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# Risk factors of textbook outcome in laparoscopic pancreatoduodenectomy: results from a prospective high-volume center study

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## Abstract

**Objective** Achieving textbook outcome (TO) implies a smooth recovery post-operation without specified composite complications. This study aimed to evaluate TO in laparoscopic pancreaticoduodenectomy (LPD) and identify independent risk factors associated with achieving TO.

**Methods** We conducted a retrospective analysis of data from a randomized controlled trial on LPD at West China Hospital (ChiCTR1900026653). Patients were categorized into the TO and non-TO groups. Perioperative variables were compared between these groups. Multivariate logistic regression was utilized to identify the risk factors.

**Results** A total of 200 consecutive patients undergoing LPD were included in this study. TO was achieved in 82.5% ($n=165$) of the patients. Female patients (OR: 2.877, 95% CI: 1.219–6.790; $P=0.016$) and those with a hard pancreatic texture (OR: 2.435, 95% CI: 1.018–5.827; $P=0.046$) were associated with an increased likelihood of achieving TO.

**Conclusions** TO can be achieved in more than 80% of patients in a high-volume LPD center. Independent risk factors associated with achieving TO included gender (male) and pancreatic texture (soft).

**Keywords** Laparoscopic pancreaticoduodenectomy, Textbook Outcome, High-volume center, Risk factors, Complications

## Introduction

Laparoscopic pancreaticoduodenectomy (LPD) is gaining increasing popularity worldwide [1]. In high-volume centers, LPD is recommended as a standard surgical approach for periampullary benign or malignant tumors [2]. Despite its growing acceptance, LPD remains a technically challenging procedure with high rates of postoperative complications [3, 4]. Assessing the quality of such complex surgeries is crucial. Previous studies have predominantly focused on individual outcome measures such as mortality, morbidity, and length of hospital stay (LOS) for quality assessments [5, 6]. However, these individual outcomes do not fully capture the entire recovery

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process, and composite measures may offer a more comprehensive comparison of hospital performance in surgical quality.

Textbook outcome (TO) is a composite outcome measure first described in 2013 by Dutch colorectal surgeons to provide a comprehensive summary of hospital performance [7]. Since then, TO has been widely adopted for quality assessment in various surgical procedures [8–10]. However, the definitions of TO differ across surgical specialties [11, 12]. In 2020, van Roessel et al. proposed a definition of TO specific to pancreatic surgery [13]. While there have been studies on TO in open pancreatic surgery, data on TO in LPD remain scarce [14]. Furthermore, our center is a high-volume institution, performing over 1,400 LPDs [2, 15]. The objective of this study was to assess TO among patients undergoing LPD and identify independent factors associated with achieving TO in a high-volume center.

## Methods

### Study design and cohort

This study utilized data from a randomized controlled trial (RCT) (ChiCTR1900026653, www.chictr.org.cn) conducted by the Department of Pancreatic Surgery at West China Hospital, Sichuan University. This large-sample, single-center RCT employed a 1:1 allocation ratio to investigate the clinical outcomes of pancreaticojejunostomy without pancreatic duct stenting in LPD [16]. The inclusion and exclusion criteria for the study are detailed in Table 1. Between November 2019 and November 2022, a total of 200 consecutive patients were enrolled in the RCT. All patient data were collected prospectively for analysis. The study received approval from the Biomedical Research Ethics Committee of West China Hospital, Sichuan University, on October 4, 2019 (approval number 2019(1180)).

### Perioperative monitoring [17]

All patients underwent computed tomography angiography to confirm the clinical diagnosis and determine tumor resectability. Additional routine examinations included blood tests, liver and renal function tests, tumor marker evaluations, electrocardiograms, and chest computed tomography. Selective percutaneous transhepatic biliary drainage was performed for patients with severe jaundice. Postoperatively, the nasogastric tube was removed one day after surgery, and oral intake was progressively resumed as tolerated. Blood tests and concurrent analysis of amylase levels in drainage fluid were conducted on postoperative days 1, 3, and 5 to monitor for pancreatic fistula formation. A chest and abdominal computed tomography scan was performed on postoperative day 4 to evaluate the chest and abdominal cavity. Drainage tube removal was based on amylase levels, drainage volume, and fluid characteristics. Early tube removal was considered if amylase levels were below 5000 U/L and drainage volume was less than 300 mL. Patients were discharged upon tolerating oral intake and moderate activity, without abnormal postoperative complications or laboratory findings.

### Surgical technique[17]

Patients were positioned supine with legs apart. Under general anesthesia, pneumoperitoneum was established with a $CO_2$ pressure of 12–14 mmHg. Trocar placement involved a 10 mm trocar for laparoscopy inserted below the umbilicus, two 12 mm trocars along the left midclavicular line, one 5 mm trocar along the right anterior axillary line below the costal margin, and one 12 mm trocar inserted along the right midclavicular line at the umbilical level. The procedure began with fully exploring the abdominal cavity to confirm the absence of metastases. The gastrocolic ligament was dissected below the gastroepiploic vessels using an ultrasonic dissector. This was followed by mobilization of the hepatic flexure of the colon and the third portion of the duodenum from the

**Table 1** Eligibility criteria in the RCT

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|---|
| Inclusion |
| Aged 18–75 years old; |
| Patients with surgical indication with no history of chemotherapy and radiotherapy; |
| Normal cardiopulmonary function; |
| Good physical condition and Karnofsky score ≥ 70; |
| Classified by the American Society of Anesthesiologists (ASA) physical status classification scheme of classes I–III; |
| Signed informed consent. |
| Exclusion |
| Conversion to laparotomy due to various reasons during operation; |
| The pancreatic duct could not be found during the operation; |
| Pregnant and lactating women or family planning patients of childbearing age; |
| Severe heart, liver, and kidney dysfunction; |
| Patients with mental disorder or history of mental disorder and unable to cooperate autonomously; |
| Participants in other clinical trials within three months; |
| Any other situation in which the researcher believes that the subject is unable to participate in the experiment. |

mesocolon. The Kocher maneuver was performed up to the anterior portion of the aorta. The superior mesenteric vein (SMV) was identified by tracing Henle's trunk at the inferior pancreas border. The right gastroepiploic vessels were identified and ligated with clips. The distal stomach was transected 2–3 cm from the pylorus using an endoscopic linear stapler. Cholecystectomy was performed, and the hepatoduodenal ligament was skeletonized. The bile duct was transected at the common hepatic duct level. The gastroduodenal artery was identified, double-ligated with clips, and transected. The jejunum was transected 15–20 cm distal from the Treitz ligament using a linear stapler. The pancreatic neck was transected with ultrasound shears and the pancreatic duct was transected with scissors. The uncinate process was dissected from the superior mesenteric vessels, with large tributary vessels clipped. The specimen was placed in a retrieval bag and extracted through a 5 cm extended umbilical site. Reconstruction comprised pancreatojejunostomy, hepaticojejunostomy, and gastrojejunostomy in that order. Pancreatojejunostomy involved a two-layer duct-to-mucosa anastomosis using Bing's anastomosis. Approximately 10 cm distal to the anastomosis, an end-to-side hepaticojejunostomy was performed. Antecolic gastrojejunostomy was performed 40–45 cm downstream from the hepaticojejunostomy. Operative drains were placed routinely: one in Morrison's pouch, one near the hepaticojejunostomy, and one each superior and inferior to the pancreatojejunostomy.

#### Bing's anastomosis

Bing's anastomosis is a duct-to-mucosa pancreatojejunostomy technique that we have previously detailed in our publications [18]. This method can be performed with or without the placement of a pancreatic duct stent and involves four layers of sutures [16]. Initially, a running suture using 4−0 Prolene is made between the posterior wall of the pancreatic stump and the seromuscular layer of the jejunum. A plastic stent, sized to match the diameter of the pancreatic duct, is then inserted into the main pancreatic duct, and a corresponding hole is created in the jejunum. For the second layer, a 5−0 PDS is used to create a figure-eight suture between the posterior wall of the main pancreatic duct and the full thickness of the jejunum. The stent is inserted into the jejunal hole, and in the internal stent group, it is secured with 5−0 PDS. In the third layer, another 5−0 PDS is used to make a running suture between the anterior wall of the main pancreatic duct and the anterior wall of the jejunum. In the internal stent group, the knot is tied, whereas in the no stent group, the stent is removed, and knots are tied intermittently. For the fourth layer, the same 4−0 Prolene used in the first layer is employed for a running suture between the anterior wall of the pancreatic stump and the seromuscular layer of the jejunum. Finally, the knot is tied to close the space between the jejunum and the pancreatic stump. This technique ensures secure anastomosis and minimizes the risk of leakage and other complications.

#### Variables and definitions of TO

The complications were graded into mild (I-II) and severe complications (≥III) according to the Clavien–Dindo classification [19]. The pancreatic surgery-related complications such as postoperative pancreatic fistula (POPF) and post-pancreatectomy hemorrhage (PPH) were defined by the International Study Group on Pancreatic Surgery (ISGPS) [20, 21]. Bile leakage was defined according to international Study Group of Liver Surgery (ISGLS) [22]. TO was defined as the absence of PPH, POPF, bile leakage (all ISGPS or ISGLS grades B/C), severe complications (Clavien–Dindo grade≥III), in-hospital or 30-day mortality, readmission within 30 days after discharge according to Roessel et al [13].

#### Data analysis

The percentage of patients achieving TO was calculated. Preoperative and intraoperative variables were compared between the TO and non-TO groups. For continuous data following a normal distribution, the results were expressed as mean (standard deviation) and compared using the Student's t-test. For continuous data not following a normal distribution, the results were expressed as median (interquartile range) and compared using the Mann–Whitney U test. Categorical variables were presented as numbers and percentages, and comparisons were made using Pearson's $\chi 2$ test or Fisher's exact test. Univariate and multivariate logistic regression analyses were performed to evaluate the factors associated with achieving TO, with results presented as odds ratios (OR) and 95% confidence intervals (CI). Variables with a $P$ value less than 0.05 in the univariate analysis were included in the multivariate analysis. All analyses were conducted using SPSS version 24.0. Two-tailed P values less than 0.05 were considered statistically significant.

## Results

Among the 200 patients who underwent LPD, TO was achieved in 165 (82.5%) patients. Figure 1 presents the results for the six individual outcome metrics. The least frequently realized TO outcome metric was "no POPF (ISGPS grades B/C)" (90.0%), followed by "no Clavien–Dindo grade≥III complications" (92.5%), while the most frequently realized metrics were "no mortality" and "no bile leakage" (99%).

Table 2 shows the baseline characteristics of patients who did and did not achieve TO. Significant differences were observed between the TO and non-TO groups

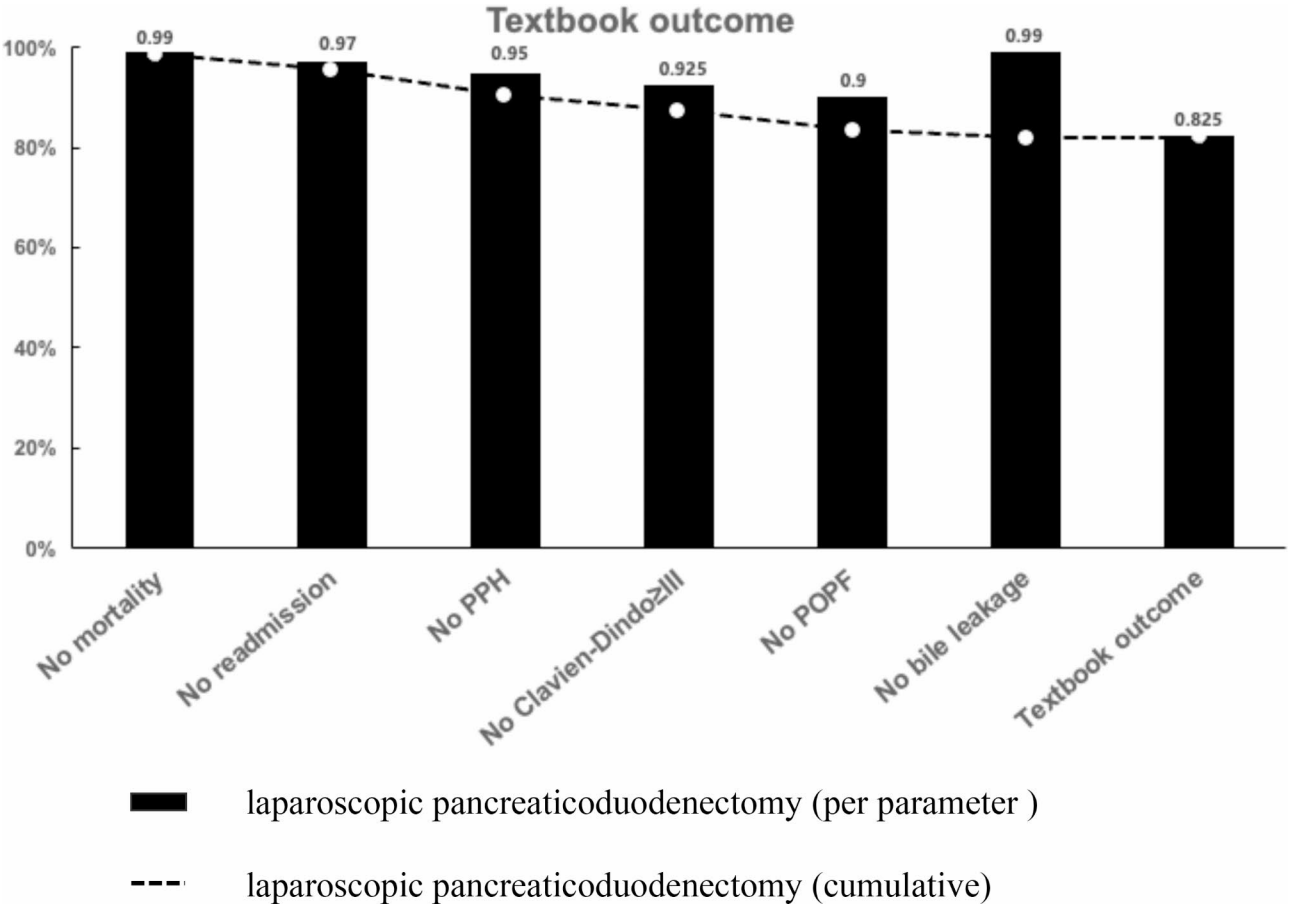


**Fig. 1** Textbook outcome: a composite measure of outcome parameters after laparoscopic pancreaticoduodenectomy in the entire cohort. PPH, post pancreatectomy hemorrhage. POPF, post-operative pancreatic fistula (ISGPS grades B/C)

in terms of sex, activated partial thromboplastin time (APTT), creatinine levels, pancreatic texture, diameter of the main pancreatic duct (MPD), diagnosis, and postoperative hospital stays (all $P<0.05$). Other factors did not show significant differences (all $P>0.05$).

Univariate and multivariate analyses identified female sex and hard pancreatic texture as independent factors associated with achieving TO among patients undergoing LPD (Table 3). Specifically, female patients (OR: 2.877, 95% CI: 1.219–6.790; $P=0.016$) and patients with a hard pancreatic texture (OR: 2.435, 95% CI: 1.018–5.827; $P=0.046$) had an increased probability of achieving TO. The forest plot of the logistic regression analysis factors is shown in Fig. 2.

## Discussion

LPD, a highly intricate procedure, demands meticulous quality assessment due to its complexity. The most prevalent composite outcome measure for quality assessment is TO [8–10]. However, the definition of TO varies among surgeries, often encompassing the absence of morbidity and mortality, a short LOS, and no readmissions. Although an international expert consensus defined TO for pancreatic surgery in 2020 [7], data specifically addressing LPD remain scarce [14]. In line with this definition, 82.5% of LPD patients in our center achieved TO, surpassing rates reported in previous articles on both open and laparoscopic pancreaticoduodenectomy [14, 23]. Notably, our study identified several factors independently associated with achieving TO, including soft pancreatic texture and male gender. Previous studies have linked soft pancreatic texture and male gender to POPF, a key component of TO after pancreaticoduodenectomy [24–27]. The identification of these factors holds significance for perioperative management, underscoring the need for heightened attention to male patients or those with soft pancreatic texture.

Patients failing to achieve TO exhibited prolonged LOS compared to those who did. While the absence of prolonged LOS wasn't initially included in the TO definition by van Roessel et al. [7], it's commonly included in other surgical procedures [7] was most commonly included in other surgical procedures [8–10]. Despite a low bile leakage rate in our experience and others (1.6% in 550

**Table 2** Baseline characteristics of patients with or without achieving textbook outcome after laparoscopic pancreaticoduodenectomy

| Variables | TO (+) (*n* = 165, 82.5%) | TO (-) (*n* = 35, 17.5%) | *P* |
|---|---|---|---|
| Age (years)* | 59.6(9.4) | 57.4(13.2) | 0.338 |
| Sex (M) (n, %) | 88 (53.3%) | 26(74.3%) | **0.023** |
| BMI (kg/m$^2$) * | 22.6(3.2) | 23.0(3.6) | 0.542 |
| ASA score | | | 0.724 |
| II (n, %) | 108(65.5%) | 24(68.6%) | - |
| III (n, %) | 57(34.5%) | 11(31.4%) | - |
| APTT† | 27.1(25.7–28.9) | 28.3(26.3–30.3) | **0.029** |
| PT† | 11.4(10.8–12.1) | 11.5(11.0-12.3) | 0.453 |
| Hemoglobin (g/L) * | 122.2(21.8) | 128.7(23.5) | 0.114 |
| Albumin (g/L) * | 39.5(5.3) | 38.8(4.5) | 0.439 |
| Creatinine (μmol/L) † | 64.0(56.0–78.0) | 69.0(62.0–82.0) | **0.043** |
| Total bilirubin (μmol/L) † | 16.1(10.1–97.3) | 16.9(8.7-121.8) | 0.922 |
| Biliary drainage (n, %) | 32(19.4%) | 8(22.9%) | 0.642 |
| Tumor size (cm)† | 2.8(2.0-3.6) | 2.5(2.0-3.5) | 0.501 |
| OT (min)* | 305.3(69.3) | 307.0(75.8) | 0.896 |
| EBL (mL)† | 100.0(100.0-200.0) | 150.0(100.0-200.0) | 0.078 |
| Blood transfusion (n, %) | 14(8.5%) | 5(14.3%) | 0.456 |
| Time of PJ (min)† | 22.0(17.5–29.5) | 21.0(18.0–28.0) | 0.553 |
| MPD stent (Y) (n, %) | 86 (52.1%) | 15(42.9%) | 0.319 |
| Pancreatic texture | | | **0.005** |
| Soft (n, %) | 80(48.5%) | 26(74.3%) | - |
| Hard (n, %) | 85(51.5%) | 9(25.7%) | - |
| Diameter of MPD (mm)† | 4.0(3.0–5.0) | 3.0(2.0–4.0) | **0.027** |
| Postoperative hospital stays (d) | 15.8(8.2) | 29.0(14.0) | **< 0.001** |
| Diagnosis (n, %) | | | |
| Duodenum cancer | 7(4.2%) | 5(14.3%) | **0.002** |
| Pancreatic cancer | 61(37.0%) | 3(8.6%) | |
| Distal biliary duct cancer | 14(8.5%) | 5(14.3%) | |
| Ampullary cancer | 33(20.0%) | 3(8.6%) | |
| Pancreatic cystic tumors | 24(14.5%) | 9(25.7%) | |
| Chronic Pancreatitis | 11(6.7%) | 5(14.3%) | |
| Others§ | 15(9.1%) | 5(14.3%) | |
| Pathological outcomes (n, %) | | | 0.098 |
| Malignant | 126(76.3%) | 22(62.9%) | - |
| Benign | 39(23.6%) | 13(37.1%) | - |

The bold value indicates statistical significance $P < 0.05$; Values are *mean(s.d.) and †median (i.q.r.); TO (+), textbook outcome positive; TO (-), textbook outcome negative; BMI, body mass index; ASA score, American Society of Anesthesiologists classification score; APTT, activated partial thromboplastin time; PT, prothrombin time; M, male; Y, yes; OT, operation time; EBL, estimated blood loss; PJ, Pancreaticojejunostomy; MPD, main pancreatic duct; *P*: TO (+) vs. TO (-);[§]Others, neuroendocrine tumor, gastrointestinal stromal tumor (GIST), teratoma, etc.

**Table 3** Univariate and multivariable logistic regression analysis of factors associated with textbook outcome after laparoscopic pancreaticoduodenectomy

| Patient Variables | Univariate analysis | | Multivariate analysis | |
|---|---|---|---|---|
| | OR (95% CI) | *P* value | OR (95% CI) | *P* value |
| Sex (female) | 2.528(1.116–5.724) | **0.026** | 2.877(1.219–6.790) | **0.016** |
| Biliary drainage (Yes) | 0.812(0.337–1.954) | 0.642 | | |
| Blood transfusion (Yes) | 0.556(0.186–1.661) | 0.293 | | |
| MPD stent (Yes) | 1.451(0.695–3.030) | 0.321 | | |
| Pancreatic texture (Hard) | 3.069(1.356–6.950) | **0.007** | 2.435(1.018–5.827) | **0.046** |
| Diameter of MPD (> 3 mm) | 2.667(1.185–5.99) | **0.018** | 2.323(0.945–5.705) | 0.066 |
| Pathological outcomes (Malignant) | 1.909(0.880–4.140) | 0.102 | | |

The bold value indicates statistical significance $P < 0.05$; MPD, main pancreatic duct

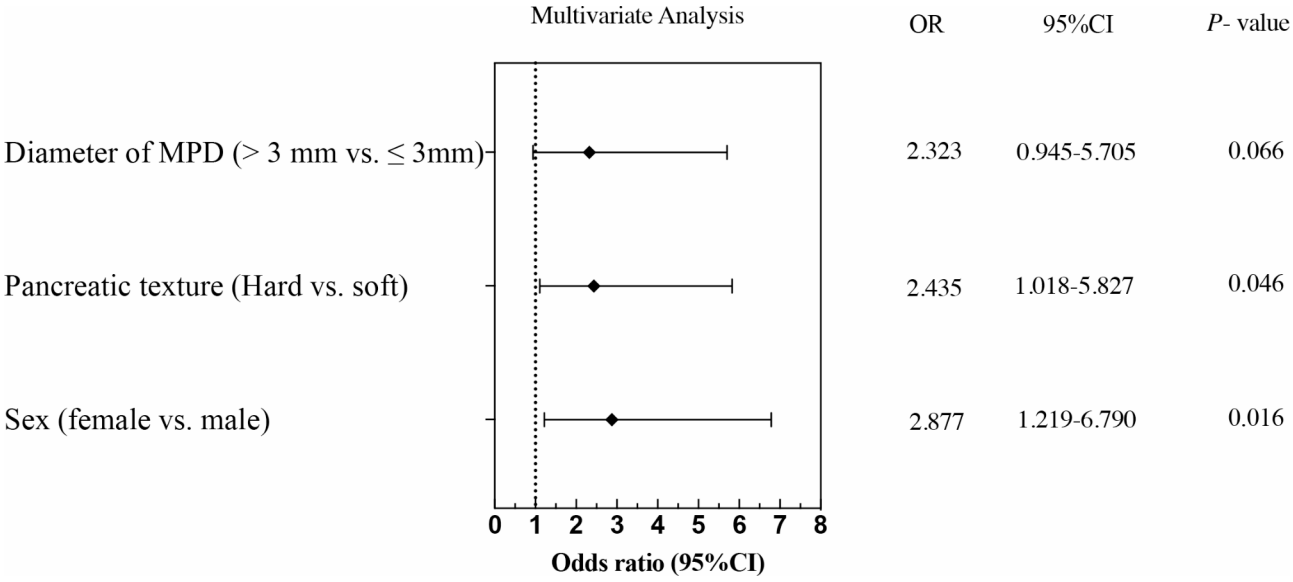


**Fig. 2** Forest Plot of Logistic Regression Analysis Factors Associated with the Textbook Outcome in Laparoscopic Pancreaticoduodenectomy. MPD, main pancreatic duct

patients, 1% in 200 patients, and 0.6% in 500 patients) [2, 14, 28]. it may not be apt for LPD quality assessment, as supported by previous studies [14]. Consequently, we substituted "absence of bile leakage" with "no prolonged LOS (LOS<75th percentile)" to better reflect postoperative recovery. However, only 133 (66.5%) patients achieved the modified TO [Supplementary material: Fig. S1], with the major hindrance being "no prolonged LOS." Prolonged hospital stay encompasses various factors such as biliary or chylous leaks, abdominal infections, distension, and poor diet, all contributing to an extended stay. Choosing "no prolonged length of stay" as a target outcome allows for a comprehensive evaluation of postoperative recovery, factoring in complications, patient health status, and postoperative care strategies. These considerations are vital as they not only prolong LOS but also escalate hospitalization costs and medical burden.

This study has limitations, notably its single-center design, potentially leading to selection bias. Nonetheless, being a high-volume center with extensive LPD experience lends credibility to our findings [2, 29]. Data were prospectively collected from a large cohort within an RCT conducted from November 2019 to November 2022, enhancing the realism and reliability of results. Inclusion and exclusion criteria are outlined in Table 1, with only 35 patients excluded, suggesting generalizability of results [16]. However, long-term follow-up data are lacking, precluding observation of whether patients achieving TO exhibit better long-term outcomes, including pancreatic insufficiency, biliary-enteric anastomotic stenosis, and survival rates. Future research directions should focus on multi-center, prospective, and longer-term studies.

## Conclusions

TO can be achieved in more than 80% of patients in a high-volume LPD center. Independent risk factors associated with achieving TO include male gender and soft pancreatic texture.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-024-02529-6.

Supplementary Material 1

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### Author contributions

HC, FL, PG, YC, and BP designed and wrote the study. MZ and YL collected the data. XW, LM, and YC analyzed the data. All authors read and approved the final manuscript.

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### Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

## Declarations

### Ethics approval and consent to participate

The study was approved by the Ethics Committee of Sichuan University (approval number 2019(1180), and it satisfies the Declaration of Helsinki standard. Informed consent was obtained from all participants.

### Consent for publication

Not applicable.

**Competing interests**
The authors declare no competing interests.

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