Original Article

Assessing the Role of Pancreatic Duct and Consistency in Forecasting Post-Pancraticodoudenectomy Pancreatic Fistula; A prospective Study

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ABSTRACT

Background and Aim: Postoperative pancreatic fistula (POPF) is one of the serious complications that can happen after pancreatic surgery, especially pancreaticoduodenectomy. The morbidity after pancreatic resection was mainly caused by POPF. Clinical prediction patterns have been proposed with the anticipation of detecting patients who have high risk of POPF. Persistent abdominal pain, vomiting, and postoperative secondary hemorrhage might suggest the occurrence of POPF. The current study aimed to detect possible risk factors for POPF involved size of pancreatic duct, consistency of the pancreas (soft or firm), intraoperative blood loss, etc.

Methods: In our study we prospectively analyzed the factors which are associated with postoperative pancreatic fistula formation following pancreaticoduodenectomy. This research was accomplished at the General Surgery Department in Assiut University Hospitals and Al-Rajhi Liver Hospital from March 2023 till March 2024. A total of 62 patients were scheduled for pancreaticoduodenectomy were enrolled.

Results: The patients had a mean age of 54.40±12.82 years. The utmost frequent diagnosis in the studied patients was pancreatic cancer (59.7%). A wound infection was reported in 15(24.2%) patients. Length of stay was <7 and >7 days in 34(54.8%) and 28(45.2%) patients, respectively. POPF occurred in 16(25.8%) patients. patients with POPF had significantly higher mean age (60.34±5.67 vs. 44.66±8.90 (years), mean body mass index (19.45±2.22 vs. 23.03±2.89(kg/m^2) and lower albumin (32.09±2.19 vs. 39.44±4.21(mg/dl). Also, majority of patients with POPF had soft pancreatic consistency (68.8%) and small pancreatic duct (68.8%). Predictors of POPF were low albumin, soft pancreatic consistency and small pancreatic duct. Soft pancreatic consistency had 84.5% accuracy for prediction POPF. Meanwhile, small pancreatic duct had 81.2% accuracy. Also, low albumin had 63% sensitivity, 67% specificity and 66% accuracy for prediction POPF

Conclusion: Patients with soft pancreatic consistency with small pancreatic duct are more liable to POPF. Strict follow of those risky patients after pancreatoduodenectomy is highly recommended. Future work, including a larger number of patients, is assured to verify such results.

Key Words: Pancreatic fistula, Pancreatic duct, Pancreatoduodenectomy, Soft pancreatic consistency.

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INTRODUCTION

Pancreatectomy is recognized as one of the difficult aspects of abdominal surgical procedures. Concentration on the high-capacity institutions has resulted in improved short-term outcomes in patients. However, morbidity in the postoperative period stays significant. Nevertheless, the kind of pancreatoduodenectomy (PD), the majority of serious problems are caused by the pancreatic stump failure and leakage, which eventually causes the postoperative pancreatic fistula (POPF)[1].

The post-pancreatectomy mortality rate has been informed in the range of 2% to 9%, and the best results come from high-volume institutions. Surveys investigating the underlying sources of the post-pancreatectomy mortality have found POPF contributing to around half of mortality postoperatively[2-4]. The main cause of the development of POPF is the leakage of digestive enzymes from the pancreatic stump. This leakage can lead to inflammation of the surrounding tissues, infection, formation of a localized abscess, further may lead to erosion of the blood vessels causing a serious hemorrhage. The pancreatic leakage may result from soft pancreatic parenchyma, which cannot withstand the sutures, leading to disruption of the pancreatic stump. Furthermore, small-sized pancreatic duct faces technical difficulties in the creation of adequate anastomosis, increasing the risk of leakage.

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Risk factors for pancreatic fistula development afterward pancreaticoduodenectomy comprise non-pancreatic tumor, soft pancreatic consistency, small sized pancreatic duct (<0.3cm), surgery in acute pancreatitis, intraoperative bleeding (>1L), excess fluid administration, and increased pancreatic parenchymal remnant volume[5,6]. POPF can be classified into three categories: Grade A, which is distinguished by elevated levels of serum amylase on the drain with no pointed clinical features, while Grade B is detected by the observed clinical symptoms necessitating either therapeutic drugs or less-invasive interventions. Lastly, in Grade C, the patient is severely ill with sepsis and usually needs invasive intervention[7]. The current study aimed to determine the risk factors for POPF after PD. These possible risk factors included size of pancreatic duct, consistency of the pancreas (soft or firm), intraoperative blood loss, body mass index …. etc. The estimation of these factors facilitates the early detection of pancreatic fistula to decrease the morbidity and mortality after PD.

PATIENTS AND METHODS

Study setting and design

A cohort observational hospital-based study. This research was performed at the General Surgery Department in Assiut University Hospitals and Al-Rajhi Liver Hospital from March 2023 till March 2024. The current study was approved (received No. 04-2023-200063) by the ethical committee of faculty of medicine, Assiut University and was conducted in compliance with the ethical guidelines and regulations. In addition, it was registered at Clinical-Trials with registration No. NCT05654636.

Selection criteria

a. Age was between 18-70 years old.

b. Resectable tumors.

c. Surgically fit patients.

d. duration less than 1 year.

Exclusion criteria

Patients with one or more of the subsequent conditions were excluded; jaundice with serum bilirubin above 200mml/dl, bleeding tendency until corrected, advanced and metastatic malignancy, cardiopulmonary diseases and/or advanced comorbidities (decompensated heart failure, chest disease).

Sample size calculation

A total coverage sample technique was applied in the current study where all patients who were scheduled for PD during the study period and fulfilled the selection criteria were enrolled. Sixty-two patients were registered in the research.

Preoperative assessment

Complete history taking and clinical examinations for all patients were conducted. The following data were recorded, age, sex, body mass index, and underlying comorbidities.

Preoperative assessment for the diagnosis and staging of periampullary tumor involved presentation, physical examination, liver function, full blood count, tumor markers, and imaging [abdominal sonography, magnetic-resonance-cholangiopancreatography, multislice abdominal computed tomography (CT), in addition to CT angiography].

Endoscopic retrograde cholangiopancreatography (ERCP) and stenting was accomplished in cases presented with borderline tumor managed by neoadjuvant chemotherapy, cholangitis, or hepatic dysfunction.

Surgical intervention

For all cases, pylorus sparing PD or distal gastrectomy was performed with a classical PD. Pancreatic reconstruction was performed to the jejunum by pancreaticojejunostomy (Figure 1). Bilioenteric anastomosis (HJ) was done in the retrocolic fashion, in an end-to-side approach. Using vicryl or PDS sutures 4/0, HJ was performed in either interrupted, continuous, or combined manner. Gastrojejunostomy antecolic was performed side to side using a gastrointestinal tract stapler.

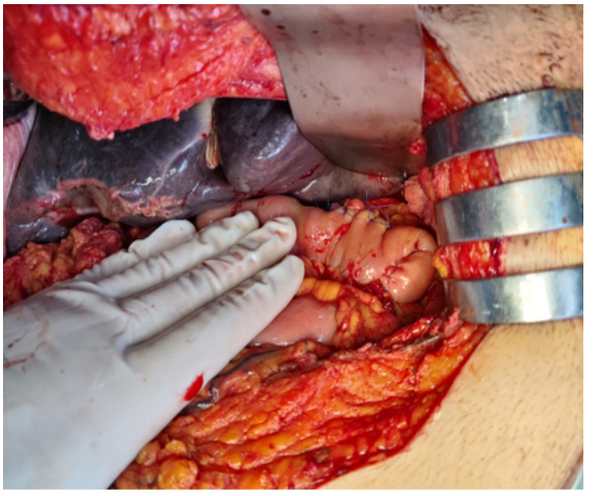

Figure 1: Pancreaticojejunostomy.

Postoperative management

Postoperative ICU stay was for 1 day for all patients, who were then transferred the next day to the general ward. Prophylactic antibiotics were administered intraoperatively and proceeded postoperatively for 5 days. For risky patients, subcutaneous octreotide was administered postoperatively for 3 days.

Regular documentation was provided of vital signs, intravenous fluid, and drain outputs. If intestinal sounds are heard, patients were able to begin fluid intake orally. When oral intake was tolerated, patients were discharged without any complications, and thereafter, the drains were removed.

Follow-up

Postoperative follow-up was scheduled for 7 days, 4 weeks, 4 months, as well as 6 months. The follow-up included clinical evaluation; laboratory, functions, such as amylase, complete blood count, liver function, tumor marker (CEA and CA19-9), and abdominal CT to determine any complication and recurrence risk.

Study definitions

a. As stated by the Pancreatic Surgery International Study Group, the definition of pancreatic fistula was regarded as any measurable aliquot of fluid in the drain with level of amylase more than three times the normal level of serum amylase, correlated to a clinically applicable condition directly associated with POPF. POPF of grade A was deemed as biochemical leakage and both grade B and C were considered clinically related POPF[7].

b. Cases which died during hospital admission or during 30-days postoperatively was counted as peri-operative mortality.

Data collection

The database contained the following variable: demographic data, previous abdominal surgery, symptom length, BMI, comorbidity laboratory finding, radiological finding, surgical date, operational information, complications within 30 first postoperative days, and length of hospital stays.

Outcomes of the study

The POPF frequency was the main primary outcome. Meanwhile, secondary outcomes involved predictors of POPF, the duration of operation, blood loss, blood transfusion, pancreatic stump criteria including texture and pancreatic duct diameter, technical difficulties, type of pancreatic reconstruction, hospital stay, mortality rate, and mass size.

Statistical analysis

For categorical variables, descriptive data was displayed as percentages and counts. Continuous factors were described as a median. All statistical analysis was conducted through SPSS-17 software (SPSS Inc; Chicago; Illinois; USA).

Comparison of two classes of categorical variables was done by χ^2, and Student's t testing was applied for the continuous parameters. A significant value is *P* less than 0.05. In multivariate logistic regression, preoperative data including demographic data, clinical presentation, comorbidity, and preoperative endoscopic retrograde cholangiopancreatography (ERCP) were entered to determine predictors of POPF. Accuracy of different predictors for prediction of POPF was determined by receiver operator characteristics (ROC) curve.

RESULTS

Data of the involved patients

As shown in Table (1), patients had a mean age of was 54.40±12.82 years. The most frequent diagnosis in the studied patients was pancreatic cancer (59.7%) followed by ampullary cancer (32.3%) and duodenal mass (8.1%).

Table 1: Baseline and Peri-operative data of enrolled patients:

Parameter	*N*= 62
Age (years)	54.40±12.82
Range	18-75
Sex	
Male	37(59.7%)
Female	25(40.3%)
Body mass index (kg/m2)	21.33±4.33
Diagnosis	
Pancreatic cancer	37(59.7%)
Ampullary cancer	20(32.3%)
Duodenal mass	5(8.1%)
Bilirubin (mmol/l)	103.74±97.03
Direct bilirubin (mmol/l)	73.65±63.88
Albumin (mg/dl)	36.78±4.61
ERCP	40(64.5%)
Operative time (minute)	245.68±24.89
Pancreatic consistency	
Firm	39(62.9%)
Soft	23(37.1%)
Pancreatic duct size	
Large	40(64.5%)
Small	22(35.5%)
Intraoperative stent	57(91.9%)
Amylase in drain (U/L)	3052.20±371.46

Data expressed as frequency (percentage); mean±(SD); ERCP: Endoscopic Retrograde Cholangiopancreatography.

Peri-operative data among the patients

In Table (1), pancreatic consistency was firm in 39(62.9%) patients and soft in 23(37.1%) patients. Large pancreatic duct (>3mm) was found in 40(64.5%) patients and small pancreatic duct (<3mm) was found in 22(35.5%) patients. Intraoperative stenting was done in 57(91.9%) patients.

Outcome in the studied patients

Table (2) verifies that wound infection was reported in 15(24.2%) patients. A total of 54(87.1%) patients were

get better and discharged and 8(12.8%) patients were worsened and died (6 cases had septic shock and two cases had pulmonary embolism).

Table 2: Outcome among the studied patients:

Parameter	*N*= 62
Wound infection	15(24.2%)
Pancreatic fistula	16(25.8%)
Hospital stays	
<7 days	34(54.8%)
>7 days	28(45.2%)
Survival	
Alive	54(87.1%)
Died	8(12.9%)

Data expressed as frequency (percentage)

Pancreatic fistula occurred in 16(25.8%) patients. Out of those patients with POPF, 8 patients were of grade (A), 5 patients of grade (B), and the other 3 cases were of grade C. Eight cases were conservatively managed, two cases needed surgical intervention and were successfully managed with distal pancreatectomy, while the other 6 cases died with septic shock.

Characteristics of patients based on development of POPF

Majority of patients with POPF had soft pancreatic consistency (68.8%) and small pancreatic duct (68.8%). Meanwhile, majority of patients without POPF had firm consistency (73.9%) and large pancreatic duct (76.1%), referring to (Figure 2). Figure (3,4) represents both small and large pancreatic duct.

Wound infection was reported with higher frequency in patients with POPF (43.8% vs. 17.4%; p= 0.04). Also, patients with POPF had significantly longer stay where all of them had stayed more than 7 days and majority (73.9%) of patients without POPF had stayed < 7 days. Table (3) summarizes the characteristics of patients based on POPF development.

Predictors of post-operative pancreatic fistula

Predictors of POPF were low serum albumin (odd's ratio (OR) was 2.11), soft pancreatic consistency with OR was 4.89 and small pancreatic duct with OR was 3.90. According to ROC curve analysis (Figure 6), soft pancreatic consistency had 84.5% accuracy for prediction POPF. Meanwhile, small pancreatic duct had 81.2% accuracy for prediction POPF and low serum albumin had 66% accuracy for prediction POPF (Table 4).

Table 3: Characteristics of studied patients based on development of POPF:

Parameter	POPF		*P*-value
	No (*n*= 46)	Yes (*n*= 16)	
Baseline data			
Age (years)	44.66±8.90	60.34±5.67	<0.001
Sex			
Male	29(63%)	8(50%)	0.26
Female	17(37%)	8(50%)	
Body mass index (kg/m^2)	20.03±2.89	27.45±2.22	0.03
Diagnosis			
Pancreatic cancer	30(65.2%)	7(43.8%)	0.12
Ampullary cancer	14(30.4%)	6(37.5%)	
Duodenal mass	2(4.3%)	3(18.8%)	
Bilirubin (mmol/l)	95.83±11.65	124.67±36.77	0.32
Direct bilirubin (mmol/l)	70.05±57.82	79.95±20.73	0.61
Albumin (mg/dl)	39.44±4.21	32.09±2.19	<0.001
Perioperative data			
ERCP	28(60.9%)	12(75%)	0.49
Operative time (minute)	240.68±19.45	255.67±39.45	0.06
Pancreatic consistency			
Firm	34(73.9%)	5(31.3%)	<0.001
Soft	12(26.1%)	11(68.8%)	
Pancreatic duct size			
Large	35(76.1%)	5(31.3%)	<0.001
Small	11(23.9%)	11(68.8%)	
Intraoperative stent	42(91.3%)	15(93.8%)	0.62
Amylase in drain (U/L)	488.76±21.46	3843.73±1352.45	<0.001
Outcome			
Wound infection	8(17.4%)	7(43.8%)	0.04

Parameter	POPF		*P*-value
	No (*n*= 46)	Yes (*n*= 16)	
Hospital stays			
<7 days	34(73.9%)	0	<0.001
>7 days	12(26.1%)	16(100%)	
Survival			
Alive	44(95.7%)	10(62.5%)	0.003
Died	2(4.3%)	6(37.5%)	

Data expressed as mean±(SD), frequency (percentage); *P*-value was significant if <0.05; POPF: Post-Operative Pancreatic Fistula; ERCP: Endoscopic Retro-Grade Cholangiopancreatography.

Table 4: Accuracy of different predictors in predicting the POPF

Parameter	Low serum albumin	Soft pancreatic consistency	Small pancreatic duct
Sensitivity	63%	88%	75%
Specificity	67%	83.3%	83.3%
PPV	71.4%	88%	86%
NPV	57.1%	83.3%	71%
Accuracy	66%	84.5%	81.2%
AUC	0.64	0.85	0.79
P value	0.34	0.002	0.02

P-value was significant if < 0.05; POPF: Post-Operative Pancreatic Fistula; PPV: Positive Predictive Value; NPV: Negative Predictive value; AUC: Area Under Curve.

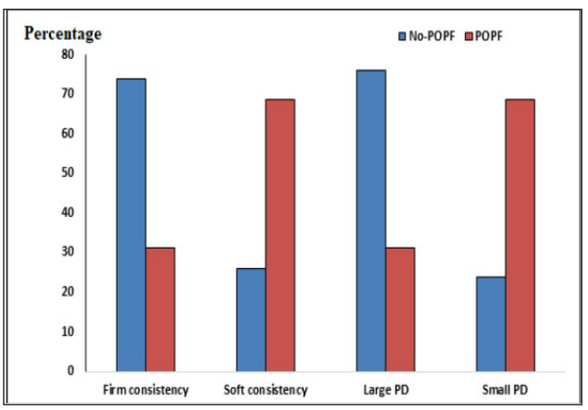

Figure 2: Operative data among patients based on the development of POPF; POPF: Postoperative Pancreatic Fistula; PD: Pancreatic Duct.

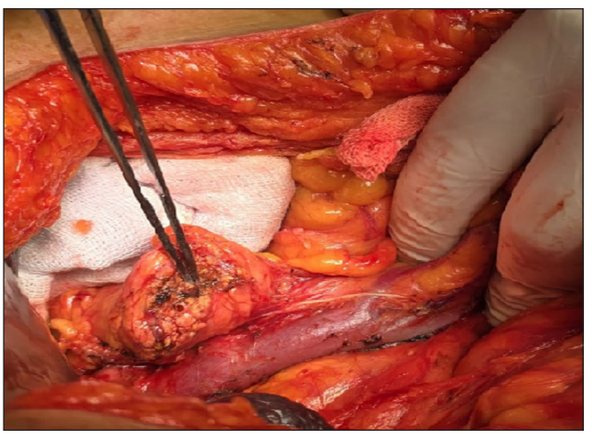

Figure 3: Small pancreatic duct.

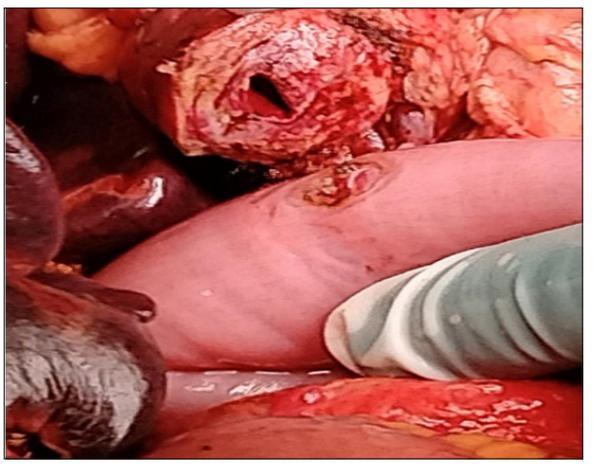

Figure 4: Large pancreatic duct.

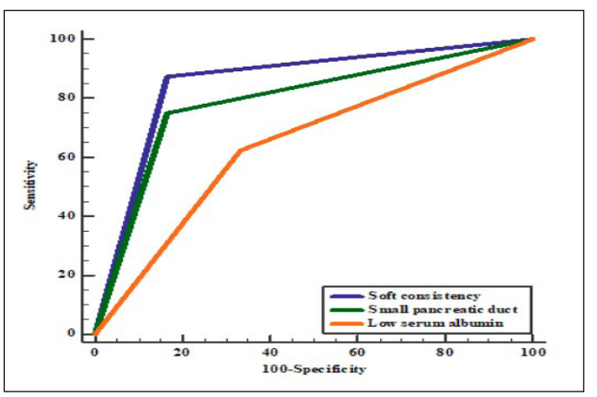

Figure 6: Accuracy of different predictors in the prediction of postoperative pancreatic fistula in the current study. pancreatic duct.

DISCUSSION

POPF is considered as a significant complication of pancreatic surgical procedure. Failure of pancreatic anastomosis is one of the principal causes of POPF. While sepsis and pain are the foremost morbidity factors of POPF. Critical side effects such as post-pancreatectomy bleeding may lead to mortality[8].

To enhance the prognostic capability of individual clinical and pathological parameters, numerous prognostic scoring methods have been suggested that merge various factors. Until now, however, there is insufficient data on the popularity of the abovementioned scoring methods. Choice and delamination of patients into groups in accordance with POPF risk are valuable for applying further clinical and surgical approaches for treatment of patients[1,9].

The present work aims to predicate early the pancreatic fistula after pancreaticoduodenectomy to facilitate timely intervention after pancreaticoduodenectomy. Sixty-two patients scheduled for PD were enrolled in the current research.

Out of those patients, a total of 16(25.8%) patients developed POPF; 8 patients were of grade (A), 5 patients of grade (B), and the other three patients were of grade (C). Eight cases were conservatively managed, two cases needed surgical intervention and were successfully managed, while the other 6 cases died with septic shock.

Figure (5) of POPF was consistent with literature that denoted that incidence of POPF has been shown to be ranged between 13-41%[1,10,11]. This wide range of frequency may be explained by different sample sizes, underlying etiology, selection bias and different patients' characteristics with underlying comorbidities

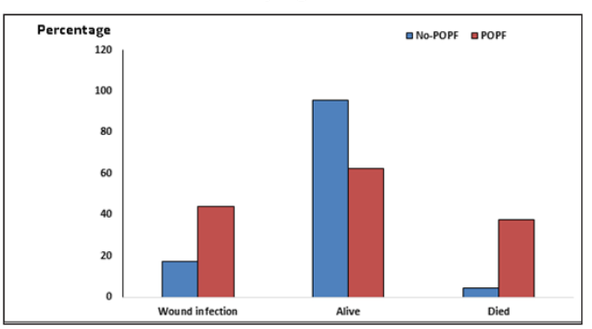

Figure 5: Outcome among patients based on development of POPF. POPF: post-operative pancreatic fistula.

In previous Egyptian study, 95 cases had experienced pancreaticoduodenectomy. In line the current study, the authors of the later study noticed male predilection (60%). The study reported frequency of POPF was 35(36.8%) cases. Among them, 7 cases were grade A, 23 cases were grade B, while the remaining 5 cases were of grade C. A 29 cases were successfully managed conservatively, 4 cases needed surgical intervention and were successfully managed, while the other 2 cases (5%) died[12].

Another finding in our study was that a total of 54(87.1%) patients were getting better and discharged, while 8(12.8%) patients were worsened and passed away. Six patients from those died had POPF. The post-pancreatectomy mortality rate has been informed in the range of 2%-9% with the most beneficial results conveyed from high-capacity institutions[1,3].

Surveys investigating the critical sources for the post-pancreatectomy mortality rate have recognized POPF to provide about half of the mortality after operation. Moreover, POPF has been proven to link to the deteriorated overall tumor recurrence and survival for pancreatic cancer[13-16].

In the present study, it was found that POPF patients had considerably higher mean age (60.34±5.67 vs 44.66±8.90 years; $p< 0.001$). There was a debate about the effect of age as a potential predisposing factor for developing POPF. Elmelegy *et al,* (2021) reported that patients older than 60 years had a considerably greater incidence of POPF after PD[17].

Conversely, Williamsson *et al.,* (2020) reported no correlation between age and the development of POPF, which disagrees with our findings[18]. Nevertheless, Wente *et al.,* (2007) reported that the older group would have a greater mortality rate due to POPF, as reported by 1.9% for patients <75 years versus 5.9% for patients ≥75 years[19].

Also, we found that POPF group had higher mean body mass index (27.45±2.22 vs. 20.03±2.89(kg/m^2); $p= 0.03$). Many theories have been suggested to explain the role of BMI in pancreatic fistula development such as increased intra-abdominal and peripancreatic fat content, the possibility of soft pancreatic tissue, and also the technical difficulty of a pancreatic-jejunal anastomosis[20-22].

We noticed a lower serum albumin in POPF group (32.09±2.19 vs. 39.44±4.2(mg/dl); $p< 0.001$) in comparison to those without POPF. Similarly, previous study reported that preoperative albumin less than 3.6gm/dl was associated with a significant ($p= 0.009$) higher incidence of POPF[12].

Conversely, Fujiara *et al.,* (2015) stated that POPF was not correlated to preoperative albumin, but it likely occurred in patients with low postoperative albumin ($p= 0.04$). This may be because albumin is among the negative acute phase proteins, which decline during inflammatory processes such as POPF. Therefore, it may be used as a predictor for pancreatic leak rather than a predisposing factor[23].

Also, we found that wound infection was reported with higher frequency in patients with POPF (43.8% vs. 17.4%; p= 0.04). Also, patients with POPF had significantly longer stay length where all of them had stayed more than 7 days and majority (73.9%) of patients without POPF had stay <7 days.

In agreement with the current study, the statistical mean of hospital stay was longer in cases that developed POPF than those who did not develop (27.9 versus 12.7 days, respectively; p< 0.001). The development of POPF and its consequences significantly strain the health system since they increase the length of hospital stays and the number of secondary readmissions while necessitating comparatively more intensive care unit stays, complete parenteral nutrition, and interventional radiology operations[12].

The main findings in the current study were that majority of patients with POPF had soft pancreatic consistency (68.8%) and small pancreatic duct (68.8%). Meanwhile, majority of patients without POPF had firm consistency (73.9%) and large pancreatic duct (76.1%).

Similarly, Shah *et al.,* (2020) found that soft consistency of the pancreas (p= 0.022) and small-sized pancreatic duct (p= 0.002) were extensively correlated to POPF occurrence[24]. Also, another study, in patients with clinically relevant pancreatic fistula, the incidence of wound infection increased, and the hospital admission was extended to >7 days compared with other group with no fistula (p= 0.040 and <0.001, respectively)[20].

Pancreatic soft consistency has higher fat deposition which leads to diminished mechanical resistance on the site of the anastomosis as well as enhanced lipolysis with pancreatic coenzymes. Consequently, pancreatic soft consistency is considered one of the major risk factors of POPF acquirement. Likewise soft pancreas texture, small-sized pancreatic duct, as well as intraoperative bleeding were investigated as threat issues for the incidence of POPF[25-27].

This is consistent with another study that revealed patients who had soft pancreas were expected to have POPF (44.4%) than those with hard pancreas (16.7%) with a statistically significant difference (p= 0.036). Besides, multivariate regression analyses demonstrated that pancreatic soft consistency was the main risk issue of POPF[20].

Unlike these results, a study by Ryu *et al.,* (2019) showed a significant association between a soft pancreas and a POPF on univariate analysis. Though, in the multivariate analyses, a soft pancreas was a dependent predictive threat aspect for a POPF[28]. Moreover, a meta-analysis explained that soft pancreatic texture was not a risk factor for a CR-POPF[29].

Recently, Sok *et al.,* (2024) reported that small-sized pancreatic duct and soft pancreatic tissue were related to POPF[30]. Many explanations have been suggested in other reports such as soft pancreas can't persist the materials of suture cut across pancreatic tissue, suture tension, failure of the anastomosis, and a soft pancreas is more prone to ischemic tension[29,31].

Also, pancreatic duct size has been identified as a predictive risk feature for POPF in many studies[30,32,33]. The most widely used cutoff value for the duct diameter related to the incidence of POPF was 3mm diameter[32,34].

Pancreatic duct size was measured either preoperatively by imaging or intraoperatively by the surgeon. The smaller ducts are more technically challenging for duct to mucosa anastomosis and more liable to be obstructed or disrupted leading to a pancreatic leak and fistula[35,36].

In a previous study, the patients having a small-sized pancreatic duct (≤0.3cm) had a higher incidence of pancreatic fistula (56.3%) than others with a larger pancreatic duct (>3mm) in whom a POPF occurred in 12.5%. Univariate analyses presented a significant difference between both groups (p= 0.001). Additionally, multivariate regression demonstrated pancreatic duct diameter as an independent risk issue of the POPF (p= 0.003)[20].

Also, we found that predictors of POPF were low serum albumin (odd's ratio (OR) was 2.11), soft pancreatic consistency with OR was 4.89 and small pancreatic duct with OR was 3.90. With ROC curve analysis, soft pancreatic consistency had 88% sensitivity, 83.3% specificity and 84.5% accuracy with area under curve was 0.85 for prediction POPF.

Meanwhile, small pancreatic duct had 75% sensitivity, 83.3% specificity and 81.2% accuracy with area under curve was 0.79 for prediction POPF. Also, it was found that low serum albumin had 63% sensitivity, 67% specificity and 66% accuracy with area under curve was 0.64 for prediction POPF

The study of Sok *et al.,* (2024) stated that POPF happened in 33 of 204 patients (16.2%). Pancreatic soft texture (OR 3.47, p= 0.012), in addition to the size of the pancreatic duct ≤0.3cm (OR 4.55, p= 0.01) as independent risk parameters for POPF following pancreaticoduodenectomy[30]. Hassan *et al.,* (2022) revealed that body mass index of >28, pancreatic soft texture, a small-sized pancreatic duct of ≤0.3 cm, as well as a high level of amylase in the drainage postoperative day 3 (>644IU) were independent risk aspects for POPF occurrence[20].

A negative strength of correlation was observed in the history of weight loss (OR 0.51), occurrence of pancreatitis (OR 0.43), low level of C-reactive protein postoperatively

(OR 0.50), in addition to large-sized pancreatic duct (OR 0.58). Highly positive power of correlation with the risk of occurrence of POPF was noted in patients with a pancreatic soft texture (OR 13.65). Patients with a pancreatic duct diameter <0.3cm had extreme odds (OR 12.89) of developing POPF[9].

Numerous limitations of the current research encountered that merit further observation. Firstly, consistency of the pancreas was evaluated at the discrimination of the surgeon, and was categorized as either soft or hard, rather than on a gradient as some others have illustrated. Nor do we possess any formal histopathology correlated to this estimation. Secondly, the relationship between intraoperative bleeding and the incidence of the fistula is inadequately implied and wasn't discussed during the present analyses.

It is assumed that excessive intraoperative bleeding triggers hypoperfusion, and consequently affects the restoration of the pancreatojejunostomy. Nevertheless, it is feasible that high fluid intake and excess blood transfusion may cause edema at the site of pancreatojejunostomy that may lead to the failure of anastomosis.

Finally, the study was accomplished in one institution with reasonably small size of sample that restricts the ability to draw a firm conclusion about the results. Any, yet prospective nature of the current study and being conducted in a higher tertiary center were points of strength.

CONCLUSION

Postoperative pancreatic fistula is a common serious complication in patient underwent pancreaticoduodenectomy. Patients with low albumin level, soft pancreatic tissue and small pancreatic duct are vulnerable to developing postoperative pancreatic fistula.

It's recommended to perform such study in large multiple centers with large number of patients to draw firm conclusion. A multicenter prospective study is recommended while exploring the influence of different techniques in pancreatoenteric anastomosis on developing postoperative pancreatic fistula because it requires a large number of cases

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCES

1. Bonsdorff A., Sallinen V. (2023). Prediction of postoperative pancreatic fistula and pancreatitis after pancreatoduodenectomy or distal pancreatectomy: A review. Scandinavian Journal of Surgery; 112:126-134.
2. El Amrani M., Clement G., Lenne X., Farges O., Delpero J-R., Theis D., *et al*. (2018). Failure-to-rescue in patients undergoing pancreatectomy: is hospital volume a standard for quality improvement programs? Nationwide analysis of 12,333 patients. Annals of surgery;268:799-807.
3. Nymo LS., Myklebust TA., Hamre H., Møller B., Lassen K. (2022). Treatment and survival of patients with pancreatic ductal adenocarcinoma: 15-year national cohort. BJS open; 6:zrac004.
4. Pedrazzoli S. (2017). Pancreatoduodenectomy (PD) and postoperative pancreatic fistula (POPF): a systematic review and analysis of the POPF-related mortality rate in 60,739 patients retrieved from the English literature published between 1990 and 2015. Medicine;96: e6858.
5. Hu B-Y., Wan T., Zhang W-Z., Dong J-H. (2016). Risk factors for postoperative pancreatic fistula: analysis of 539 successive cases of pancreaticoduodenectomy. World journal of gastroenterology; 22: 7797.
6. Zhang Biao, Yuan Qihang, Li. Shuang, Xu. Zhaohui, Chen Xu., Li. Lunxu, *et al*. (2022). Risk factors of clinically relevant postoperative pancreatic fistula after pancreaticoduodenectomy: A systematic review and meta-analysis. Medicine; 101: e29757.
7. Bassi Claudio, Marchegiani Giovanni, Dervenis Christos, Sarr Micheal, Hilal Mohammad Abu, Adham Mustapha, *et al*. (2017). The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 years after. Surgery; 161:584-591.
8. Nentwich Michael F., El Gammal Alexander T., Lemcke Torben, Ghadban Tarik, Bellon Eugen, Melling Nathaniel, *et al*. (2015). Salvage Completion Pancreatectomies as Damage Control for Post-pancreatic Surgery Complications: A Single-Center Retrospective Analysis. World Journal of Surgery; 39:1550-1556.
9. Adamu Mariam, Plodeck Verena, Adam Claudia, Roehnert Anne, Welsch Thilo, Weitz Juergen, *et al*. (2022). Predicting postoperative pancreatic fistula in pancreatic head resections: which score fits all? Langenbeck's Archives of Surgery; 407:175-188.
10. Grützmann Robert, Rückert Felix, Hippe-Davies Nele, Distler Marius, Saeger Hans-Detlev. (2012). Evaluation of the International Study Group of Pancreatic Surgery definition of post-pancreatectomy hemorrhage in a high-volume center. Surgery; 151:612-620.
11. Wolk Steffen, Grützmann Robert, Rahbari Nuh N., Hoffmann Ralf T., Plodeck Verena, Weitz Jürgen, *et al*. (2017). Management of clinically relevant postpancreatectomy hemorrhage (PPH) over two decades–A comparative study of 1 450 consecutive patients undergoing pancreatic resection. Pancreatology; 17:943-950.
12. Abd Elmesseh Anthony Nozhy, Allam Rasha Mahmoud,Elkordy Mohamed Atef. (2023). Predictors of Pancreatic Leak Post Pancreaticoduodenectomy. Retrospective Study. The Egyptian Journal of Hospital Medicine; 90:2429-2434.

13. Demir E., Abdelhai K., Demir IE., Jäger C., Scheufele F., Schorn S., *et al*. (2020). Association of bacteria in pancreatic fistula fluid with complications after pancreatic surgery. BJS open; 4:432-437.

14. Dhayat Sameer A., Tamim Ahmad NJ., Jacob Marius, Ebeling Georg, Kerschke Laura, Kabar Iyad, *et al*. (2021). Postoperative pancreatic fistula affects recurrence-free survival of pancreatic cancer patients. PLoS One; 16:e0252727.

15. Mcmillan Matthew T., Christein John D., Callery Mark P., Behrman Stephen W., Drebin Jeffrey A., Hollis Robert H., *et al*. (2016). Comparing the burden of pancreatic fistulas after pancreatoduodenectomy and distal pancreatectomy. Surgery; 159:1013-1022.

16. Perri G., Marchegiani G., Burelli A., Bassi C., Salvia R. (2021). High-risk pancreatic anastomosis vs. total pancreatectomy after pancreatoduodenectomy. Abstracts/Pancreatology; 21:S101.

17. Elmelegy Mohamed H., Ayoub Islam I., Elhady Ashraf ZEA., Aboushady Abdalla M, Mohamed Moharam AE. (2021). Risk factors for pancreatic fistula after pancreaticoduodenectomy. The Egyptian Journal of Surgery; 40:1412-1422.

18. Williamsson C., Stenvall K., Wennerblom J., Andersson R., Andersson B.,Tingstedt B. (2020). Predictive factors for postoperative pancreatic fistula—a Swedish nationwide register-based study. World journal of surgery; 44:4207-4213.

19. Wente Moritz N., Veit Johannes A., Bassi Claudio, Dervenis Christos, Fingerhut Abe, Gouma Dirk J., *et al*. (2007). Postpancreatectomy hemorrhage (PPH)–an international study group of pancreatic surgery (ISGPS) definition. surgery; 142: 20-25.

20. Hassan Ramy A., Zidan Ahmed, Jabir Murad A., Abdelshafy Mohamed, Abdallah Mariam,Taha Ahmed M.I. (2022). Risk factors predicting the development of a pancreatic fistula following pancreaticoduodenectomy: A retrospective cohort study. International Journal of Surgery Open; 45:100509.

21. Chen Ji-Ye., Feng Jian, Wang Xian-Qiang, Cai Shou-Wang, Dong Jia-Hong,Chen Yong-Liang. (2015). Risk scoring system and predictor for clinically relevant pancreatic fistula after pancreaticoduodenectomy. World journal of gastroenterology WJG; 21:5926.

22. Lee Seung Eun, Jang Jin-Young, Lim Chang-Sup, Kang Mee Joo, Kim Se Hyung, Kim Min-A, *et al*. (2010). Measurement of pancreatic fat by magnetic resonance imaging: predicting the occurrence of pancreatic fistula after pancreatoduodenectomy. Annals of surgery; 251: 932-936.

23. Fujiwara Yuki, Shiba Hiroaki, Shirai Yoshihiro, Iwase Ryota, Haruki Koichiro, Furukawa Kenei, *et al*. (2015). Perioperative serum albumin correlates with postoperative pancreatic fistula after pancreaticoduodenectomy. Anticancer research; 35:499-503.

24. Shah Surendra, Ghimire Bikal, Paudel Sharma, Singh Yogendra Prasad. (2020). Pancreatic Configuration Index in Predicting postoperative pancreatic fistula in a tertiary care center in Nepal.

25. Hong Jung Joo, Park Hyun Jeong, Lee Eun Sun, Kim Min Ju. (2024). Severity of hyperechoic pancreas on preoperative ultrasonography: high potential as a clinically useful predictor of a postoperative pancreatic fistula. Ultrasonography; 43:272.

26. Kawai Manabu, Kondo Satoshi, Yamaue Hiroki, Wada Keita, Sano Keiji, Motoi Fuyuhiko, *et al*. (2011). Predictive risk factors for clinically relevant pancreatic fistula analyzed in 1,239 patients with pancreaticoduodenectomy: multicenter data collection as a project study of pancreatic surgery by the Japanese Society of Hepato-Biliary-Pancreatic Surgery. Journal of Hepato-biliary-pancreatic Sciences; 18:601-608.

27. Takebayashi Takaaki, Watanabe Jota, Sakamoto Katsunori, Ogawa Kohei, Kitazawa Riko, Takada Yasutsugu. (2023). Association between preoperative pancreatic exocrine function and pathological evaluation with postoperative pancreatic fistulas following pancreaticoduodenectomy. Anticancer Research; 43:3563-3569.

28. Ryu Youngju, Shin Sang Hyun, Park Dae Joon, Kim Naru, Heo Jin Seok, Choi Dong Wook, *et al*. (2019). Validation of original and alternative fistula risk scores in postoperative pancreatic fistula. Journal of Hepato-Biliary-Pancreatic Sciences; 26:354-359

29. Vallance Abigail E., Young Alastair L., Macutkiewicz Christian, Roberts Keith J., Smith Andrew M. (2015). Calculating the risk of a pancreatic fistula after a pancreaticoduodenectomy: a systematic review. Hpb; 17:1040-1048.

30. Sok Caitlin, Sandhu Sameer, Shah Hardik, Ajay Pranay S., Russell Maria C., Cardona Kenneth, *et al*. (2024). Simple preoperative imaging measurements predict postoperative pancreatic fistula after pancreatoduodenectomy. Annals of surgical oncology; 31:1898-1905.

31. Callery Mark P., Pratt Wande B., Kent Tara S., Chaikof Elliot L., Vollmer Jr. Charles M. (2013). A prospectively validated clinical risk score accurately predicts pancreatic fistula after pancreatoduodenectomy. Journal of the American College of Surgeons; 216:1-14.

32. Braga Marco, Capretti Giovanni, Pecorelli Nicolò, Balzano Gianpaolo, Doglioni Claudio, Ariotti Riccardo, *et al*. (2011). A prognostic score to predict major complications after pancreaticoduodenectomy. Annals of surgery; 254: 702-708.

33. Yang Yin-Mo, Tian Xiao-Dong, Zhuang Yan, Wang Wei-Min, Wan Yuan-Lian,Huang Yan-Ting. (2005). Risk factors of pancreatic leakage after pancreaticoduodenectomy. World journal of gastroenterology: WJG; 11: 2456

34. Tajima Yoshitsugu, Kawabata Yasunari, Hirahara Noriyuki. (2018). Preoperative imaging evaluation of pancreatic

pathologies for the objective prediction of pancreatic fistula after pancreaticoduodenectomy. Surgery today; 48:140-150.

35. Harada Nobuhiro, Ishizawa Takeaki, Inoue Yosuke, Aoki Taku, Sakamoto Yoshihiro, Hasegawa Kiyoshi, *et al*. (2014). Acoustic radiation force impulse imaging of the pancreas for estimation of pathologic fibrosis and risk of postoperative pancreatic fistula. Journal of the American College of Surgeons; 219:887-894. e5.

36. Pande Rupaly, Halle-Smith James M., Thorne Thomas, Hiddema Lydia, Hodson James, Roberts Keith J., *et al*. (2022). Can trainees safely perform pancreatoenteric anastomosis? A systematic review, meta-analysis, and risk-adjusted analysis of postoperative pancreatic fistula. Surgery; 172:319-328.