–9.10	4.0–9.25		

P value less than 0.05 is significant, *P* value less than 0.01 is highly significant. SD, Standard deviation; χ^2, Chi- Square test; ^{Z}MWU, Mann- Whitney *U* test.

Table 6 Comparison between the studied groups regarding postoperative complications.

Postoperative complications	Group (A) *Duct-to-mucosa group* (*n*=25) *n* (%)	Group (B) *Invagination group* (*n*=25) *n* (%)	χ^2	*P*-value
POPF				
No	24 (96.0%)	20 (80.0%)		
Grade A	0	0	3.364	0.186
Grade B	1 (4.0%)	3 (12.0%)		
Grade C	0	2 (8.0%)		
DGE				
No	15 (60.0%)	20 (80.0%)		
Grade A	5 (20.0%)	5 (20.0%)	5.714	0.126
Grade B	4 (16.0%)	0		
Grade C	1 (4.0%)	0		
PPH				
No	22 (88.0%)	22 (88.0%)		
Grade A	1 (4.0%)	1 (4.0%)	0.0	1.00
Grade B	0	0		
Grade C	2 (8.0%)	2 (8.0%)		
Bile leakage				
No	24 (96.0%)	20 (80.0%)	3.663	0.055
Yes	1 (4.0%)	5 (20.0%)		

P value less than 0.05 is significant, *P* value less than 0.01 is highly significant. SD, Standard deviation; χ^2, Chi- Square test.

two cases needed Pig tail insertion for collection, two cases needed re-exploration for intra peritoneal hemorrhage, one case needed re-exploration for intra peritoneal leakage and one case managed for pancreatic leakage while in group B, three cases needed Pig tail insertion for collection, two cases needed re-exploration for intra peritoneal hemorrhage and three cases needed re-exploration for intra peritoneal leakage. (Table 7).

The previous table shows no statistically significant difference between the two groups regarding type of tumor regarding histopathological examination ($P > 0.05$) as the majority patients in both group A (96%) and group B (92%) had adenocarcinoma. Table 8

Discussion

Following pancreatoduodenectomy, the pancreatic stump is frequently rebuilt using surgical techniques such pancreatojejunostomy (PJ) and pancreatogastrostomy (PG). Postoperative complications are a non-negligible risk with both treatments [8]. Even though surgical techniques have improved recently, post-PD complications like POPF, biliary fistula, intra-abdominal fluid collection, intra-abdominal hemorrhage, and delayed gastric emptying are still common. As a result, patients must stay in the hospital longer and pay more for their care [9].

In this study, patients undergoing PD had their early outcomes of the two primary pancreatic anastomosis procedures compared (duct-to-mucosa vs. invagination). This is the first comparative prospective study that included between group A (duct-to-mucosa PG) and group B (invagination PG).

In the present study, age differences between the two groups were not statistically significant. Similar results were found by Serafe *and* Khalifa [10], there was no statistically significant difference between the two groups, with group A (duct-to-mucosa) patients' ages ranging from (58±15) and group B (invagination) patients' ages ranging from (60±11). Conceding with these results, Wu *et al.* [11], After propensity score matching (PSM), it was discovered that the age difference between the two research groups was not statistically significant (P=0.696). Also, in Bai *et al.* [12], study regarding age, there was no statistically significant difference between the two groups, which included 64 patients in the duct-to-mucosa group and 68 patients in the invagination group (P=0.671).

There was no statistically significant gender difference between the two groups in the current study (P=1.00). In agreement with these findings, Wu *et al.* [11], using PSM analysis, found no statistically significant gender differences between the two study groups (P=0.754). In addition, Bai *et al.* [12], Study results indicated that there was no statistically significant difference in sex between the two study groups (P=0.814). Similarly, Serafe *and* Khalifa [10], there was no statistically significant difference between the two study groups, which had male: female ratios of 10:2 for group A (invagination) and 8:4 for group B (duct-to-mucosa).

Table 7 Comparison between the studied groups regarding Postoperative interventional procedures

	Group (A) Duct-to-mucosa group (n=25) n (%)	Group (B) Invagination group (n=25) n (%)	X^2	P-value
Postoperative interventional procedures				
No	19 (76.0%)	17 (68.0%)		
Pig tail insertion for collection	2 (8.0%)	3 (12.0%)		
Re-exploration for intra peritoneal hemorrhage	2 (8.0%)	2 (8.0%)	2.311	0.679
Re-exploration for intra peritoneal leakage	1 (4.0%)	3 (12.0%)		

P value less than 0.05 is significant, P value less than 0.01 is highly significant. SD, Standard deviation; χ^2, Chi- Square test.

Table 8 Comparison between the studied groups regarding type of tumor regarding histopathological examination

	Group (A) Duct-to-mucosa group (n=25) n (%)	Group (B) Invagination group (n=25) n (%)	χ^2	P-value
Type				
Adenocarcinoma	24 (96.0%)	23 (92.0%)		
GIST	1 (4.0%)	0	3.021	0.388
Lymphoma	0	1 (4.0%)		
Neuroendocrine Carcinoma	0	1 (4.0%)		

P value less than 0.05 is significant, P value less than 0.01 is highly significant. SD, Standard deviation; χ^2, Chi- Square test.

An intriguing conclusion from this study was that there was no statistically significant difference in weight or BMI between the two groups (P=0.057 and P=0.383, respectively). These findings concur with El Nakeeb *et al.* [13], study, which found no statistically significant difference between the two groups in terms of weight loss. There was no statistically significant difference between the groups in terms of BMI when comparing the various forms of pancreatic anastomosis following PD, claim Casadei *et al.* [14], in their study.

According to this study, the most frequent diagnosis was a pancreatic head mass (PHM), which was discovered in 68% of patients in group A and 48% of patients in group B. There was no statistically significant difference in diagnosis between the two study groups (P>0.05). These results are comparable to those of Serafe and Khalifa [10], investigation, which concluded that there was no statistically significant difference in pathological diagnosis between the two groups under examination.

The fact that there was no statistically significant difference in smoking and certain other comorbidities between the two study groups (P>0.05) was an intriguing finding. These findings are consistent with those of the Lavu *et al.* [15], study, in which there was no statistically significant difference between the two study groups' smoking rates (P=0.45) and many other comorbidities were not statistically significant.

In the present study, patients in group A had significantly lower median hemoglobin levels than those in group B (P=0.015). Meanwhile, other laboratory data did not show a statistically significant difference between the two groups (P>0.05). These findings are analogous to those obtained by EL Nakeeb *et al.* [13], who found that according on laboratory results, there was no statistically significant difference between the two groups' albumin and bilirubin levels.

Regarding the reconstruction technique, MPD diameter, pancreatic texture, anastomosis duration, intraoperative blood loss, and blood transfusion, there was no statistically significant difference between the two groups. While, in comparison to group B, group A had a substantially longer mean total operational duration (6.17 vs. 6.89 hrs., P=0.026). These findings align with those of El Nakeeb *et al.* [13], since there was a statistically significant difference in the operative time for anastomosis between the two groups (P=0.002). On the other hand, Kim *et al.* [16], study results showed that, although preoperative status was not statistically significant, there were changes in duct size and pancreatic thickness between the duct-to-mucosa PG and invagination PG procedures (P<0.05).

According to this study, POPF less appeared in 1 patient of group A 1(4%) and 5 patients in group B, (20%) with no discernible variations in severity. Based on these findings, POPF appeared in 11 (20.8%) patients in group 1 and 8 (14.8%), P¼ 0.46, patients in group 2. With no discernible changes, group 1 (Duct to mucosa) showed more severe POPF symptoms [13]. In agreement with these results, Serafe and Khalifa [10], showed the duct-to-mucosa technique revealed a higher incidence of POPF in PD patients than invagination, although there were no appreciable differences between the two techniques in terms of POPF [17].

According to this study, DGE was higher in PG duct to mucosa group than PG invagination group but also was no statistically Significant. Similarly, Bai *et al.* [12], showed there was no significant difference in the total DGE rate between the duct-to-mucosa group and the invagination group after PD (4.7% in the duct-to-mucosa group and 8.9% in the invagination group; P=0.494). In agreement with these results, El Nakeeb *et al.* [13], showed There were 8 patients in the duct-to-mucosa group (15.1%) and 7 patients in the invagination group (13%), and there were no statistically significant differences between the two groups regarding the DGE. DGE occurred in a total of 27.7% of cases. Pancreatic fistula and other intra-abdominal complications were closely related to DGE. In terms of the pancreatic reconstruction, the PG had DGE more frequently than the PJ [18].

In this study, regarding the severity of PPH, there were no noteworthy differences between the two group (P=1.00). In line with these findings, Bai *et al.* [12], found that patients in the invagination group had a higher incidence of PPH than patients in the duct-to-mucosa group, but there was still no statistically significant difference between the two groups (P=0.681). Six RCTs revealed the total PPH incidence in the PG and PJ groups (81/555 vs. 48/523), respectively. PJ was found to be significantly superior to PG in a meta-analysis of the six investigations using a fixed-effect model (RR, 1.65; 95% CI, 1.13-2.42, P=0.01). Multicenter studies comprised three RCTs that reported the total PPH incidence. These three investigations were combined into a meta-analysis, which revealed that PJ

considerably outperformed PG (RR, 1.80; 95% CI, 1.19-2.72; *P*=0.005). The overall PPH incidence in single centers was reported by four RCTs. These four trials were combined into a meta-analysis, which revealed that PJ was not significantly better than PG (RR, 1.09; 95% CI, 0.44-2.67; *P*=0.85). The overall PPH incidence following 2-layer PG was reported by two RCTs [19].

As regarding postoperative bile leak. It was higher in PG invagination technique than PG duet to mucosa but with no statistically significant. However, in a comparison study conducted within the PG group, the duct-to-mucosa approach had a lower bile leak rate than invagination. Against these outcomes, Serafe and Khalifa [10], study showed that in neither group did any patients develop a postoperative biliary fistula. In line with these findings, El Nakeeb *et al.* [13], showed that as one patient in each group had bile leakage, there were no differences between the two groups that were statistically significant.

In this study, postoperative interventional procedures did not statistically significant difference between the two groups. While there was no discernible difference between patients treated with invagination and those treated with duct-to-mucosa anastomosis in terms of the overall complication rate [38 of 68 (55.9%) vs. 30 of 64 (46.9%); *P* ¼ 0.301] in Bai *et al.* [12], study, In comparison to patients treated with duct-to-mucosa anastomosis, those treated with invagination were considerably more likely to need subsequent treatments as a result of severe problems (grades IIIa, IIIb, IV, and V).

An intriguing result of this study was that there was no statistically significant difference between the two groups in terms of the type of tumor based on histopathological examination ($P>0.05$), even though adenocarcinomas were the most common type of tumor in both group A (96%) and group B (92%). According to Serafe and Khalifa [10], PF is significantly associated with the final histopathological diagnosis of the resected specimen, with lower risk in adenocarcinoma and high risk in cystic neoplasms, or diseases originating from the bile duct. However, there is no clear evidence from previous studies that the histopathological examination of the tumor influences the choice of the PG technique.

The results of Payne and Pain [20], study suggested that whipple's PD can be repaired with a duct-to-mucosa two-layered PG, which is a safe and dependable anastomosis; however, more research is needed to determine the long-term effects on pancreatic exocrine function. For reconstruction following PD, Kim *et al.* [16] suggested PG duct-to-mucosa due to safety and good duct patency, particularly for less experienced surgeons. In comparison to the invagination procedure, the duct-to-mucosa method is less risky, has better duct patency, and results in less pancreatic atrophy. Additionally, PG invagination is riskier than PG duct-to-mucosa, but not in the PJ group.

Conclusions

PG duct to mucosa technique is safer anastomosis. Following pancreatico duodenectomy than invagination technique

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