



Pancreaticoduodenectomy with longitudinal pancreatojejunostomy for chronic pancreatitis with suspicious pancreatic head mass: our initial experience with open, laparoscopic, and robotic approaches

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Abstract

Introduction This study aims to evaluate the clinical outcomes of pancreaticoduodenectomy combined with longitudinal pancreatojejunostomy (PD-L) for chronic pancreatitis with a suspicious pancreatic head mass. We evaluated these derived surgical procedures with a focus on pain relief, functional preservation, and oncologic vigilance.

Methods This retrospective single-center cohort study analyzed clinical data from 20 consecutive patients diagnosed with chronic pancreatitis who underwent PD-L at the Hepatobiliary Surgery Department of the First Affiliated Hospital of Xi'an Jiaotong University between December 2021 and December 2024. We systematically analyzed perioperative parameters, morbidity profiles, and histopathological characteristics. Post-discharge monitoring focused on quantitative pain assessment, pancreatic exocrine and endocrine functional status, and surveillance.

Results The patients' cohort comprised 20 male patients (mean age 52.3 ± 10.1 years, range 32–70) who underwent PD-L procedures: open ($n = 15$), laparoscopic ($n = 3$), and robotic-assisted ($n = 2$) approaches. The mean operative time was (387.7 ± 75.1) minutes, with an average intraoperative blood loss of (286 ± 141.0) mL. The mean total length of hospital stay was (18.9 ± 4.6) days. Postoperative complications occurred in 2 patients: one case of abdominal hemorrhage requiring angiographic embolization and one case of delayed gastric emptying managed through endoscopic drainage. Notably, no pancreatic fistula were observed in any case. Pathology revealed chronic pancreatitis in 9 patients, PanIN in 9 (6 PanIN-1, 3 PanIN-2), and pancreatic cancer in 2. Preoperative comparisons between the CP group ($n = 9$) and the PanIN/malignant group ($n = 11$) showed no significant differences. Although considerable differences in the smoking index were observed between the two groups, they did not reach statistical significance ($p = 0.081$). During a median follow-up of 14.5 months, 78.9% (15/19) achieved sustained pain relief without the need for analgesics. Improvements in BMI and enhancements in glycemic regulation were observed in 6 and 5 patients, respectively.

Conclusion PD-L is a safe and effective surgical option for selected CP patients those with a space-occupying lesion in the pancreatic head that may raise suspicion of malignancy, concurrent with calculi-associated dilatation of the main pancreatic duct in the distal pancreatic body and tail segments.

Keywords Longitudinal pancreatojejunostomy · Chronic pancreatitis · Pancreatoduodenectomy

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Chronic pancreatitis (CP) represents a progressive fibro-inflammatory disorder characterized by a sustained pathological response to pancreatic injury or stress, driven by genetic, environmental, or other risk factors. Chronic inflammation leads to parenchymal atrophy, fibrosis, and intraductal calculi, resulting in the gradual loss of both exocrine and endocrine function. Clinical manifestations typically encompass a triad of persistent abdominal pain, diabetes mellitus, and nutrient malabsorption syndrome, with long-standing

cases carrying potential malignant transformation risks [1]. Contemporary therapeutic strategies emphasize early surgical intervention over repetitive endoscopic approaches, and advances in minimally invasive techniques, including laparoscopy and robotics, have further enhanced the safety and efficacy of surgical approaches. Current surgical paradigms prioritize two principal objectives: complete clearance of obstructive ductal calculi and anatomical restoration of pancreatic drainage pathways [2]. Duodenum-preserving pancreatic head resection and pancreatojejunostomy (DPPHR) are among the most commonly selected surgical approaches for chronic pancreatitis [3]. However, clinical decision-making faces significant challenges when confronting pancreatic head mass lesions with ambiguous malignancy potential. In such diagnostically equivocal cases where malignant transformation cannot be reliably excluded through preoperative evaluation, pancreaticoduodenectomy remains an imperative surgical consideration to ensure oncological safety [4].

To overcome the clinical challenges of CP complicated by the pancreatic head mass suspected of malignancy, concurrent with pancreatic duct dilatation and calculi in the body and tail of the pancreas, our center has proposed a modified surgical approach: pancreaticoduodenectomy combined with longitudinal pancreatojejunostomy (PD-L). This procedure enables en bloc resection of suspicious lesions and effective drainage of the remnant pancreas. This study conducts a comprehensive retrospective analysis of PD-L cases to systematically evaluate (1) postoperative complication profiles and pain management outcomes, and (2) longitudinal changes in pancreatic endocrine/exocrine functional status following PD-L. The investigation aims to establish evidence-based insights into the surgical strategy's capacity to address both oncological safety and functional preservation in this specific clinical management of chronic pancreatitis.

Data and methods

Patients' cohort

This study is a retrospective cohort study. The clinical data of 20 patients with chronic pancreatitis who were consecutively admitted to the Department of Hepatobiliary Surgery of our hospital from December 2021 to December 2024 and received PD-L treatment were retrospectively collected. These patients presented with the following clinical features: pancreatic head lesions suspicious for malignant transformation accompanied by characteristic distal pancreatic body/tail manifestations, including main pancreatic duct dilation with calculi formation (Fig. 1).

The study protocol received ethical approval from the Institutional Review Board (Approval

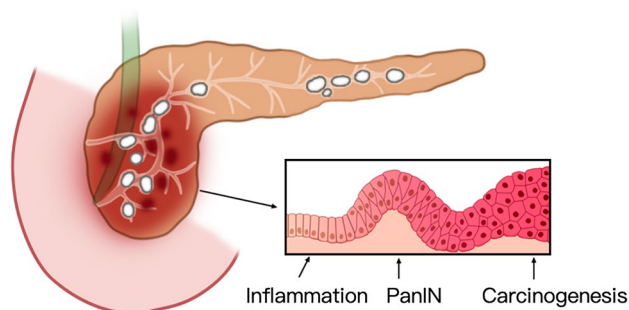


Fig. 1 Schematic diagram of pancreatic head mass, pancreatic duct stone, and pancreatic duct dilatation

No.XJTU1AF2015LSL-057) with waived informed consent due to the retrospective nature of data collection.

Indications and contraindications for PD-L

1. Indications (Fig. 2), all of the following criteria are fulfilled:

(1) Chronic pancreatitis (CP) complicated by:

The pancreatic head mass in which malignant was suspected;

And/or the presence of complications involving adjacent organs, such as biliary or gastrointestinal obstruction;

And/or multiple calcified stones in the pancreatic head- indicating the need for PD.

(2) Pancreatic ductal pathology characterized by:

Multiple segmental strictures and dilatations of the main pancreatic duct in the body and tail;

And/or the presence of multiple intraductal calculi, indicating the need for longitudinal pancreatojejunostomy (Partington-Rochelle procedure).

2. Contraindications:

(1) Non-candidacy for major abdominal surgery due to compromised systemic condition (e.g., severe cardiopulmonary insufficiency, uncorrectable coagulopathy);

(2) Calcification of the branch pancreatic ducts or parenchyma with a nondilated main pancreatic duct;

(3) Presence of a space-occupying lesion in the pancreatic body or tail with suspected malignant potential;

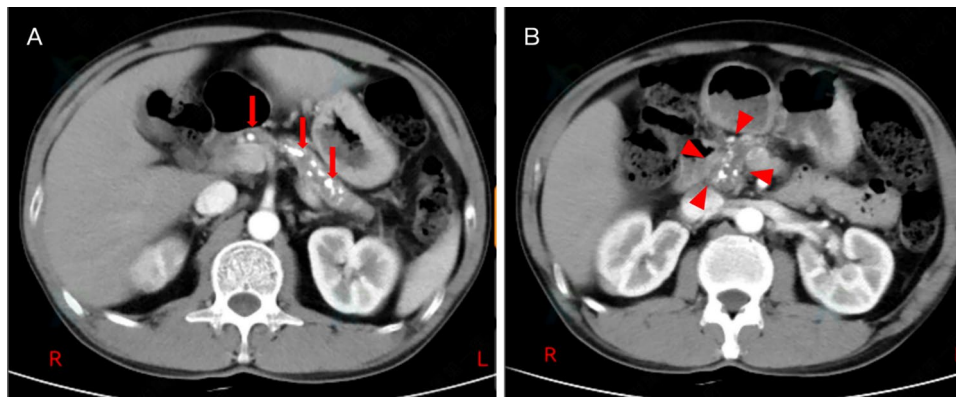


Fig. 2 Preoperative enhanced abdominal CT images of a patient with chronic pancreatitis and suspected malignant masses in the pancreatic head and pancreatic duct stones in the pancreatic body and tail: **A** shows multiple stones and calcifications in the pancreatic body and

tail, distal pancreatic duct dilatation (red arrow); **B** shows uneven enhancement in the pancreatic head area, pancreatic tumors cannot be excluded, and multiple stones can be seen in the uncinate process area (red triangle)

- (4) Severe portal hypertension secondary to chronic pancreatic inflammation (manifesting as gastroesophageal varices or splenic vein thrombosis).

Key points of PD-L operation (Fig. 3)

1. *Surgical approaches and radical resection* The surgical techniques employed comprised open surgery, laparoscopy, and robot-assisted procedures. Intraoperative exploration is performed to assess for distant metastasis and adjacent organ invasion. After standardized pancreaticoduodenectomy, resection margin status was confirmed through intraoperative frozen section analysis to ensure R0 resection. Regional lymphadenectomy was routinely performed as part of the standard surgical procedure.
2. *Pancreatic ductal decompression and reconstruction* Starting at the dilated main pancreatic duct at the pancreatic stump, the duct is longitudinally incised toward the tail of the remnant pancreas. The length of the ductotomy is typically 5 to 6 cm to ensure adequate decompression of the main pancreatic duct and facilitate the removal of intraductal stones from both the main duct and its branches. If necessary, an intraoperative ultrasound of the distal pancreas may be performed to localize residual calculi. Choledochoscopy with basket extraction was selectively employed to achieve complete ductal clearance. For reconstruction, the distal jejunum is mobilized, and a longitudinal incision is made approximately 3 cm proximal to the blind end on the mesenteric border. A single-layer continuous anastomosis is performed using absorbable sutures (barbed sutures were preferentially utilized in minimally invasive cases), approximating the jejunal seromuscular layer, pancreatic capsule, and a portion of the pancreatic parenchyma. Mucosa-to-mucosa anastomosis is not emphasized to avoid excessive penetration of the pancreatic tissue, which may compro-

mise the drainage of smaller branch ducts. Anastomosis begins from the caudal end; when reaching the pancreatic neck stump, ensure that the longitudinal jejunal incision adequately covers the stump to achieve an end-to-end anastomosis. The cranial side is sutured in the same fashion. Following cephalad suture continuation, meticulous inspection of the anastomotic integrity—particularly at the ventral junction—was performed. Critical reinforcement of wider suture intervals was implemented as needed to mitigate anastomotic leakage risk.

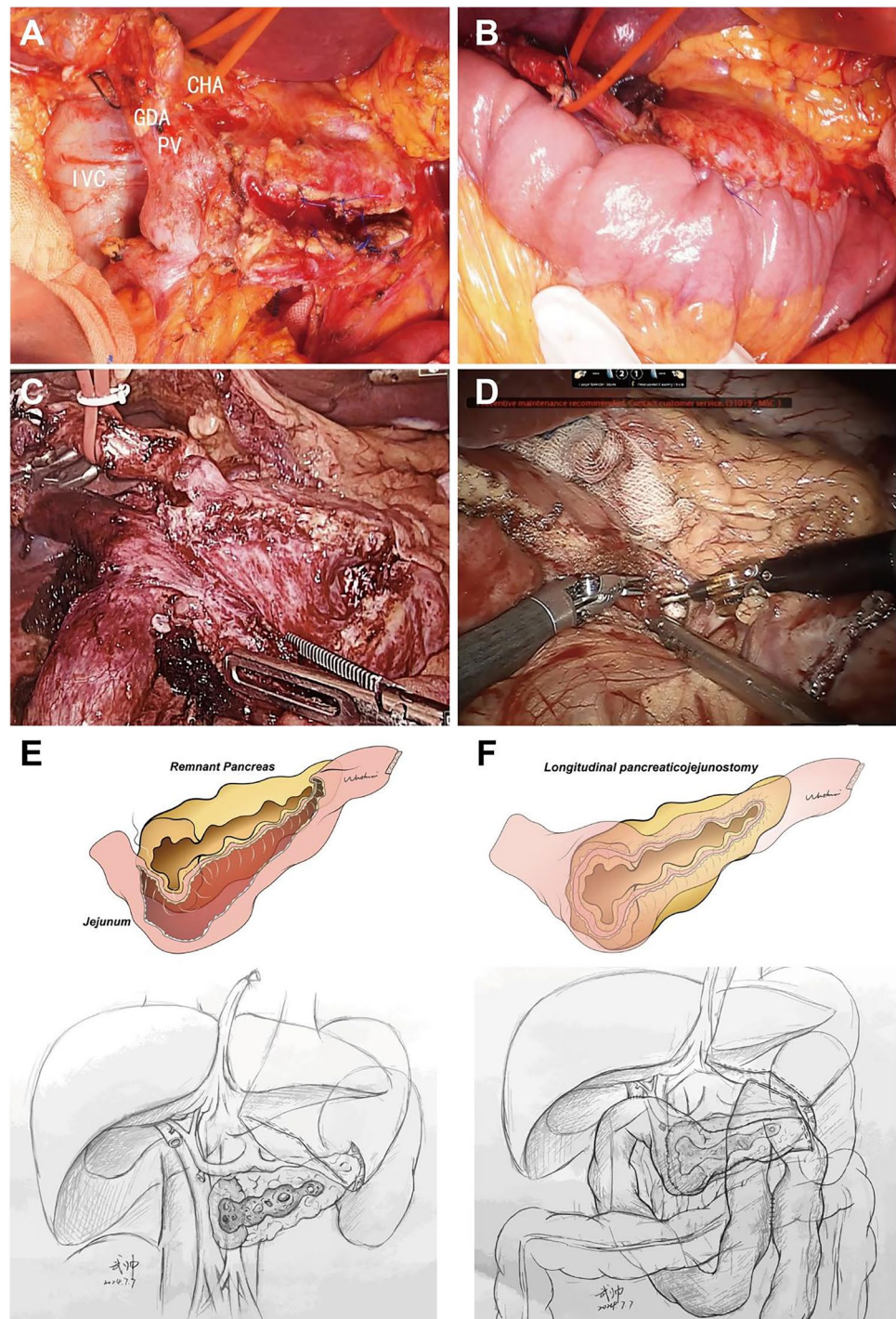
3. Bilioenteric and gastroenteric anastomoses are then performed following standard protocols. Drainage tubes are placed below the pancreaticojejunal anastomosis and within the left subhepatic space to monitor for potential postoperative complications.

Perioperative and postoperative evaluation

Perioperative complications and longitudinal follow-up data were systematically collected. The visual analogue scale (VAS) was employed to assess and compare preoperative and postoperative pain severity in patients with chronic pancreatitis. Postoperative pancreatic fistula, hemorrhage, and delayed gastric emptying were graded according to the criteria established by the International Study Group on Pancreatic Surgery (ISGPS) [5–7].

Pancreatic endocrine function was evaluated based on fasting blood glucose levels, glycated hemoglobin (HbA1c), and preprandial insulin dosage. Exocrine pancreatic function was assessed using body mass index (BMI), presence of abdominal distension, diarrhea, and steatorrhea (graded semi-quantitatively as –, +, ++, or +++), as well as the required dosage of pancreatic enzyme supplements.

Fig. 3 Intraoperative images and schematic diagrams of pancreaticoduodenectomy with longitudinal dissection and pancreatojejunostomy (PD-L). **A:** Longitudinal dissection of the residual pancreatic duct during open surgery. (green arrow: pancreatic duct). **B:** pancreatojejunostomy with longitudinal anastomosis of the residual pancreatic body and tail. **C:** Robotic view showing the longitudinally opened dilated distal pancreatic duct with an exposed stone. (green arrow: pancreatic duct; green circle: intraductal stones). **D:** Laparoscopic view. (green arrow: pancreatic duct; green circle: intraductal stones). **E:** Schematic diagram after specimen removal showing longitudinal dissection of the residual pancreatic duct, relief of ductal stenosis, stone removal, and subsequent jejunopancreatic duct anastomosis. **F:** Final schematic of the reconstructed digestive tract. (green arrow: pancreatic duct; green circle: intraductal calculi) Note: *GDA*, gastroduodenal artery; *CHA*, common hepatic artery; *PV*, portal vein; *IVC*, inferior vena cava; the green arrow indicates the opened duct; and the green circle marks the visible stone



A structured follow-up protocol was implemented, commencing with monthly structured telephone interviews post-discharge and supplemented by protocol-driven outpatient evaluations when clinically warranted. Follow-up assessments included evaluation of abdominal pain, endocrine and exocrine pancreatic function, and surveillance for tumor recurrence. The last follow-up period concluded in March 2025.

Statistical methods

Statistical analysis was conducted using SPSS 22.0 software. Normality was tested by the Kolmogorov–Smirnov method. Quantitative data that conformed to the normal distribution were presented in the form of $\bar{x} \pm s$, and the independent sample *t* test was used for comparison between the two groups; non-normally distributed variables were presented

in the form of M (IQR), and the Mann–Whitney U test was used for comparison between the two groups. Categorical data were presented as the number of cases (percentage), and the chi-square test with continuity correction was used for comparison between the two groups. All statistical tests were two-tailed; $P < 0.05$ was considered statistically significant.

Results

Clinical characteristics

All patients were male, aged (52.3 ± 10.1) years (range: 32–70 years). Seventeen patients had abdominal pain symptoms before surgery, 19 cases had a history of smoking, 9 cases had a history of pancreatitis, 10 cases had a history of diabetes (Table 1).

Surgical outcomes and postoperative complications

All patients successfully underwent surgical procedures, including 15 open surgeries, 3 laparoscopic surgeries, and 2 robotic-assisted surgeries. The mean operative time was (387.7 ± 75.1) minutes, with an average intraoperative blood loss of (286 ± 141.0) mL. The mean total length of hospital stay was (18.9 ± 4.6) days, and the mean postoperative hospital stay was (11.98 ± 4.0) days. No perioperative mortality was observed.

No cases of clinically relevant postoperative pancreatic fistula (POPF) were observed. Postoperative complications occurred in two patients. One patient developed postoperative abdominal hemorrhage, which was successfully managed with interventional embolization, allowing for subsequent discharge. Another patient experienced delayed gastric emptying, which resolved following endoscopic placement of a jejunal drainage tube combined with nutritional support. According to the Clavien-Dindo classification system, complications were graded as follows: Grade II in 1 patient, and Grade IIIa in 1 patient. No Grade I, Grade IIIb, IV, or V complications were reported.

Histopathological findings and comparative analysis

Among the 20 patients, final histopathological examination of the surgical specimens revealed CP in 9 cases. The remaining 11 cases showed CP with additional pathological changes: 9 patients had PanIN on a background of CP, including 6 cases of PanIN-1, 3 cases of PanIN-2, and 2 patients were diagnosed with pancreatic cancer concomitant with CP.

Based on the definitive pathological diagnoses, patients were categorized into two groups: the chronic pancreatitis group ($n = 9$) and the PanIN/malignant group ($n = 11$).

Preoperative characteristics were compared between the two groups (Table 2). The results indicated that patients in the Statistical analysis revealed no significant differences between the two groups in terms of age, abdominal pain, history of acute pancreatitis, smoking index, new-onset diabetes, or tumor markers. The smoking index is defined as the number of cigarettes smoked per day multiplied by the duration of smoking in years, a measure commonly used in Chinese clinical studies to quantify cumulative tobacco exposure. Although the smoking index showed borderline statistical significance ($p = 0.081$), this parameter exhibited notable clinical relevance. Notably, emerging evidence suggested that long-term heavy smoking may contribute to the development of PanIN and even malignant transformation.

Outcome of PD-L

Among the 20 patients who underwent PD-L, the median follow-up duration was 14.5 (7.8–16.8) months (range: 3–33 months). Regrettably, the first patient included in this study underwent surgery in December 2021 and was ultimately diagnosed with pancreatic cancer (T2N0M0) based on pathological findings. Despite receiving three cycles of adjuvant chemotherapy, the patient subsequently developed liver and lung metastases and was lost to follow-up during the COVID-19 pandemic. The second pancreatic cancer patient recovered without complications and was initiated on adjuvant modified FOLFIRINOX chemotherapy.

Preoperative and postoperative abdominal pain, body mass index, abdominal distension, steatorrhea, and pancreatic enzyme dosage are shown in Table 3. The abdominal pain after surgery was relieved in 78.9% (15/19) patients compared with that before surgery, and no analgesics were required after surgery. Body mass index improved in 31.5% (6/19) patients compared with that before surgery.

Postoperative endocrine function indicators of the 20 patients are shown in Table 4. Postoperative glycosylated hemoglobin and fasting blood glucose improved in 26.3% (5/19) of patients with diabetes.

Discussion

Over the past decade, comprehensive management strategies for CP have progressively shifted toward prioritizing early surgical intervention [8]. Accumulating high-level evidence now supports this approach: in patients with painful CP, early surgery has demonstrated superior outcomes in terms of long-term pain control and patient satisfaction compared to an initial endoscopy-first strategy, with benefits persisting over a follow-up period of approximately 8 years. Notably, patients who transitioned

Table 1 Preoperative characteristics, surgical procedures and histopathological findings in 20 patients undergoing PD-L for chronic pancreatitis

No	Gender	Age	Abdominal pain	History of acute pancreatitis	The smoking index	History of diabetes (months)	Diameter of the widest part of the pancreatic duct (mm) ^a	Ca19-9 (μmol/L)	CEA (ng/mL)	Surgical procedures	Histopathological findings	Operation time (min)	Intraoperative bleeding (mL)	Length of hospital stay (days)	Postoperative length of hospital stay (days)
1	Male	50	Yes	No	1 800	84	6.3	132.7	6.14	O	CP, PDAC	359	200	22	16
2	Male	59	Yes	No	300	48	7.6	192.9	10.3	R	CP	510	200	20	9
3	Male	32	Yes	Yes	800	No	7.5	27.6	2.01	O	CP, PanIN-1	345	200	22	11
4	Male	41	No	No	600	No	5.8	<0.6	5.93	O	CP	450	300	15	12
5	Male	50	Yes	Yes	450	4	10.8	37.5	9.41	O	CP	360	350	19	17
6	Male	70	Yes	No	800	No	8.5	1066	3.01	O	CP, PanIN-1	420	400	21	13
7	Male	46	Yes	No	400	No	12.1	72.8	3.13	O	CP	415	600	25	16
8	Male	54	Yes	Yes	400	36	14.0	108.7	3.88	O	CP, PanIN-1	375	100	21	17
9	Male	42	Yes	No	600	3	8.9	44.1	5.47	O	CP	345	100	27	17
10	Male	59	Yes	Yes	600	No	8.6	26.8	8.85	O	CP, PanIN-2	340	400	15	8
11	Male	36	No	No	300	18	6.1	31.3	8.1	O	CP	285	220	9	7
12	Male	65	Yes	No	800	No	27.7	24	5.26	O	CP, p-NET (G1), PanIN-1	360	300	20	11
13	Male	60	Yes	No	1200	No	11.4	203.8	5.65	O	CP, PanIN-2	360	300	26	20
14	Male	59	Yes	Yes	400	No	13.4	3.7	1.57	O	CP	300	500	15	8
15	Male	65	Yes	No	1000	6	10.8	10	5.09	L	CP	510	300	18	7
16	Male	53	Yes	Yes	600	36	12.5	26.7	3.21	O	CP, PanIN-1	480	400	16	11
17	Male	43	Yes	Yes	200	No	7.8	77	4.4	R	CP	510	100	21	9
18	Male	56	Yes	Yes	1200	24	5.1	161.2	5.08	O	CP, PanIN-2	350	150	18	9
19	Male	58	Yes	No	No	No	12.3	5.7	1.65	L	C, PanIN-1	390	200	16	8
20	Male	47	No	Yes	700	12	8.2	18.4	3.6	L	CP, PDAC	305	150	12	9

^aMeasured by preoperative imaging examination images; *O* open surgery, *L* laparoscopic surgery, *R* robotic-assisted surgery, *CP* chronic pancreatitis, *PanIN* pancreatic ductal intraepithelial neoplasia, *PDAC* pancreatic ductal adenocarcinoma, *p-NET* pancreatic neuroendocrine tumor

Table 2 Comparison of clinical characteristics in patients with CP group and PanIN/ PDAC group

	All patients (n = 20)	Subgroups		Statistics (Z or χ^2)	P
		CP (n = 9)	PDAC/PanIN (n = 11)		
Age				1.684	0.194
< 45	5	4	1		
≥ 45	15	5	19		
Abdominal pain				0.036	0.850
No	3	2	1		
Yes	17	7	10		
History of acute pancreatitis				1.961	0.161
No	11	7	4		
Yes	9	2	7		
Index of cigarettes smoked				3.039	0.081
< 600	8	6	2		
≥ 600	12	3	9		
New onset diabetes (with 2 years)				0	1.000
No	14	6	8		
Yes	6	3	3		
CEA	5.1 (3.2, 6.1)	5.5 (3.8, 8.8)	3.9 (3.0, 5.7)	- 1.178	0.239
CA199	34.3 (19.8, 126.7)	37.5 (6.9, 74.9)	27.6 (24.0, 161.2)	- 0.722	0.470

Table 3 Follow-up of pancreatic exocrine function results of 20 patients who underwent PD-L

	Follow-up time (months)	Preoperative pain score	Postoperative pain score	Use of postoperative analgesics	Preoperative body mass index (kg/m ²)	Postoperative body mass index (kg/m ²)	Abdominal bloating	Steatorrhea	Pancreatin ^b supplementation (mg/meal)
1 ^a	3	4	-	-	18.9	-	-	-	750 ^a
2	33	1	0	No	20.2	15.2	+++	++	300
3	21	4	1	No	17.3	17.3	+	+	450
4	20	0	0	No	21.0	20.3	++	++	450
5	19	1	0	No	19.5	20.8	-	-	300
6	17	2	0	No	17.7	17.4	-	-	450
7	16	0	0	No	19.1	17.1	-	+	450
8	16	5	0	No	23.7	24.6	-	-	300
9	15	4	0	No	17.8	17.6	-	+	300
10	15	1	0	No	17.1	18.1	-	-	300
11	15	0	0	No	18.4	19.2	-	-	450
12	14	5	1	No	18.7	19.4	-	-	600
13	12	3	1	No	24.5	24.5	-	-	600
14	12	3	0	No	23.0	23.0	-	-	150
15	12	4	1	No	23.0	24.0	-	+	0
16	10	4	0	No	23.0	23.0	++	-	0
17	7	6	0	No	19.4	19.0	-	+	600
18	5	3	1	No	23.0	21.6	++	+++	0
19	4	7	1	No	23.4	23.4	-	-	600
20	2	0	0	No	21.5	20.9	-	+	0

^aIndicates that the patient was lost to follow-up 3 months after surgery, and the data in the table are the data at the last follow-up; ^bPancreatic enzyme supplementation drugs are pancreatic enzyme enteric-coated capsules; the severity of abdominal distension and steatorrhea is recorded semi-quantitatively using -, +, ++, and +++; - indicates missing data

Table 4 Follow-up of pancreatic endocrine function results of 20 patients who underwent PD-L

	Follow-up time (months)	Preoperative			Postoperative		
		Glycated hemoglobin (%)	Fasting blood glucose (mmol/L)	Pre-meal insulin (IU)	Glycated hemoglobin (%)	Fasting blood glucose (mmol/L)	Pre-meal insulin (IU)
1 ^a	3	8.7	6~9	5	–	–	–
2	33	10.5	13~33	6	14.0	3~33	12
3	21	6.1	4~7	0	5.5	4~6	0
4	20	5.7	–	–	–	–	–
5	19	7.6	7~10	8	7.0	5~6	6
6	17	4.8	–	–	–	–	–
7	16	4.7	–	–	–	–	–
8	16	10.7	8~12	0	8.4	8~9	6
9	15	10.6	7~10	4	9.5	6~8	6
10	15	6.1	–	–	–	–	–
11	15	14.5	6~14	6	14.0	6~12	6
12	14	7.3	–	–	–	–	–
13	12	7.1	6~10	0	8.2	11	0
14	12	4.9	–	–	–	–	–
15	12	6.6	5~8	0	–	–	0
16	10	6.2	5~6	0	6.6	5~6	0
17	7	4.6	–	–	6.1	–	–
18	5	8.3	8~10	6	8.6	5	8
19	4	5.8	–	–	–	–	–
20	2	6.6	5~7	4	–	9	6

^aIndicates that the patient was lost to follow-up 3 months after surgery. The postoperative data in the table are the data at the last follow-up; – indicates missing data

from endoscopic therapy to surgery experienced poorer outcomes than those who underwent primary surgical intervention, and endoscopic duct clearance did not improve long-term prognosis [9].

From a pancreatic function preservation standpoint, DPPHR including the Beger and Frey procedures, remains a cornerstone in surgical treatment. Multiple studies have shown that DPPHR is associated with lower complication rates and mortality compared to conventional PD, while achieving similar improvements in pain relief and both endocrine and exocrine pancreatic function [10]. DPPHR is generally more suitable for conditions such as pancreatic cystic neoplasms and neuroendocrine tumors, which carry a significant risk of malignant transformation [11]. CP is recognized as a risk factor for the progression of pancreatic cancer. A retrospective study conducted in China, for instance, reported that among 650 patients, pancreatic cancer was identified in 12 individuals (1.8%) after a median follow-up of 4.4 years [12]. However, in cases where a malignant lesion in the pancreatic head is strongly suspected, pancreaticoduodenectomy remains the more appropriate surgical approach. Nevertheless, critical oncological considerations emerge when managing chronic pancreatitis cases presenting

with pancreatic head masses suspicious for malignancy. NCCN guidelines and expert consensus recommend proceeding with PD without awaiting definitive preoperative histological confirmation [13, 14]. Among the 20 patients in our cohort, three were preoperatively suspected of having pancreatic cancer. Postoperative pathological examination confirmed malignancy in two of these cases. Notably, one of the patients with confirmed malignancy had normal preoperative tumor markers, including CA19-9 and CEA. In contrast, another patient with a preoperative suspicion of malignancy exhibited markedly elevated CA19-9 levels; however, postoperative pathology revealed no evidence of cancer, and the elevation was ultimately attributed to suppurative pancreatitis. This patient's CA19-9 levels decreased significantly following surgical resection, further supporting the non-malignant origin of the elevation. After thorough multidisciplinary discussion and patient-family counseling, all cases underwent PD. Postoperative pathology revealed that 55% (11/20) of patients had PanIN or even PDAC. These findings underscore the potential risk of misdiagnosis or delayed cancer treatment if a parenchyma-preserving procedure like DPPHR is selected in such cases.

Chronic inflammation in the pancreatic body and tail can lead to sinistral portal hypertension and carries the same risks of dysplasia and malignant transformation [15]. In these patients, active surgical resection can not only alleviate left-sided portal hypertension but also remove premalignant lesions or achieve oncologic radicality when cancer is present. Some authors suggest that isolated pancreatic body and tail stones may be managed conservatively if asymptomatic, particularly given the endoscopic focus on extracorporeal shock wave lithotripsy (ESWL) and stone retrieval via ERCP [16]. However, persistent ductal stones are a key contributor to ductal hypertension, recurrent inflammation, and malignant transformation [17]. While recent advances in endoscopy have enabled some success in treating distal duct stones, these techniques remain technically challenging compared to surgical options [18]. In our modified PD-L, for patients with head-dominant disease plus distal ductal stones, the main pancreatic duct was opened longitudinally along its distal segment to extract stones and relieve strictures, similar to the Partington or Frey procedure. This not only ensured adequate ductal drainage but also improved stone clearance. Postoperative follow-up in our cohort showed significant reductions in pain scores and marked improvements in both exocrine and endocrine function. Specifically, body mass index increased in 31.5% (6/19) of patients compared to preoperative levels. Among patients with diabetes, postoperative glycated hemoglobin and fasting blood glucose improved in 26.3% (5/19). However, the assessment of pancreatic function in this study was limited by the heterogeneity in evaluation methods, missing data, and relatively short follow-up duration. These factors may affect the accuracy and reliability of interpreting functional outcomes. A standardized and longitudinal assessment in future studies is needed to draw more definitive conclusions. In fact, we observed that although the second patient experienced pain relief after surgery, there was no significant improvement in exocrine pancreatic function. Follow-up revealed that the patient had not been taking pancreatic enzyme supplements regularly. After initiating consistent pancreatic enzyme replacement therapy, the patient's symptoms markedly improved. Importantly, the ductotomy also provided an opportunity to excise and submit suspicious tissue for frozen section analysis. In one case, firm tissue adjacent to an obstructing stone was found to harbor cancer on frozen section, leading to a timely conversion to total pancreaticoduodenectomy. The strong association between chronic ductal obstruction, inflammation, and malignant progression highlights the value of intraoperative vigilance. Among our patients, 9 patients were found to have PanIN and two patients were confirmed as PDAC. Compared to CP patients, smoking index showed a trend toward significance ($p=0.081$). Notably, numerous previous studies have suggested that long-term heavy smoking may contribute to

the development of PanIN and even malignant transformation [19]. Interestingly, all 20 patients in this cohort were male, likely reflecting both the limited sample size and the higher smoking prevalence among Chinese men [20]. While this may align with local epidemiological patterns, it limits the generalizability of our findings to broader populations, including female patients and those in different geographic or demographic settings. This gender homogeneity should be considered when interpreting the applicability of our results.

One of the key concerns in pancreatic surgery is the risk of complications, particularly pancreatic fistula. Our previous comparison between PD-L and standard PD demonstrated no significant difference in operative time, despite the additional steps of ductotomy and stone clearance. Furthermore, there were no significant differences between the two groups in terms of clinically relevant pancreatic fistula, postoperative hemorrhage, intra-abdominal infection, or delayed gastric emptying. Notably, the PD-L group exhibited reduced intraoperative blood loss, shorter overall hospital stay, and shorter postoperative hospitalization compared to the standard PD group [21]. In the current study, the POPF rate was 0%, although this should be interpreted as CP-specific factors rather than intrinsic PD-L procedural superiority. The low risk may be attributed to two protective factors present in our cohort: the absence of soft pancreatic texture and the presence of a dilated duct, both of which are known to reduce POPF risk in CP patients [22]. We employed a single-layer, continuous, mucosa-to-mucosa pancreatojejunostomy using barbed or Prolene sutures. For narrow (<3 mm) distal ducts, we avoided ductotomy due to the anatomical proximity to splenic vessels and the increased complexity of anastomosis. While the Hamburg technique offers solutions for small-duct anastomosis, we did not attempt this in the current cohort [23]. Another study reported the 'Whip-Stow' modification in 10 patients undergoing surgery for premalignant or malignant pancreatic head lesions. The management of the pancreatic remnant, via pancreatojejunostomy, was consistent with our method, and resulted in no mortality, leaks, or postoperative bleeding. Although all operations were open, the outcomes further substantiate the safety of pancreatojejunostomy as a reconstructive technique [24].

This study provides a focused assessment of the PD-L procedure in CP, including operative details, pathology findings, complication rates, and postoperative functional outcomes. Its strengths include comprehensive intraoperative evaluation and prospective functional follow-up. However, limitations include the retrospective single-center design, limited sample size, and the lack of long-term outcome data. Nevertheless, we have initiated minimally invasive approaches, including five PD-L cases (two robot-assisted, three laparoscopic), demonstrating the feasibility of this technique. Preoperative imaging assessment remains essential in planning the approach and avoiding unnecessary

conversion. When surgical complexity is anticipated, upfront open surgery may be preferable.

Conclusion

PD-L represents a safe and effective surgical strategy for selected CP patients with combined pancreatic head disease, ductal dilation, and multiple distal stones. It combines oncologic radicality in the head with functional drainage of the distal duct, enabling both stone clearance and improved ductal outflow. Our results confirm high rates of pain relief, improved pancreatic function, and low postoperative morbidity. Our findings highlight PD-L as a key surgical option for treating complicated chronic pancreatitis in modern practice, particularly when balancing oncological concerns with disease management and functional preservation. Future multicenter trials are needed to compare these outcomes with alternative approaches.

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Declarations

Disclosures Mr. Xue Yang, Mr. Shuai Wu, Mr. Wanxing Duan, Mr. Jingpeng Zhao, Ms Wanzhen Wei, Mr. Kongyuan Wei, Mr. Qingyong Ma, Mr. Zheng Wu and Mr. Zheng Wang have no conflicts of interest or financial ties to disclose.

Ethical Approval All patients signed the patient informed consent form approved by the Ethics Committee of our hospital, and this study was approved by the Medical Ethics Committee of our hospital [Ethics Approval No.: 2015 Lunshenlinzi No. (057) XJTU1AF2015LSL-057].

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