Pancreatico-jejunostomy versus pancreatico-gasrostomy after pancreatico-duodenectomy in decreasing postoperative pancreatic fistula

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Background
Pancreatico-duodenectomy is still the cornerstone in curating pancreatic and periampullary cancers. Many techniques for pancreatic anastomosis were described. Pancreatico-gastrostomy (PG) may be a suitable technique, especially in small pancreatic ducts where the stitching of duct to mucosa may be difficult. Still, the results of pancreatico-gastrostomy compared to pancreatico-jejunostomy (PJ) in terms of morbidity are not well studied; hence, this study was designed to investigate.

Objective
To compare pancreatico-gastrostomy versus pancreatico-jejunostomy post pancreatico-duodenectomy from points of operative techniques and characteristics, and postoperative morbidity and mortality.

Patients and methods
The Cohort study included all cases diagnosed with either pancreatic head or periampullary cancers and underwent pancreatico-duodenectomy at National Cancer Institute (NCI), Cairo University, between January 2021 and February 2023. Cases were enrolled into one of the two groups, group 1: underwent pancreatico-gastrostomy, while group 2 underwent pancreatico-jejunostomy. The two groups were compared by: Demographic characteristics, preoperative investigations results, operative, postoperative data and histopathological results of the specimens resected.

Results
Incidence of the pancreatic leak was not significantly different in both groups (17.6% versus 15.8% for PG and PJ respectively, P=0.833), operative time was shorter in a pancreatico-gastrostomy group (310, 355 min, P=0.001), Delayed gastric emptying (DGE) was less occurred in cases of pancreatico-gastrostomy (5.9%, 31.6%, P=0.006). Postoperative mortality was not different in both groups (8.8%, 2.6% for PG and PJ respectively, P=0.338).

Conclusion
Regarding the incidence of postoperative pancreatic fistula, both reconstruction methods produce comparable postoperative results. Pancreatico-gastrostomy is a good alternative technique to the standard pancreatico-jejunostomy.

Keywords:
Whipple, pancreatico-duodenectomy, leak, fistula, mortality

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Criteria for inclusion in the authors: 1- **Sayed Shaker Shaeir**. Consept, design and data collection. **2- Mohamed Atef ElKordy** * Data collection and analysis, Literature search; manuscript preparation, editing and review. **3- Mohamed Emam Sobeih** Literature research and manuscriprt review. **4- Rasha Mahmoud Allam** Statistical analysis, interpretation and manuscript review. **5- Ayman Hanafy:** Data collection, manuscript review and editing.

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Introduction

Pancreatic cancer is a rare type of tumors as it represents only 3% of all cancers, but it's still a major concern due to its dismal prognosis and the high morbidity of its operations. It is estimated that

64,050 Americans will have pancreatic cancer in 2023, and 50,550 will die due to it [1].

Pancreatico-duodenectomy (PD) is the standard operation and the cornerstone of curative treatment of both head of the pancreas and periampullary cancers [2]. With the advances in surgical techniques and postoperative care, especially in high-volume centres, the mortality of pancreatico-duodenectomy declined dramatically. Historically, it was reported that the mortality of PD operation was as high as 25%, but in recent literature, it declined in specialized centres to around 2% [3–5].

Even though the death rate for pancreatico-duodenectomy has decreased, postoperative morbidity can reach up to 30% to 50%. One of the most significant post-PD consequences is pancreatic fistula (PF) from pancreatic-enteric anastomosis, which occurs between 10% and 28% of the time [6]. In addition to extending hospital stays and increasing expenses, postoperative pancreatic fistula (POPF) increases the risk of other morbidities like postoperative haemorrhage, abdominal infections, and even mortality rates [7–9]. POPF must be prevented and treated as soon as possible, so it is important to investigate and find the best technique for pancreatic-enteric anastomosis.

Many techniques are used in pancreatico-enteric anastomosis, but still, the best one has yet to be known. According to many studies comparing pancreatico-gastrostomy and pancreatico-jejunostomy post pancreatico-duodenectomy, there was no difference between both techniques regarding POPF incidence [10]. Others, however, demonstrated that post-PG, fewer postoperative fistulas occurred [11].

Aim of the study

This study aimed to discuss different techniques of pancreatico-enteric anastomosis post pancreatico-duodenctomy for pancreatic cancers used in a tertiary referral oncology center, and comparing pancreatico-gastrostomy and pancreatico-jejunostomy for their pros and cons and how they affect pancreatic leaks and morbidity.

Patients and methods

This cohort study included all pancreatic head and periampullary cancers patients attending the National Cancer Institute (NCI) between January 2021 and February 2023 and undergoing pancreatico-duodenectomy procedures in NCI.

Patients were grouped according to the type of pancreatico-enteric anastomosis into a group (1) underwent pancreatico-gastrostomy and group (2) underwent pancreatico-jejunostomy.

Patients' characteristics included Sex, age, and comorbidities also history of preoperative stenting of CBD, preoperative laboratory investigations, including serum bilirubin and serum CA19-9 were collected and analyzed. The surgical data included the surgical procedure performed including the type of pancreatico-enteric anastomosis, duration of operation, intraoperative administration of blood, and postoperative complications such as wound infection, fistula and sepsis, and postoperative mortality before discharge. The final histopathological data included the origin of malignancy (pancreatic or periampullary), type of pathology, tumour grade, the size of the neoplasm, margins of resection, and involvement of lymph nodes.

The Postoperative pancreatic fistula was defined according to the International Study Group for Pancreatic Surgery (ISGPS) definition as drain amylase >3 times than the normal serum amylase [12]. Grading of the pancreatic fistula was done according to ISGPS classification as: Grade A 'Biochemical pancreatic fistula' which is just elevation of drains' amylase without clinically significant and no need for change postoperative management, Grade B fistula which needs to leave drains for >3 weeks or needs non-operative management like percutaneous drainage while Grade C was defined as a fistula need re-exploration or leads to one or more organ failure [12,13].

Surgical technique

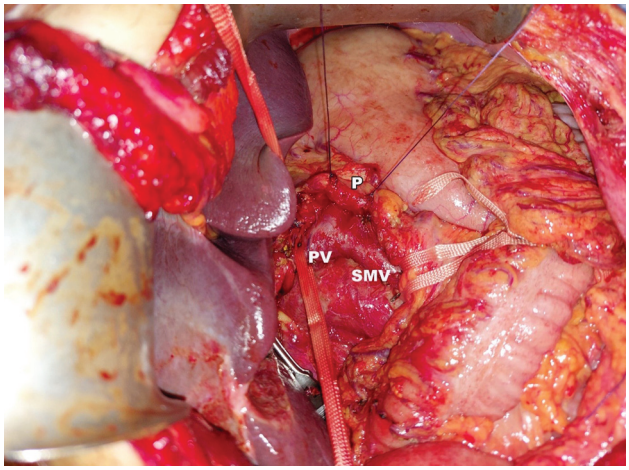
After pancreatico-duodenectomy (Fig. 1), the pancreatico-enteric anastomosis was done as follows:

Pancreatico-jejunostomy:
According to surgeon preference, either Cattel Warren [14] or Blumgart technique [15] was used.

(a) Cattel Warren technique (Figs. 2–4):
    (1) Suturing the posterior border of the pancreatic stump and seromuscular layer of the jejunum by Polydiaxanone (PDS) 3-0 in a continuous or interrupted fashion.
    (2) Opening of jejunum opposite to pancreatic duct.
    (3) Duct to mucosa was done by suturing the posterior wall of the pancreatic duct and posterior layer of jejunal mucosal opening by PDS 5-0 in an interrupted fashion.

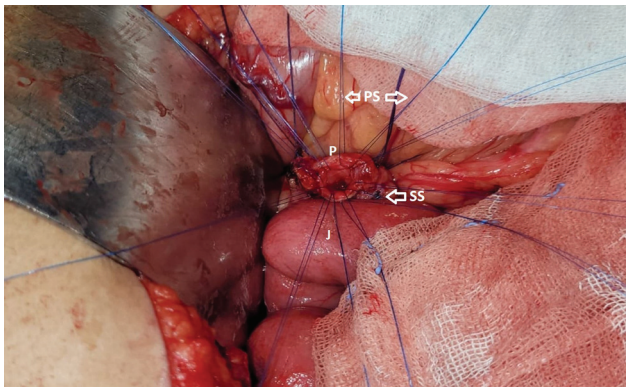
(4) Suturing the anterior wall of the pancreatic duct and anterior layer of jejunal mucosa opening by PDS 5-0 in an interrupted fashion

Figure 1



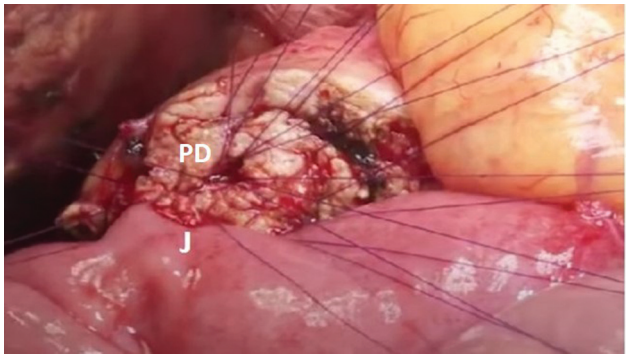
Operative bed after pancreatico-duodenectomy. P: Pancreatic stump, PV: Portal vein, SMV: Superior mesenteric vein. **Pancreatico-jejunostomy: Cattel Warren**.

Figure 2



Take inturrupted pancreatic duct sutures after suturing of posterior pancreatic border and seromuscular layer of jejunum. P: Pancreatic stump, J: Jejunum, PS:Pancreatic duct sutures, SS: Sutures between seromuscular layer of jejunum and pancreatic stump.

Figure 3



Duct to mucosa suturing. J: jejunal opening, PD: Pancreatic duct.

(5) Suturing the anterior border of the pancreatic stump and seromuscular layer of the jejunum by PDS 3-0 in a continuous or interrupted fashion.

(b) Blumgart Technique (Figs. 5–9):

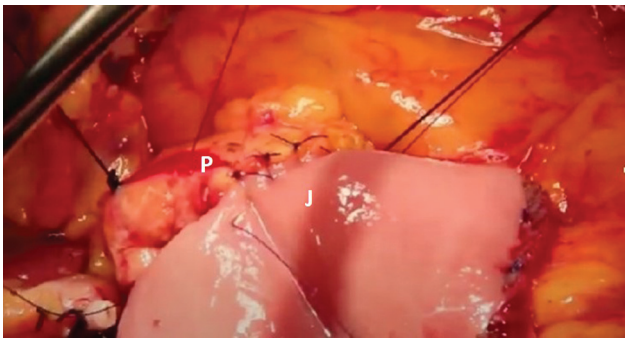
(1) Transpancreatic sutures were taken by PDS 3-0 by full through sutures through pancreatic tissue from its anterior surface to its posterior surface, then through seromuscular of the jejunum transversely and then back full through the pancreas with the probe inside the pancreatic duct to avoid transfixion of it (usually 4-5 sutures used).

(2) Duct to mucosa posterior layer was done by PDS 5-0 in an interrupted fashion.

(3) Anterior layer of duct to mucosa was done by PDS 5-0 in an interrupted fashion.

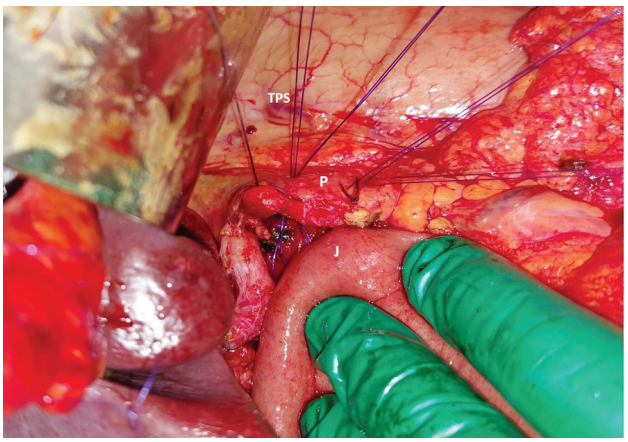
(4) Then, take seromuscular sutures through the jejunum by the previously taken transpancreatic sutures to invaginate the pancreas into the jejunum.

Figure 4



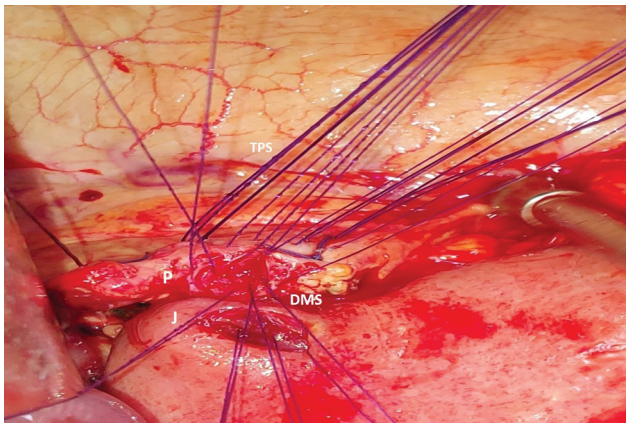
Suturing anterior border of pancreas to seromuscular layer of jejunum. P: pancreatic stump, J: Jejunum. **Pancreatico-jejunostomy: Blumgart**.

Figure 5



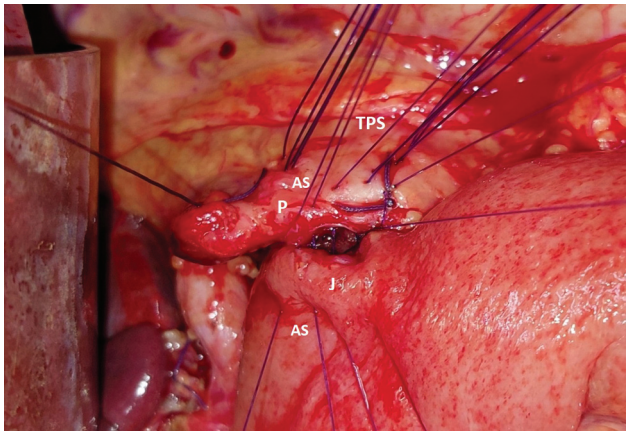
Taking full through pancreatic sutures. P: Pancreatic stump, J: Jejunum, TPS: Transpancreatic sutures.

Figure 6



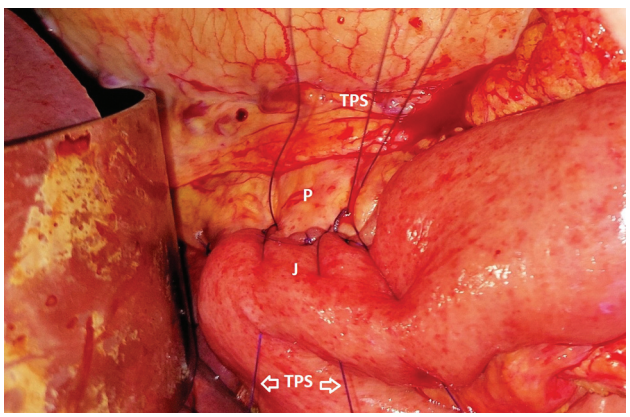
Taking sutures between posterior layer of pancreatic duct and jejunal opening: P: Pancreatic stump, J: Jejunum, TPS: Transpancreatic sutures, DMS: Pancreatic duct to jejunal mucosa sutures.

Figure 7



Taking anterior layer duct to mucosa suturing. P: Pancreatic stump, J: Jejunum, TPS: Transpancreatic sutures, AS: Anterior layer sutures of pancreatic duct to jejunal mucosa.

Figure 8



Take seromuscular layer of jejunum by the transpancreatic sutures. P: Pancreatic stump, J: Jejunum, TPS: Transpancreatic sutures.

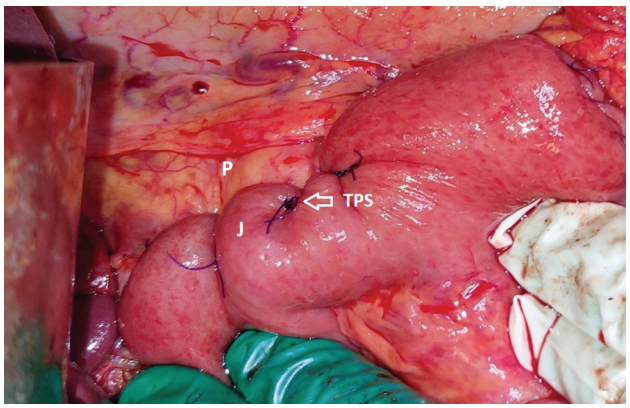
Pancreatico-gastrostomy (Figs. 10–12):

(1) Transverse incision was made in both the anterior and posterior walls of the stomach.
(2) 1 or 2 Purse string sutures were taken by Polyglactin (Vicryl) or PDS 2-0 around the posterior gastric opening.
(3) Delivery of at least 2 cm in length of the pancreas inside the stomach through the posterior opening.
(4) Suturing of the pancreatic stump to the stomach wall by PDS 3-0 interrupted sutures.
(5) Tighten the purse string sutures.

Ethical approval

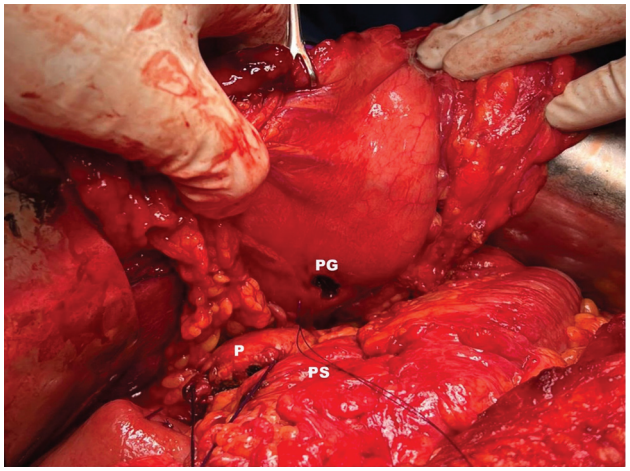
The Institutional Review Board (IRB) of the National Cancer Institute, Cairo University, granted permission for this research with approval number 2212-510-028.

Figure 9



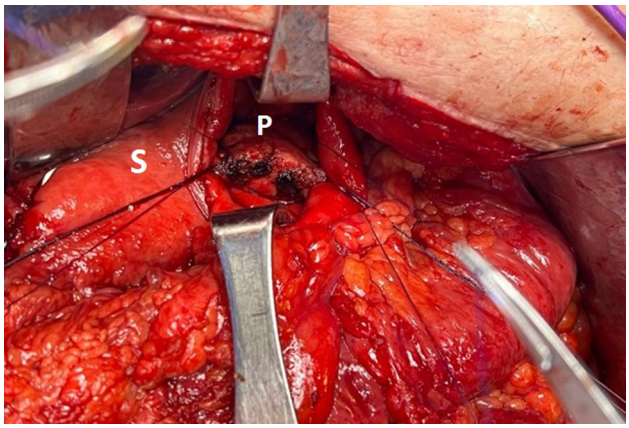
Invagination of pancreas into jejunum by the transpancreatic sutures. P: Pancreatic stump, J: Jejunum, TPS: Transpancreatic sutures. **Pancreatico-gastrostomy**.

Figure 10



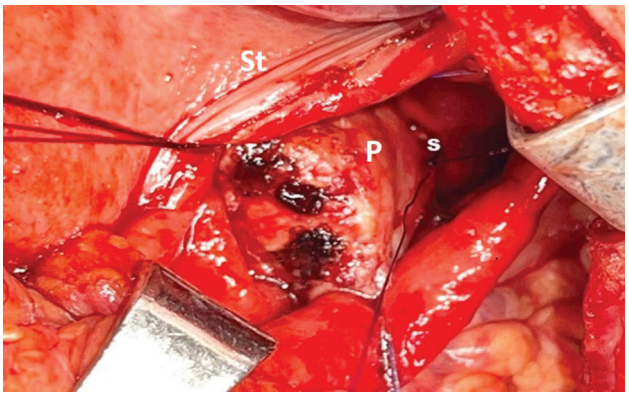
Opening of posterior gastric wall and take purse string suture around it. P: Pancreatic stump, PG: posterior gastric opening, PS: purse string suture.

Figure 11



Delivery of pancreas through posterior gastric opening. P: Pancreatic stump, S: Stomach.

Figure 12



Suturing of pancreas to posterior gastric wall. St: Stomach, P: Pancreatic stump, S: Suture.

Statistical methodology

Data were analyzed using SPSS (Statistical Package for Social Science), version 24. Numerical data was described as a median and range, while qualitative data were expressed as frequency and percentage.

Numerical variables were tested for normality using the Kolmogrov-Smirnov test and Shapiro-Wilk test. Comparison between 2 groups concerning numerical variables was made using a nonparametric t-test, the Mann-Whitney U test.

Qualitative data were compared using the appropriate Chi-square test or Fisher's exact.

P values less than or equal to 0.05 were considered significant. All tests were two-tailed.

Results

During the period of the study, 72 cases underwent pancreatico-duodenectomy. 34 cases underwent pancreatico-gastrostomy, while the other 38 cases underwent pancreatico-jejunostomy. Regarding demographic and preoperative comorbidities and characteristics, no major significant differences between both groups. Little male preference was found in both groups (58.8%, 68.4% for pancreatico-gastrostomy vs pancreatico-jejunostomy, respectively), with a younger median of age in the pancreatico-jejunostomy group (55.5 years' vs. 58.5 years). Most cases in both groups underwent biliary stenting preoperatively (24/34, 29/38 for pancreatico-gastrostomy and pancreatico-jejunostomy groups). Patients' characteristics are illustrated in Table 1.

The current study showed significantly shorter operative time with less delayed gastric emptying postoperatively in the pancreatico-gastrostomy group compared to the pancreatico-jejunostomy group (*P* value =0.001, 0.006). Despite the higher incidence of a pancreatic leak in the pancreatico-gastrostomy group, it was non-statistically significant (17.6, 15.8% respectively, *P*=0.833), as illustrated in Table 2.

Different management plans were used to treat pancreatic leaks according to their grade. All cases with grade A and B pancreatic leaks were managed conservatively. Somatostatin analogues were used in all cases, closely monitoring the patient's vital signs, abdominal examinations, and drains. Daily TLC and CRP were done with Abdominal ultrasound or CT scan every three days or as indicated to exclude intraperitoneal collection. Percutaneous image-guided drainage was used in only one case with grade B pancreatic leakage.

Both of the 2 cases that had grade C pancreatic leaks were explored. Peritoneal wash and drainage were done while redo of the anastomosis was done in the only case in the pancreatico-gastrostomy group, but this patient developed septic shock and die in day 10 postoperatively and this was the only case died due to pancreatic leak in this study.

In the whole cohort, 4 cases (5.5%) died in the 60 days postoperatively (3 cases in the pancreatico-gastrostomy group while the other case in the pancreatico-jejunostomy group, *P*=0.338). One case had septic shock (due to pancreatic leak in PG group); 2 cases developed hematemesis postoperatively with failure of control by endoscopy. And one case developed liver failure.

The final operative specimens' pathology analysis showed comparable findings regarding the size of

Table 1 Patients' demographic and preoperative characteristics

	Pancreatico-gastrostomy *n*=34	Pancreatico-jejunostomy *n*=38	*P* value
Sex			
Male	20 (58.8%)	26 (68.4%)	0.397
Female	14 (41.2%)	12 (31.6%)	
Age (year)			
Median (range)	58.5 (8–75)	55.5 (15–75)	0.426
Comorbidities			
Diabetic			
Yes	10 (29.4%)	12 (31.6%)	0.842
No	24 (70.6%)	26 (68.4%)	
Hypertensive			
Yes	4 (11.8%)	4 (10.5%)	1.00
No	30 (88.2%)	34 (89.5%)	
Ischemic Heart			
Yes	2 (5.9%)	2 (5.3%)	1.00
No	32 (94.1%)	36 (94.7%)	
Hepatitis			
Yes	4 (11.8%)	5 (13.2%)	1.00
No	30 (88.2%)	33 (86.8%)	
Preoperative biliary stenting			
Yes	25 (73.5%)	29 (76.3%)	0.785
No	9 (26.5%)	9 (23.7%)	
Neoadjuvant chemotherapy received			
Yes	1 (2.9%)	5 (13.2%)	-
No	33 (97.1%)	33 (86.8%)	
CA 19-9			
Median (range)	27.8 (0.5–1635)	31.0 (1.3–1248)	0.765
CEA			
Median (range)	2.8 (0.3–25.0)	3.2 (0.5–13.0)	0.584

tumours, nodal positively, and perineural and lymphovascular invasion, as illustrated in Table 3. The surgical margin was positive in 6 cases (8.3%).

Discussion

Pancreatico-duodenectomy (PD) is a very complex operation; despite a declining mortality rate with advances in techniques and postoperative care but the rate of morbidity of PD, especially postoperative pancreatic fistula (POPF), is still high. In the literature, the incidence of POPF post-PD is still higher than 10%, with bad outcomes regarding the increased incidence of postoperative infection, bleeding, and even deaths [16].

In 2005, An international working group (the International Study Group of Pancreatic Fistula [ISGPF]) comprised of 37 pancreatic surgeons developed a consensus description of postoperative pancreatic fistula (POPF). POPF has been settled upon as fluid output of any measurable volume through a surgically implanted drain with an amylase level higher than three times the upper normal serum value; they graded POPF into three grades: A, B, C [12]. The grading system was revised in 2016 into a biochemical leak of insignificant clinical outcomes (previously grade A) and clinically significant pancreatic leak (grade B, C). In grade B the pancreatic fistula causes prolongation of placement of drains to more than three weeks or needs percutaneous drainage or endoscopic management, while grade C is POPF need reoperation or results in organ failure or mortality related to its sequences [13]. Many risk factors for the development of POPF were studied. **Yang *et al.*** reported that the texture of the pancreas and diameter of the pancreatic duct was the most important risk factors for the development of POPF, as cases with soft pancreas or pancreatic duct diameter of less than 3 mm were associated with a higher incidence of development of POPF (32% vs 3% [P=0.004], 38% vs. 5% [P=0.002], respectively) [17]. **Jin *et al.*** reported that operative time higher than 320 min was a significant risk factor associated with POPF ((OR =6.061; P<0.001)) [18].

Different techniques in pancreatic anastomosis are present. The exact impact and the best technique

Table 2 Operative and postoperative outcomes

	Pancreatico-gastrostomy (*n*=34)	Pancreatico-jejunostomy (*n*=38)	*P* value
Operative time (min)			
Median (range)	310 (240–490)	355 (255–580)	0.001
Vascular resection (Portal vein)			
Yes	2 (5.9%)	3 (7.9%)	1.000
No	32 (94.1%)	35 (92.1%)	
Intraoperative Blood transfusion (Units number)	1 (0–5)	1 (0–4)	0.402
Intraoperative Plasma transfusion (Units number)	4 (0–14)	2 (0–8)	0.020
Pancreatic leak			
Yes	6 (17.6%)	6 (15.8%)	0.833
No	28 (82.4%)	32 (84.2%)	
Pancreatic leak grade (n=12)			
Grade A	3 (50%)	4 (66.6%)	-
Grade B	2 (33.3)	1 (16.7%)	
Grade C	1 (16.7%)	1 (16.7%)	
Delayed gastric empty			
Yes	2 (5.9%)	12 (31.6%)	0.006
No	32 (94.1%)	26 (68.4%)	
Biliary leak			
Yes	3 (8.8%)	5 (13.2%)	0.714
No	31 (91.2%)	33 (86.8%)	
Wound infection			
Yes	15 (44.1%)	17 (44.7%)	0.958
No	19 (55.9%)	21 (55.3%)	
Time to start oral feeding (days)			
Median (range)	7 (3–13)	5.5 (2–12)	0.073
Postoperative hospital stays (days)			
Median (range)	12.5 (0–43)	13 (7–60)	0.986
Postoperative mortality			
Yes	3 (8.8%)	1 (2.6%)	0.338
No	31 (91.2%)	37 (97.4%)	

Table 3 Specimen's pathology results

	Pancreatico-gastrostomy (*n*=34)	Pancreatico-jejunostomy (*n*=38)	*P* Value
Pathological type			
Pancreatic adenocarcinoma	27 (79.4%)	31 (81.6%)	-
Pancreatic neuroendocrine	1 (2.9%)	1 (2.6%)	
Pancreatic Solid pseudopapillary tumor	3 (8.8%)	3 (7.9%)	
Pancreatic mucinous tumor	0 (0%)	1 (2.6%)	
Periampullary carcinoma	3 (8.8%)	2 (5.3%)	
Pathology grade (*n*=63)			
Grade 1	5 (16.7%)	0 (0%)	0.028
Grade 2	21 (70%)	31 (93.9%)	
Grade 3	4 (13.3%)	2 (6.1%)	
Tumor maximum diameter (cm)			
Median (range)	3.3 (0.5–14.0)	4.0 (1.5–14.0)	0.128
Lymphovascular or perineural invasion			
Yes	13 (38.2%)	13 (34.2%)	0.723
No	21 (61.8%)	25 (65.8%)	
Lymph nodes			
Positive	11 (32.4%)	12 (31.6%)	0.944
Negative	23 (67.6%)	26 (68.4%)	
Surgical margin			
Positive	4 (11.8%)	2 (5.3%)	0.412
Negative	30 (88.2%)	36 (94.7%)	

associated with less incidence of POPF are still debatable, and the results of studies are contradicted. Many factors may contribute to these contradicted results in these studies, like an unstandardized definition of POPF, unstandardized technique, bias in the selection of specific technique, a lack of stratification of the diameter of the pancreatic duct or subjective assessment of texture of pancreas into soft/hard consistency [19].

Many pancreaticojejunostomies techniques present like Cattel Warren, Blumgart, Heidelberg, Peng's binding, Pair watch and Invagination techniques [20]. In the current study, Cattel Warren and Blumgart were the only techniques used. **Grobmyer *et al.*** reported the first series conducted on the Blumgart technique at which 187 patients from 2 institutes enrolled on this technique after PD; the results showed 6.9% clinically significant pancreatic fistula, no bleeding or mortality related to the pancreatic leak [21].

Literature regarding POPF shows a trend about the superiority of the Blumgart anastomosis (BA) technique over other techniques. In Meta-analysis included 2412 patients, **Li *et al.*** reported that: Compared to the non-Blumgart anastomosis, BA was associated with substantially lower grade B/C POPF (OR 0.38, 0.22 to 0.65; *P*=0.004) [22].

Despite that, other studies like **Lee *et al.*** reported a non-significant difference between the Blumgart and Cattel Warren technique for the rate of POPF (27.9 vs. 43.2%, *P*=0.137) [23].

In 1946, Waugh first proposed PG as an alternative to PJ for pancreatic anastomosis post-PD [24]. Since then, many studies comparing PG vs PJ for their pros and cons. **Figueras *et al.*** reported higher incidence and higher grade of POPF in PJ compared to PG ((34.5% vs. 15.4% respectively; *P*=0.014)) [25]. The same results were in the study conducted by **Topal *et al.*** reported an incidence of POPF (19.8% vs. 8% for PJ vs. PG, respectively [*P*=0.002]) [26]. In contrast, **Grendar *et al.*** reported no significant difference between the rate of POPF in PJ and PG (18% vs. 25% respectively, *P*=0.40) [27]. Also, **Keck *et al.*** reported no difference in the rate of grade B and C POPF between PJ and PG (22% vs. 20%, *P*=0.617) [28]. The same results were in the present study, which showed no statistically significant difference between both techniques regarding incidence and grades of POPF (incidence of POPF=17.6%, 15.8% for PG vs. PJ respectively [*P*=0.833]).

Delayed gastric emptying is a common complication after PD. According to the international study group of the pancreas, it was defined as the need for leave or reinsertion of nasogastric tube >three days postoperatively or inability to tolerate solid food at day seven postoperatively. Despite that, it is not a dangerous complication, resulting in prolonged hospitalization and continued parenteral feeding for a longer time [29]. The mechanism by which pancreatic anastomosis affects the stomach's motility is unclear. In the conducted study, DGE was less common in cases that underwent PG than those that experienced PJ (5.9% vs. 31.6%, *P*=0.006). In the Literature, studies reported no significant difference in the rate of DGE between PJ and PD after pancreatico-duodenectomy [30,31]. DGE is a major financial problem especially in health systems with limited resources due to increase hospital stay, prolonged duration of using IV fluids and costs for managing complications of nasogastric tube especially chest infection. Francken *et al.* reported that the cost of caring patients with DGE after pancreatico-duodenectomy is about &z.euro; 9000-10000 higher than patient without DGE [32]. The Operative time was significantly less in cases that underwent PG vs PJ (310 vs. 355, *P*=0.001) because of a smaller number of sutures taken in cases of PG as no sutures were taken between pancreatic duct and mucosa in this cohort. Both shorter operative time and lesser incidence of DGE in pancreatico-gastrostomy group make PG superior option than pancreatico-jejunostomy from point of cost.

It seems that pancreatico-gastrostomy is a similar technique to pancreatico-jejunostomy in the rate of POPF and other complications but superior on it from point of operative time and lesser incidence of developing DGE. The main limitations of this study were that it is a single-center study, the limited number of cases and the non-randomization of the cases as the type of pancreatic anastomosis in this study depended on surgeon preference.

A large multicentric randomized study conducted by expert surgeons in high-volume centres with standardization of technique and definitions of complications like POPF and DGE is needed to reach the best pancreatico-enteric anastomosis technique.

Conclusion

Regarding the incidence of postoperative pancreatic fistula, both reconstruction methods produce

comparable postoperative results. Pancreatico-gastrostomy is a good alternative to the standard pancreatico-jejunostomy.

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Conflicts of interest

There are no conflicts of interest.

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