Original Article

Transection of the pancreas and closing the pancreatic duct using linear stapler followed by dunking method pancreaticojejunostomy versus duct to the mucosa in Whipple operation

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ABSTRACT

Background: The anastomosis between the pancreatic stump and the gastrointestinal tract remains the most effective and safe method of controlling the pancreatic stump as it preserves the exocrine functions of the gland. The results of the previous literature seem contradictory.

Patients and Methods: This study was performed on 40 patients. Patients were divided into two groups. Group A was managed by a division of the pancreas with linear stapler then dunking pancreaticojejunostomy, while group B was managed by a duct to mucosa pancreaticjejunostomy. The primary outcome was the incidence of pancreatic fistula.

Results: Regarding the incidence of pancreatic fistula, group A showed a zero rate of pancreatic fistula while group B had 30% pancreatic leak. The mortality rate reached 15% in group B.

Conclusion: Invagination technique by dividing the pancreas using the linear stapler then invagination appears superior to duct to mucosa technique as regards the incidence of pancreatic fistula.

Key Words: Pancreatic fistula, pancreaticoduodenectomy, pancreaticojejunostomy.

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INTRODUCTION

The most feared consequence following pancreaticoduodenectomy is postoperative pancreatic fistula (POPF), with secondary adverse effects including sepsis and peritonitis[1] In a randomized clinical trial by Aranha *et al*.[1], the leak rate was found to be 24.4%. The main cause of death post-pancreaticoduodenectomy is pancreatic fistula[2].

Despite the fact that there have been many publications on pancreatic fistula after pancreaticoduodenectomy in recent years, most surgeons still find it to be a significant challenge in managing the pancreatic stump following pancreatic fistula morbidity and mortality[1,2]. Fu *et al*.[3] found that the type of pancreaticojejunostomy (PJ) was an independent factor that affects the incidence of pancreatic fistula. No technique has yet shown itself to be better than another[4].

A variety of different methods are currently performed to manage the pancreatic stump, such as pancreaticogastrostomy, PJ either end-to-side or end-to-end, with or without stenting of the pancreatic duct, with internal or external drainage. With no clear preference for a specific technique over others[5–9].

The pancreatoenteric anastomosis was attempted to be avoided by some techniques, such as ligation of the main pancreatic duct, fish-mouth closure of the pancreas with reinforcement of the line of the suture with fibrin glue, and ductal occlusion by glue with[10–12] or without[11–13] anastomosis. The idea is that if a fistula occurred, it would be a pure pancreatic fistula, not activated by the biliary or enteric fluid related to the fistula[14,15].

Preoperative[16] or intraoperative[17] radiation treatment are other more recent methods to reduce pancreatic output. Ductal blockage using nonresorbable glues, which requires no anastomosis after pancreatic diathesis but has been abandoned since it impairs the pancreas' exocrine function, is another method. Subsequently, resorbable glues were used[11,18–21], as they inhibit the activity of pancreatic proteases until the pancreatic stump or pancreatic-digestive anastomosis heals[10].

As the anastomosis between the pancreatic stump and the gastrointestinal tract preserves the exocrine function of the pancreas; so it continues to be the safest and most effective way to control the remaining pancreatic stump, therefore; the pancreaticoenteric anastomosis technique should be based on the best available evidence. The invagination or "dunking" technique is better than the duct-

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to-mucosa strategy, according to the biggest randomized experiment comparing end-to-side procedures to date[22]. Invagination techniques involve invaginating 1–2 cm of the pancreatic stump's proximal end into the jejunum, then either end-to-end or end-to-side, and this technique has had many modifications recently[23,24].

We aim to compare our new modification of the invagination PJ by dividing the pancreatic stump using the linear stapler after Whipple procedure with the duct to mucosa PJ regarding the incidence of pancreatic fistula.

PATIENTS AND METHODS:

This study is a retrospective and prospective study performed in the period from January 2022 to February 2024 on 40 patients who were admitted to the Surgical Department, Minia Liver Institute and Minia University Hospital, Faculty of Medicine, Minia University, with the diagnosis of periampullary carcinoma (cancer head of pancreas; ampullary carcinoma; duodenal carcinoma and lower common bile duct carcinoma). Files of all patients were revised to collect preoperative, intraoperative, and postoperative data, in the prospective part of the research; patients were randomly selected. In the retrospective period, we had 10 patients, and all were done by duct-to-mucosa PJ, while in the prospective period, 30 patients were operated on; 20 of them were done by our modified technique, and 10 patients were done by duct-to-mucosa PJ.

Patients were divided into two groups according to the method of managing the pancreatic stump remnant, where group A (20 patients) was managed by division of the pancreas with a linear stapler and then dunking PJ, while the pancreatic stump in group B (20 patient) was managed by duct to mucosa PJ. The two groups were compared. The primary outcome was the incidence of pancreatic fistula, and the secondary outcomes were operative time, intraoperative blood transfusion, abdominal pain, pancreatitis, and postoperative wound infection. Informed written consent was taken from every patient.

Pancreatic fistulas were defined according to the International Study Group (ISGPF) as "the output of any measurable size of drain fluids on or afterward 3rd day postoperatively via an operatively located drain (or a later located, percutaneous drain) with an amylase content >3 times the upper limit ordinary serum value"[25], this is the same protocol obtained to determine pancreatic fistula in our study. Pancreatic fistula has three grades; where grade A there is only biochemical fistula without clinical symptoms while grade B is defined as a fistula requiring any therapeutic intervention; and grade C: a fistula is a fistula with severe clinical sequences[26].

Inclusion criteria

(1) Age: from 18 to 80 years.

(2) Sex: both sexes.

(3) Patients diagnosed with operable and respectable cancer pancreatic head or periampullary carcinoma.

Exclusion criteria

(1) Patients unfit for surgery.

(2) Inoperable cancers.

(3) Irresectable tumors after laparotomy.

Surgical technique

All surgical procedures were performed by members of the Hepato-biliary Unit in our department. A bilateral subcostal incision (Chevron incision) was used (Fig. 1), and the liver and peritoneum were carefully examined for the presence of metastatic disease. The classic Whipple's procedure was the operation performed; pylorus-preserving maneuvers were performed according to the surgeon's decision. All the patients received prophylactic antibiotics and prophylactic anticoagulants prior to surgery.

Details of our procedure (transection of the pancreas using linear stapler followed by dunking: group A)

We start our operation by following the steps of classic Whipple operation[27] till the step of pancreatic resection, as we modify this step by transection of the pancreas and closing the pancreatic duct using a linear stapler (75 cm green cartridge) (Fig. 2), by doing this; we also close the pancreatic duct simultaneously by this linear stapler, then we continue the resection of the specimen by the same steps of classic Whipple operation till we remove the specimen and we start the reconstruction of the stapled pancreatic stump by Peng PJ (binding PJ)[28]. Our technique just modifies the step of pancreatic resection and adds safety to the Peng PJ as our theory about this technique gives some time for healing of the PJ anastomosis before the staple line bursts by the pressure of pancreatic secretions and dislodgement of clips, thus the exocrine functions of the pancreas is regained. So it ensures the occurrence of healing of PJ anastomosis first, then regaining of the exocrine functions of the pancreas after dislodgement of clips around 7–10 days, allowing reopening of the pancreatic duct (Fig. 2). Cauterization of the mucosa of the jejunal loop by spray mode of monopolar diathermy at 30° or using bipolar diathermy thus creating a raw area of mucosa that will adhere to the pancreas after invagination of the pancreatic stump into jejunal loop to avoid retraction of the pancreatic stump after invagination (Fig. 3). Then we start the posterior row of the inner layer of PJ by anastomosing

the most inner part of the mucosa of the jejunal loop to the pancreas (staple line); this is done by interrupted 4/0 prolene sutures, starting by the posterior row; with a corner stitch placed first through the superior edge of the staple line of the pancreatic remnant at 12 o'clock then towards 6 o'clock (inferior edge of the staple line of the pancreatic remnant) (Fig. 3). A total of five to seven posterior inner row sutures are placed, kept well-ordered with small arteries, and then tied with minimal tension. Care must be taken to take good bites of mucosa and good bites through the pancreatic capsule, avoiding the needle to cut through the pancreatic tissue. This can be done by using a horizontal mattress fashion, incorporating substantial bites of the posterior pancreatic capsule and underlying parenchyma, as well as good bites of the jejunal mucosa. Next, using the same technique (interrupted horizontal mattress sutures, encompassing significant bites of the anterior pancreatic capsule and underlying parenchyma at the staple line of the pancreas), we begin the anterior row of the inner layer of PJ (Fig. 4). A total of five to seven anterior inner row sutures are placed, kept in good order with small arteries, and tied with minimal tension in addition to good bites of the jejunal mucosa. After that, the two Babcocks are removed, and the cut end of the jejunal loop is turned inside out so that a 5 cm length of the mobilized pancreas is invaginated inside the jejunum's lumen. The anterior row of the outer layer of the PJ is then started using interrupted 4/0 prolene sutures. This is done by first placing a corner stitch through the pancreatic superior edge at 12 o'clock and then moving towards the inferior edge of the pancreas at 6 o'clock. A total of five to seven sutures are then placed between the entire thickness of the cut edge of the jejunal wall, the pancreatic capsule, and the parenchyma, keeping them well-ordered with small arteries. Finally, they are tied with as little tension as possible. The posterior row of the outer layer of the PJ is then started in the same way. To facilitate access to the posterior surface of the pancreas, the cut end of the thread of the two anterior layer corner sutures is made excessively long so that the assistant can use them to retract the pancreatic stump, which facilitates exposure. About 3–5 cm of the pancreas is invaginated inside the jejunal loop at the completion of the outer layer of PJ (Fig. 5).

Details of duct to mucosa pancreaticojejugenostomy

We followed the steps of classic duct to mucosa PJ[29].

Perioperative management

All the patients received prophylactic antibiotics and prophylactic anticoagulants before surgery. No prophylactic somatostatin was given to patients. All patients were admitted to the ICU for at least one night after surgery. Patients were kept nothing per oral for 5 days. The nasogastric tube was removed with an output of less than 200 ml per day.

Follow up

Patients were followed up in the first 3 weeks by clinical examination; radiological tests were performed when necessary. Serum level of amylase and lipase and the level of amylase and lipase in the peripancreatic drain were measured in the first, third, and fifth postoperative days. The complications recorded included pancreatic leak (defined as an elevated level of amylase and lipase in the drains three times than normal levels), bile leak, pancreatitis (pain and elevated serum lipase), abdominal pain and postoperative wound infection in the form of seroma or infection in the abdominal incision.

Methods of statistical analysis

Data were collected, revised, verified, coded, and then entered into a PC for statistical analysis using IBM SPSS (Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Descriptive statistics for qualitative data were expressed as number and percentage. In contrast for quantitative data as mean and SD, the χ^2 test was used for the comparison of categorical data, while the comparison of independent quantitative data was done by independent sample t test. For all tests, *P* was considered nonsignificant if more than or equal to 0.05 and significant if less than 0.05.

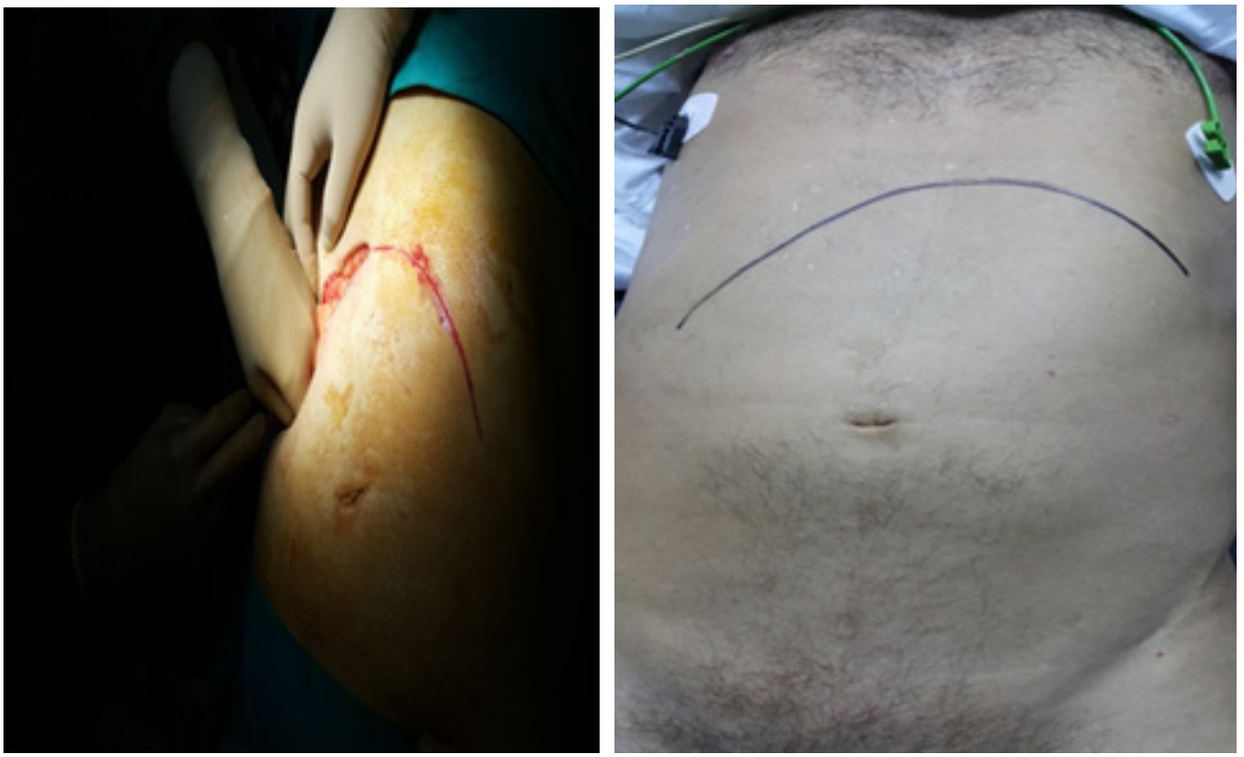

Fig. 1: Bilateral subcostal incision.

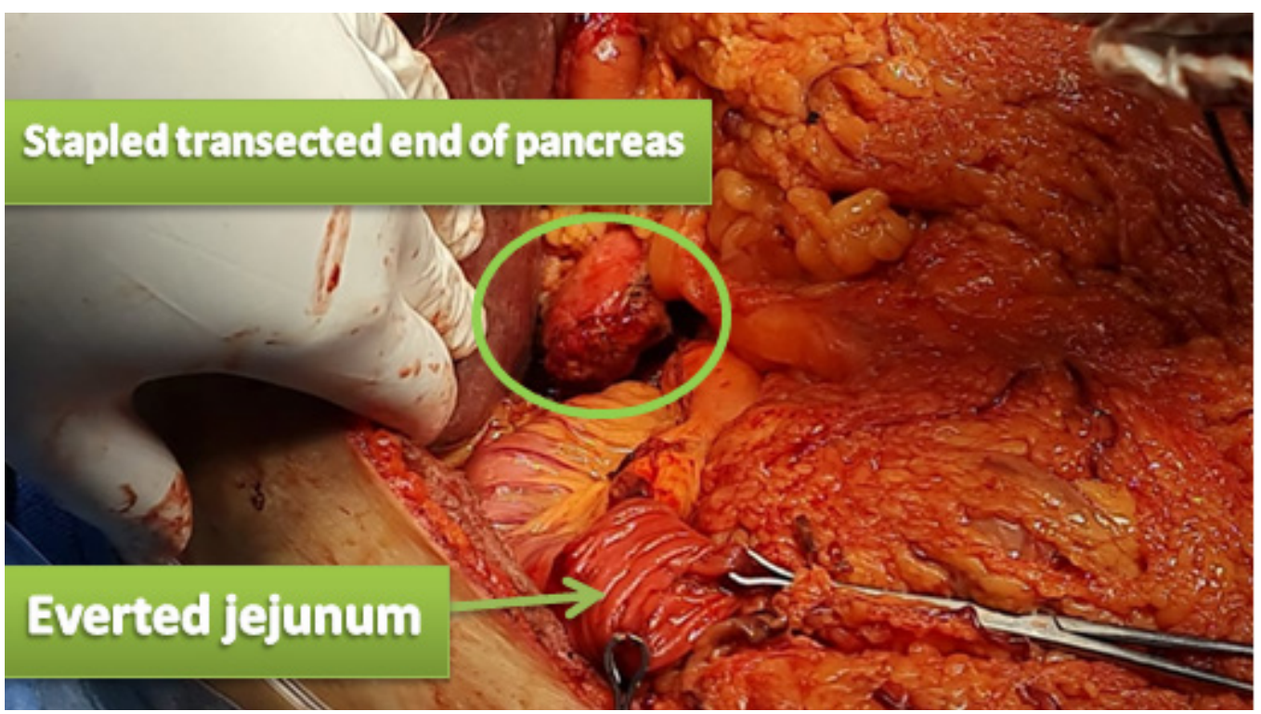

Fig. 2: Pancreatic stump after division by the stapler and the cut edge of the jejunal loop everted outwards by pulling its lining mucosa outwards using two Babcock forceps.

Fig. 3: Cauterization of the mucosa of the jejunal loop by spray mode of monopolar diathermy at 30° or using bipolar diathermy.

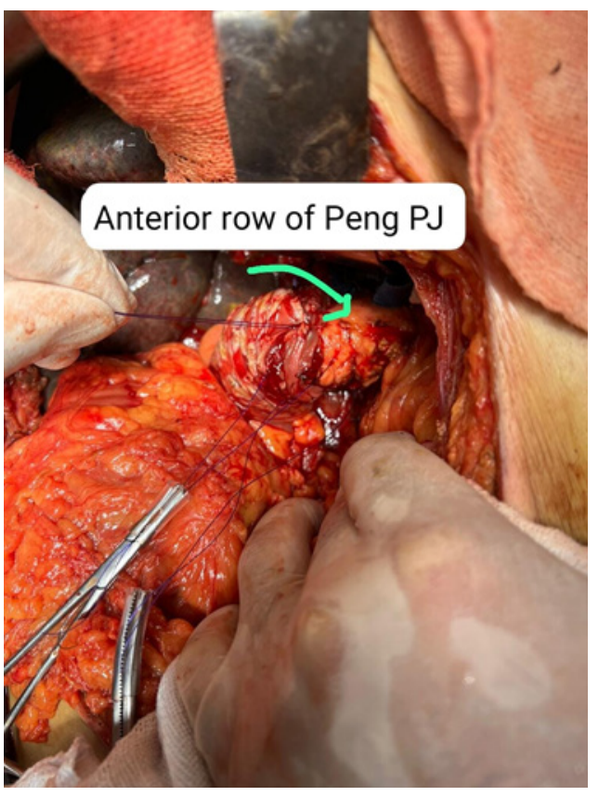

Fig. 4: The anterior row of the inner layer of pancreaticojejunostomy.

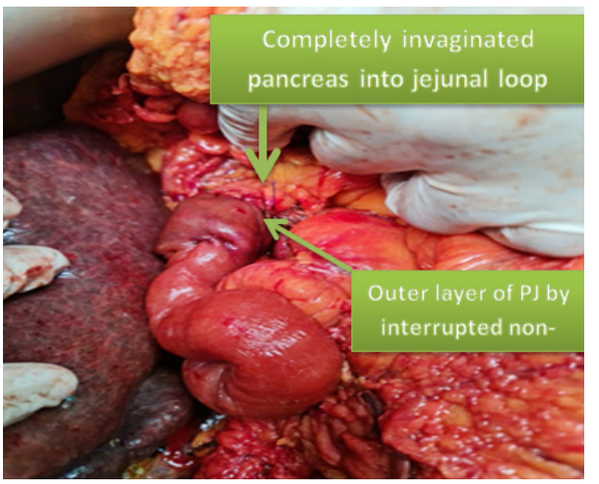

Fig. 5: Invaginated pancreaticojejunostomy.

RESULTS:

Patients demographics

Forty patients with periampullary carcinoma, including [cancer head of the pancreas (32 cases), ampullary carcinoma (four cases), duodenal carcinoma (two cases), and lower common bile duct carcinoma (two cases)] were eligible for including in this study which performed over 2 years from January 2022 to February 2024. All these patients had pancreaticoduodenectomy; patients were divided into two groups according to the method of performing the PJ. Among them seven (35%) were women and 13 (65%) were men in group A. The median age was 54 years in group A. The demographic data of both groups were comparable, as seen in (Table 1).

Intraoperative data

The intraoperative data were similar in both groups as regards mean intraoperative time, intraoperative blood loss, and intraoperative blood transfusion (Table 2). The mean total operative time was 4.6 h in group A versus 4.7 h in group B, mean intraoperative blood loss in group A was 255.4 ml while it was 289.5 ml in group B. In group A only one patient needed blood transfusion whereas two patients received intraoperative blood in group B, P values were nonsignificant in all intraoperative parameters between the two groups.

Postoperative data

A statistically significant difference between both groups as regards the development of pancreatic fistula. Our procedure in group A had no cases (zero) rate of pancreatic fistula while six (30%) cases in group B developed pancreatic fistula; the P value was 0.026, which is statistically significant (Fig. 6). Other postoperative parameters as postoperative pancreatitis; postoperative

pain; development of postoperative wound infection and biliary fistula were similar between both groups (Table 3). There were six patients in group B developed pancreatic fistula one case of them was grade A, while two cases were grade B and treated by percutaneous drainage of peripancreatic fluid collection, while three cases were grade C and required reoperation for treatment by lavage and exteriorization of pancreatic secretions by external pancreatic stent but unfortunately the three cases died after the second operation from sepsis.

Mortality

The in-hospital mortality in this study was three (15%) patients in group B. No mortality cases happened in group A. The three cases of mortality in group B had a pancreatic fistula (Table 4).

Table 1: Demographic data of both groups

Variables	Group A (*N*=20)	Group B (*N*=20)	*P* value
Age	54.3±13.1	52.6±11.8	0.668
Sex [*n* (%)]			0.273
Males	13 (65)	17 (85)	
Females	7 (35)	3 (15)	
Comorbidities			0.989
Diabetes	5 (25)	5 (25)	
Hypertension	6 (30)	4 (20)	
Chronic kidney disease	1 (5)	1 (5)	

Table 2: Intraoperative data of both groups

Variables	Group A (*N*=20)	Group B (*N*=20)	*P* value
Intraoperative time	4.6±1.2	4.7±1.3	0.801
Intraoperative blood loss	255.4±75.02	289.5±81.2	0.175
Intraoperative blood transfusion [*n* (%)]			0.990
Yes	1 (5)	2 (10)	
No	19 (95)	18 (90)	

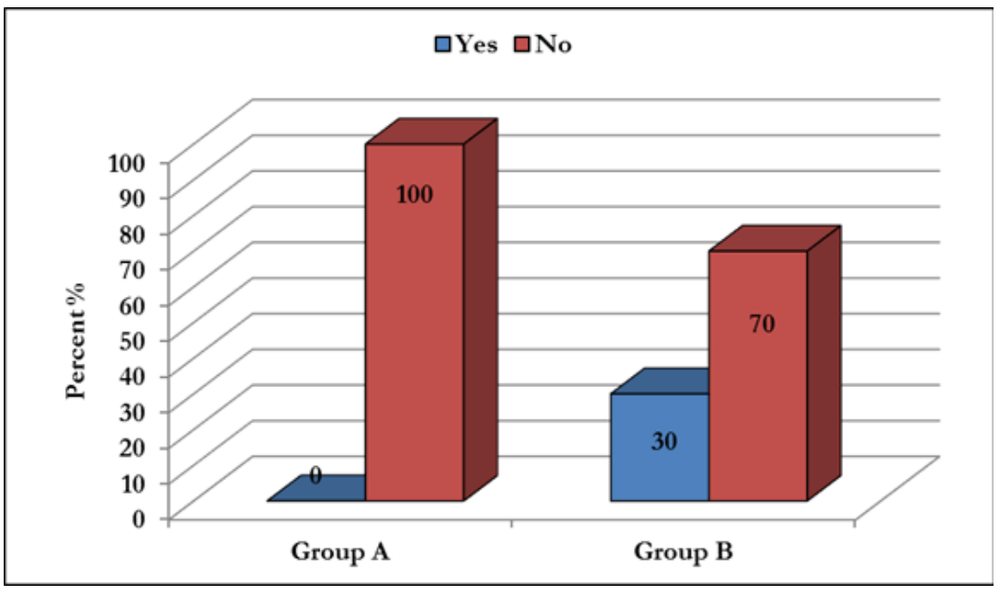

Fig. 6: Pancreatic fistula development between both groups.

Table 3: Postoperative data of both groups

Variables	Group A (*N*=20)	Group B (*N*=20)	*P* value
Postoperative pancreatic fistula [*n* (%)]			0.026*
Yes	0	6 (30)	
No	20 (100)	14 (70)	
Postoperative pancreatitis			0.998
Yes	1 (5)	0	
No	19 (95)	20 (100)	
Postoperative pain			0.715
No	14 (70)	16 (80)	
Mild	4 (20)	1 (5)	
Moderate	2 (10)	3 (15)	
Severe	0	0	
Wound seroma	1 (5)	2 (10)	0.998
Wound infection	1 (5)	3 (15)	0.598
Burst wound	0	1 (5)	0.989
Biliary leakage	0	3 (15)	0.229

**p value* is significant when it is less than 0 .05

Table 4: Mortality in both groups

Variables	Group A (*N*=20)	Group B (*N*=20)	*P* value
Postoperative mortality [*n* (%)]			0.229
No	20 (100)	17 (85)	
Yes	0	3 (15)	

DISCUSSION

Multiple techniques of PJ were used in order to identify the best procedure that gives the best outcomes. To that end, our study provides comparative insights into intraoperative and postoperative outcomes of two methods of performing PJ: dunking PJ and duct to mucosa PJ.

This is a new modification of the dunking PJ in our institution in which the pancreatic stump is transected after mobilization by a linear stapler. Our theory is that it gives some time for healing of the PJ anastomosis before the staple line bursts by the pressure of pancreatic secretions and dislodgement of clips. Thus the exocrine functions of the pancreas are regained. So it ensures the occurrence of healing of PJ anastomosis first, then regaining of the exocrine functions of the pancreas after dislodgement of clips around 7–10 days, allowing reopening of pancreatic duct.

The demographic and intraoperative data in both study groups were comparable regarding the mean intraoperative time, bleeding, and blood loss. In the study performed by Adhikari *et al*.[30], there was also no difference in perioperative variables like pancreatic texture, main pancreatic duct diameter, or intraoperative blood loss.

In the group performed by dunking PJ, we performed transection of the pancreatic stump by linear stapler; we had no patients develop pancreatic fistula. As for our knowledge, this is a new technique to transect the pancreatic stump using the linear stapler aiming to improve the patient outcomes after Whipple procedures. In group A, none of the patients developed pancreatic fistula (0%), while in group B (duct to the mucosa), six (30%) patients developed pancreatic fistula. This difference was statistically significant.

In contrast to other research, Strasberg *et al*.[31] reported a pancreatic fistula rate of only 1.6% after conducting duct-to-mucosa anastomosis in 123 patients. The rate of pancreatic fistula in the group conducted via duct to mucosa PJ in our study was very significant. In a different investigation by Tani *et al*.[32]. The stented duct-to-mucosa PJ fistula rate was 11%. In terms of the development of pressure injuries, our findings show that the invagination technique is superior to the duct-to-mucosa anastomosis. Similarly, a large randomized trial comparing end-to-side techniques also showed that the invagination, or "dunking," technique was superior to the duct-to-mucosa method[33]. Nonetheless, duct-to-mucosa anastomosis is often preferable when it is executed using single, synthetic absorbable stitches, according to certain research[34,35]. Adhikari *et al*.'s[30]

investigation came to the same conclusion, finding that while about eight (32%) patients showed clinically significant POPF after the continuous dunking PJ, just two (8%) patients did so after the modified Blumgart duct to mucosa PJ. A review of the literature by Strobel *et al*.[36] found that suturing techniques rarely affect POPF rates. Similarly, Casadei *et al*.[37] found no significant differences in the pancreatic fistula rate between the Blumgart technique and invagination (or dunking) PJ. These studies suggest that there may be variations in the type of PJ. Blumgart PJ has a notably low postoperative morbidity and death rate and can be performed on any patient with discernible pancreatic ducts, according to Grobmyer *et al*.[38].

The mortality rate in our study reached 15% in group B (duct to mucosa); all the cases had pancreatic fistulas, which are linked as the cause of mortality in these cases. The operative mortality rate after Whipple procedures is typically less than 5% in high-volume centers and it is assumed that the leading cause of death is sepsis, which is often related to a pancreatic fistula[39]. Some other studies show quite a high mortality rate ranging from 20 to 60%. Yeo *et al*.[40] review showed a rate of 40%. The Mannheim Clinic series demonstrated that 20% of pancreatic fistulas were directly responsible for the patient's postoperative deaths[41].

We have no cases of mortality in the dunking group however, there were three cases of mortality in the duct-to-mucosa group. We refer the cases of mortality to the development of pancreatic fistula, which is directly related to death after pancreaticoduodenectomy. This is in contrast to the study performed by Adhikari *et al*.[30], which concluded that a relative decrease in the mortality rate was in the modified Blumgart duct to mucosa versus dunking PJ due to a decrease in in the rate of pancreatic fistula in the duct to mucosa group. In the study, nonsignificant change regarding POPF in the study groups in contrast to Lavu *et al*.[42], who noted higher pancreatic fistula in the duct to mucosa PJ with nonsignificant changes. In the study of Kim *et al*.[43], the duct-to-mucosa group had a 3.2% risk of POPF versus 17.5% risk in the invagination group, with no significant differences in mortality. Li and Hua[44] report that in terms of avoiding POPF, clinically associated POPF, biliary leak, and reoperation rate, there were no significant differences between duct to mucosa and invagination. In contrast to the other reconstructive techniques, Binziad *et al*.[45] showed that the PJ duct-to-mucosa anastomosis was safe, resulted in a little pancreatic leak, and caused the least amount of bleeding. In comparison to instances managed with invagination, Berger *et al*.[33] found a considerably higher rate of pancreatic fistulas and clinically relevant pancreatic fistulas in cases managed with duct-to-mucosa anastomosis. In another study, duct-to-mucosa and invagination PJ techniques after pancreaticoduodenectomy were comparable in terms of POPF and clinically relevant POPF. No significant difference was also found between the two techniques in multiple secondary outcomes, including overall morbidity and mortality[46]. So, the results of the previous literature seem contradictory. This raises the need for larger, randomized, multicenter clinical trials to identify the best approach of PJ after pancreaticodoudenectomy. We had some limitations in our study as it was conducted at a single center, and the sample size was small (n=40).

CONCLUSION

We concluded that this new modification of the invagination PJ by dividing the pancreatic stump using the linear stapler significantly decreased the incidence of pancreatic fistula after Whipple procedure and have better postoperative outcomes in compared with the duct to mucosa PJ. We recommend multicenter, larger studies to confirm our findings.

CONFLICT OF INTEREST

There are no conflicts of interest.

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