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Original article

Fifteen years' experience of Distal Pancreatectomy in a Tertiary Center: Trends, Outcomes and Challenges

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ABSTRACT

Background: Distal pancreatectomy (DP) is a standard surgical approach for managing various benign and malignant pancreatic lesions. Despite advancements, postoperative pancreatic fistula (POPF) remains a significant complication, and there is ongoing debate surrounding optimal surgical techniques and stump closure methods. **Methods**: This retrospective study reviewed 110 patients who underwent DP at Mansoura University between 2010 and 2024. Data included demographics, clinical presentation, operative details, and postoperative outcomes. The primary focus was identifying risk factors for POPF using statistical comparisons between patients with and without POPF. **Results**: POPF occurred in 27.5% of cases, predominantly Grade A. Significant predictors of POPF included reduced pancreatic stump thickness (2.7 ± 1.2 mm vs. 4.2 ± 0.6 mm, $p < 0.0001$), lower pancreatic thickness-to-duct (P/D) diameter ratio (1.7 ± 0.7 vs. 2.7 ± 1.2, $p = 0.001$), use of energy-based division ($p = 0.01$), and failure to close the pancreatic duct ($p = 0.03$). Results suggested increased POPF risk was noted with anterior duct position and increased blood loss. Omental covering showed a non-significant trend towards reduced POPF. **Conclusions**: Thinner pancreatic remnants, lower P/D ratios, energy-based division, and duct non-closure are associated with increased POPF risk following DP. Recognizing these risk factors can guide surgical decision-making to improve outcomes.

Introduction

Distal pancreatectomy (DP) is a common procedure for various pancreatic conditions, including benign and malignant neoplasms and cystic lesions [1,2]. These pathologies, particularly pancreatic cancer, pose a significant clinical challenge due to their complex presentations, potential morbidity, and mortality [1]. While DP outcomes have improved, it remains a complex procedure with potential complications [3–6]. Postoperative pancreatic fistula (POPF) is a significant concern. Researchers investigate risk

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factors for POPF, including pancreatic characteristics, patient factors, and surgical techniques [7–9]. Minimally invasive DP, including robotic-assisted surgery, is also being explored [10]. However, the optimal surgical approach, especially pancreatic stump closure, remains debated.

Understanding factors contributing to DP complications is crucial for optimizing surgical strategies and improving outcomes. Studies examine POPF risk factors, including pancreatic characteristics, patient factors, and surgical techniques [7–9]. Minimally invasive DP is under investigation [10]. However, the optimal surgical approach, including minimally invasive surgery's role, remains debated. This paper presents our institutional DP experience, analyzing demographics, clinical presentations, techniques, and outcomes to identify complication risk factors and evaluate surgical strategy effectiveness, aiming to improve patient care.

Patients and Methods

Study Design

This study is a retrospective case series of patients who underwent distal pancreatectomy (DP) at the Gastrointestinal Surgery Center, Mansoura University, between January 2010 and January 2024. It was conducted in accordance with the ethical guidelines of the Declaration of Helsinki and was approved by the institutional review board (R.25.02.3081). Due to the retrospective nature of the study, informed consent was waived.

Patient Selection

All patients who underwent DP during the study period were initially considered for inclusion. Patients were identified from a prospectively maintained surgical database. The following **exclusion criteria** were applied:

1. Incomplete medical records (e.g., missing preoperative, operative, or postoperative data).
2. Concurrent major abdominal procedures unrelated to the pancreas (e.g., liver resection, gastrectomy).
3. Patients lost to follow-up within 30 days postoperatively.

Data Collection

Data were collected from electronic medical records and included the following:

- **Demographic and preoperative characteristics**: Age, sex, body mass index (BMI), clinical presentation, comorbidities (diabetes mellitus, hypertension, chronic obstructive pulmonary disease), smoking history, and preoperative imaging findings (tumor size, pancreatic duct status, liver status, and relation to surrounding vessels).
- **Operative data**: Surgical approach (open or laparoscopic), pancreatic consistency, tumor characteristics (size, nature, and location), pancreatic division technique, stump closure method, operative time, and estimated blood loss.
- **Postoperative outcomes**: Length of hospital stay, incidence and grade of postoperative pancreatic fistula (POPF), complications (classified using the Dindo–Clavien classification), and histopathological findings.

Surgical Technique

Distal pancreatectomy was performed using an open or laparoscopic approach, depending on the surgeon’s preference and patient factors. The pancreas was divided using a scalpel or energy-based devices. The pancreatic stump was closed with absorbable (Vicryl) or non-absorbable sutures (Prolene or Maxon), and the omental covering was performed in selected cases. Intraoperative decisions, such as the need for splenectomy or lymph node dissection, were made based on tumor characteristics and intraoperative findings.

Definitions and Outcome Measures

- **Postoperative pancreatic fistula (POPF)**: Defined and graded according to the International Study Group on Pancreatic Fistula (ISGPF) criteria as Grade A, B, or C.
- **Complications**: Classified using the Dindo–Clavien classification system.
- **Tumor pathology**: Diagnosed based on histopathological examination of the resected specimen.

Statistical Analysis

Categorical variables were expressed as frequencies and percentages, while continuous variables were expressed as means (± standard deviation) or medians (interquartile range), depending on the data distribution. As appropriate, comparisons between groups (e.g., patients with and without POPF) were performed using chi-square

tests, Fisher's exact tests for categorical variables, and Student's t-tests or Mann-Whitney U tests for continuous variables. A p-value of <0.05 was considered statistically significant. All statistical analyses were performed using SPSS 22.

Ethical Considerations

The study was conducted in compliance with ethical standards, and patient confidentiality was maintained throughout the data collection and analysis process. The study protocol was approved by the Institutional Review Board (R.25.02.3081):

Results

Patient Demographics and Preoperative Characteristics

A total of 110 patients underwent distal pancreatectomy. The mean age was 43.58 years (±16.51), and 69 (63%) were female. The mean BMI was 28.6 (±5.7) kg/m². The most common clinical presentation was abdominal pain (76%), followed by accidentally discovered lesions (17%) and non-specific digestive symptoms (9.1%). Associated comorbidities included diabetes mellitus (15%), hypertension (22%), and chronic obstructive pulmonary disease (8.2%). Most patients were non-smokers (81%), with 14% being smokers for less than 10 years and 5.5% for more than 10 years. Preoperative CT findings showed normal liver status in 73% of patients and a normal pancreatic duct status in 93%. The mean tumor size was 7.93 (±3.74) cm. 20.9% of tumors abutted the SMV, 6.36% the SMA, and 3.64% the CA. Most patients (63.64%) had no lymphadenopathy on preoperative CT.

Operative Data

Intraoperative findings were generally consistent with preoperative imaging. The mean tumor size was 8.54 (±4.15) cm. Pancreatic consistency was firm in 46% of cases and soft in 48%, with hard consistency observed in 5.5%. Cystic lesions were the most common (47.27%), followed by solid (32.73%) and mixed (16.36%) masses. The pancreatic division site was most commonly between the body and neck (50.1%), followed by the pancreatic body (38.18%) and the pancreatic neck (10%). The mean pancreatic stump thickness was 3.71 (±1.2) mm, and the mean pancreatic duct diameter was 1.78 (±0.82) mm. The mean operative time was 201.8 (±63.64) minutes, and the mean blood loss was 669.44 (±797.22) cc. The median units of blood transfusion were 0 (range 0-4).

Postoperative Data and Impact of Operative Variables on POPF

The mean hospital stay was 6.83 (±6.44) days. Postoperative pancreatic fistula (POPF) developed in 27.5% (n=19) of patients.

(POPF: postoperative pancreatic fistula, TPN: total parenteral nutrition, DCC: Dindo–Clavien classification, NHL: Non-Hodgkin lymphoma, GIST: Gastrointestinal stromal tumor, IPMN: Intraductal papillary mucinous neoplasia, MCN: Mucinous cystic neoplasia, SCN: Serous cystic neoplasia)

Significant Findings Related to POPF:

- **Pancreatic Margin Thickness:** Patients who developed POPF had a significantly thinner pancreatic margin (2.7 ± 1.2 mm) compared to those who did not (4.2 ± 0.6 mm) ($p < 0.0001$).
- **P/D Thickness Ratio:** The ratio of pancreatic margin thickness to duct diameter was also significantly different between the two groups. Patients with POPF had a lower ratio (1.7 ± 0.7) compared to those without (2.7 ± 1.2) ($p = 0.001$).
- **Division Technique:** The choice of division technique was significantly associated with POPF ($p = 0.01$). Energy-based division was associated with a higher rate of POPF, with 78.9% of the POPF group undergoing energy-based division compared to 46% of the no-POPF group.
- **Pancreatic Duct Closure:** Failure to close the pancreatic duct was significantly associated with a higher incidence of POPF ($p=0.03$). 89.5% of patients with POPF did not have their pancreatic duct closed, compared to 62% without POPF.
- **Position of Pancreatic Duct:** Anterior duct position appeared to be associated with a higher rate of POPF ($p = 0.1$), with 31.6% of the POPF group having an anterior duct compared to 12% of the no-POPF group.
- **Omental Covering:** There was a trend towards omental covering being associated with a lower rate of POPF ($p = 0.15$). 31.6% of the POPF group had omental covering compared to 16% of the no-POPF group.

- **Blood Loss:** Higher blood loss tended to be observed in the POPF group (p = 0.13), with a mean blood loss of 1073 ± 1093 cc in the POPF group compared to 713 ± 781 cc in the no-POPF group.

Liver status, ascites, distance to the left border of the SMV, tumor size, pancreatic division site, pancreatic consistency, and suture type did not show a statistically significant association with POPF.

Other Factors:

Table 1: Demographic and preoperative characteristics.

Age (years)	43.58 (±16.51)
Female sex	69 (63%)
BMI (kg/m^2)	28.6 (±5.7)
Clinical presentation:	
- Accidentally discovered	19 (17%)
- Abdominal pain	84 (76%)
- Non-specific digestive symptoms	10 (9.1%)
Associated co-morbidities:	
- DM	16 (15%)
- HTN	24 (22%)
- COPD	9 (8.2%)
Smoking:	
- Smoker for more than 10 years	6 (5.5%)
- Smoker for less than 10 years	15 (14%)
- Non-smoker	89 (81%)
Preoperative CT:	
- *Liver status:*	
• Normal	80 (73%)
• Fatty	17 (15%)
• Mild cirrhosis	13 (12%)
• Moderate to marked cirrhosis	None
- *Pancreatic duct status*	
• Normal	102 (93%)
• Dilated	8 (7.3%)
- Tumor size (cm)	7.93 (±3.74)
- Relation to surrounding vessels:	
• Abutting SMV	23 (20.9%)
• Abutting SMA	7 (6.36%)
• Abutting CA	4 (3.64%)
- Lymph node status:	
• No lymphadenopathy	70 (63.64%)
• Peri-pancreatic lymphadenopathy	29 (26.36%)
• Celiac lymphadenopathy	8 (7.27%)

(BMI: body mass index, DM: diabetes mellitus, HTN: hypertension, COPD: chronic obstructive pulmonary disease, CT: computerized tomography, SMA: superior mesenteric artery, SMV: superior mesenteric vein, CA: celiac axis).

Table 2: Operative data

Liver status:	
- Normal	84 (76%)
- Fatty	12 (11%)
- Mild cirrhosis	11 (10%)
- Moderate to marked cirrhosis	2 (1.8%)
Ascites:	
- No	105 (95%)
- Minimal to mild	5 (4.55%)
Tumor size (cm)	8.54 (±4.15)
Pancreatic consistency:	
- Firm	51 (46%)
- Soft	53 (48%)
- Hard	6 (5.5)
Nature of the mass:	
- Solid	36 (32.73%)
- Cystic	52 (47.27%)
- Mixed	18 (16.36%)
Pancreatic division site:	
• In pancreatic body	42 (38.18%)
• Between body and neck	56 (50.1%)
• At pancreatic neck	11 (10%)
Pancreatic stump thickness (mm)	3.71 (±1.2)
Pancreatic duct diameter (mm)	1.78 (±0.82)
P/D thickness ratio	2.91 (±1.37)
Pancreatic duct position:	
- Anterior	14 (12.73%)
- Central	37 (33.64%)
- Posterior	22 (20%)
Division technique:	
- Scalpel	46 (41.2%)
- Energy-based source:	36 (32.73%)
• Monopolar diathermy	27
• Ultrasonic dissector	9
- Stapler	27 (24.55)
MPD transfixion	6 (5.45%)
Stump closure technique:	
- Absorbable suture (Vicryl)	29 (26.36%)
- Non absorbable suture	56 (50.9%)
• Prolene	46
• Silk	10
- Combined	12 (10.9)
Omental covering	14 (11%)
Operative time (minutes)	201.8 (±63.64)
Blood loss (cc)	669.44 (±797.22)
Median units of blood transfusion	0 (0-4)

(SMV: superior mesenteric vein, MPD: main pancreatic duct, P/D thickness ratio: ratio of thickness of cut margin of the pancreas to the diameter of the main pancreatic duct).

Table 3: Postoperative data

Hospital stay (days)	6.83 (±6.44)
POPF	30 (27%)
Grade of POPF:	
- A	24 (80%)
- B	4 (13%)
- C	2 (6.7%)
Delay discharge for POPF:	
- No delay	80 (73%)
- Delay > 7 days	30 (27%)
Management of POPF:	
- Conservative	7 (23%)
- Aspiration	16 (53%)
- Tube drainage	5 (17%)
- Tube drainage and TPN	2 (6.7%)
Complications associated with POPF:	
- Secondary hemorrhage	1 (3.33%)
- Pneumonia	1 (3.33%)
- Infected abdominal collection	14 (46.67%)
- Ileus	8 (26.67%)
- Pleural effusion	7 (23%)
- Wound infection	10 (67%)
Complications other than POPF:	
- Pneumonia	2 (2.5%)
- Pleural effusion	2 (2.5%)
- Infected abdominal collection	3 (3.75%)
- Ileus	4 (5%)
- Mild wound infection	10 (13%)
- Internal hemorrhage	None
DCC of complications:	
- Grade I	11 (35%)
- Grade II	15 (48%)
- Grade IIIa	5 (16%)
- Grade IIIb	0
- Grade IV	0
- Grade V	0
Pathology:	
- Gastric NHL	1 (0.9%)
- Chronic pancreatitis	5 (4.5%)
- Colon adenocarcinoma	1 (0.9%)
- Neuroendocrine neoplasms	9 (8.2%)
- Fat necrosis	1 (0.9%)
- Gastric adenocarcinoma	1 (0.9%)
- Gastric GIST	3 (2.73%)
- Pancreatic GIST	2 (1.82%)
- IPMN	2 (1.82%)
- Lymphoepithelial cyst	2 (1.82%)
- MCN	24 (22%)
- Splenic NHL	1 (0.9%)
- Pancreatic duct adenocarcinoma	17 (15%)
- Perforated gastric ulcer	1 (0.9%)
- Pancreatic pseudocyst	8 (7.3%)
- SCN	10 (9.1%)
- Solid pseudopapillary tumor	19 (17%)
- Splenic artery aneurysm	1 (0.9%)
- Suprarenal cyst	1 (0.9%)
- Undifferentiated (sarcomatoid) carcinoma	1 (0.9%)

Discussion

This retrospective study of 110 distal pancreatectomies found a mean patient age of 43.58 years and a female predominance (63%), consistent with established trends for pancreatic lesions like solid pseudopapillary tumors (SPTs) and pancreatic neuroendocrine tumors (pNETs). A study by Reddy et al. (2009) showed that 89% of SPTs occurred in females, yielding a female-to-male ratio of 8.25 to 1, while Jilesen et al. (2016) demonstrated that female predominance of pNETs was 55% aligning with this cohort's demographics 11,12.

The primary clinical presentation was abdominal pain (76%). However, the substantial proportion of incidentally discovered lesions (17%) underscores the increasing sensitivity of modern imaging modalities.

The postoperative pancreatic fistula (POPF) rate of 27% in this series falls within the wide range reported in the literature, most of which were classified as Grade A (80%). This suggests a relatively benign clinical course requiring minimal intervention, which varies significantly depending on the definition of POPF, surgical technique, and patient selection. This finding may reflect advancements in surgical techniques and postoperative care 13.

The diverse pathological spectrum encountered in this series, including MCN (22%), pancreatic ductal adenocarcinoma (15%), SPT (17%), and neuroendocrine neoplasms (8.2%), reflects the broad range of pancreatic diseases managed with distal pancreatectomy 14. The operative details provide valuable insights into surgical decision-making and technical challenges. The distribution of pancreatic consistency and the nature of the mass significantly influence the choice of surgical technique and the likelihood of POPF. The mean pancreatic stump thickness of 3.71 mm and pancreatic duct diameter of 1.78 mm are critical factors influencing POPF risk.

A significant finding in this study was the association between pancreatic stump thickness and the P/D thickness ratio with POPF rates. Specifically, a thinner pancreatic stump and a lower P/D ratio were associated with a higher incidence of POPF ($p<0.05$). This suggests that achieving an adequate pancreatic stump thickness relative to the duct diameter is crucial for minimizing POPF. This study's P/D thickness ratio of 2.91 is consistent with findings suggesting a higher ratio may be protective against POPF. Moreover, Krueger CM et al. (2022) concluded that a cut-off D/P ratio of <0.2 was significantly associated with clinically relevant POPF 15.

Furthermore, this study found that the division technique significantly influenced POPF rates. Specifically, the use of staplers was associated with a higher incidence of POPF than scalpel division ($p<0.05$). This contrasts with some studies that have reported no significant differences in POPF rates between different division techniques 16,17. However, Kawai M et al. (2013) reported that stapler use was associated with higher rates of POPF, which is consistent with these findings 18. This discrepancy may be due to variations in surgical technique, stapler type, and patient selection across studies. The distribution of division techniques (41.2% scalpel, 32.73% energy-based, 24.55% stapler) reflects the ongoing debate regarding the optimal method for pancreatic transection. The low rate of MPD transfixion (5.45%) may indicate a preference for other stump management techniques. The predominant use of non-absorbable sutures (50.9%) for stump closure may contribute to a more robust closure.

Conversely, some variables that were not statistically significant in this study have been reported as significant in other research. For instance, while we did not find a significant association between pancreatic consistency (soft vs. firm) and POPF rates, other studies have suggested that a soft pancreas is associated with increased POPF risk 19,20. This may be due to the subjective nature of assessing pancreatic consistency and the potential for inter-observer variability. Complications other than POPF, such as wound infections (13%) and ileus (5%), are consistent with reported rates after major abdominal surgery.

This study's limitations include its retrospective design, single-center nature, and inherent heterogeneity of surgical techniques. Future prospective, multicenter studies with standardized protocols are needed.

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