Original Article

The efficacy and safety of single-incision plus one-port laparoscopic surgery *vs.* conventional five-port laparoscopic surgery for duodenum-preserving pancreatic head resection

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Background: Single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection (SILDPPHR+1) is yet to be reported, and therefore, its safety and efficacy have yet to be established. This study aimed to assess the short-term efficacy of SILDPPHR+1 in comparison to conventional laparoscopic duodenum-preserving pancreatic head resection (cLDPPHR).

Methods: Consecutive patients who underwent SILDPPHR+1 and cLDPPHR procedures were screened. An analysis of the intraoperative and postoperative data of all patients was carried out.

Results: Nineteen patients who underwent SILDPPHR+1 and 24 patients who underwent cLDPPHR at Sichuan Provincial People's Hospital from October 15, 2021, to October 30, 2023, were enrolled in this study. All baseline parameters of both groups were comparable. There was a statistically significant difference in the cosmetic score between the groups (P<0.001). No statistically significant differences were observed between the two groups regarding postoperative recovery, postoperative pancreatic fistula (POPF), bile leakage rate, delayed gastric emptying (DGE) rate, postpancreatectomy hemorrhage (PPH) rate, abdominal infection rate, or textbook outcomes.

Conclusions: SILDPPHR+1 appears to be a reliable and safe procedure for certain patients, with no increase in the operating time or complications, similar to the results of cLDPPHR. Moreover, SILDPPHR+1 offers the added advantage of superior cosmetic results.

Keywords: Laparoscopy; single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection (SILDPPHR+1); cosmetic result; duodenum-preserving pancreatic head resection (DPPHR); minimally invasive surgery

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Introduction

Benign tumors of the pancreas are being detected more frequently due to the increased utilization of advanced cross-sectional imaging techniques for the diagnosis of abdominal ailments. These entities can either be clinically apparent or asymptomatic. In high-volume centers, pancreatic cystic and neoplastic lesions have a prevalence of 8% in the adult population of Western countries (1). The most common pathologies include intraductal papillary mucinous neoplasm (IPMN), serous

cystadenoma (SCA), mucinous cystic neoplasm (MCN), pancreatic neuroendocrine neoplasm (pNEN) and solid pseudopapillary neoplasm (SPN) (2). IPMNs and SPNs are predominantly located in the pancreatic head, and they are predominantly found in males and young females, respectively. pNENs are discovered in approximately 2% of all pancreatic tumor patients. The detection rate of pNENs, which include functional and nonfunctional neoplasms, is on the rise owing to the frequent usage of high-resolution imaging diagnostics (3).

For benign tumors located in the head of the pancreas, surgical risk can be minimized by exclusively excising the affected portion. In 1985, Beger introduced the concept of duodenum-preserving pancreatic head resection (DPPHR) (4). Since then, due to the development of laparoscopic pancreatic surgery, there has been an interest in performing laparoscopic DPPHR (LDPPHR) (5-8). Unfortunately, biliary leakage occurs occasionally, and studies have revealed high rates of bile leakage, ranging from 11.8% to 16.7% (5-8). This greatly limits the use of LDPPHR due to the risk of damaging the bile ducts, which are embedded in the pancreas and cannot be directly visualized. Lu *et al.* introduced the use of indocyanine green (ICG) fluorescence imaging to visualize bile ducts during surgery (9). This technique allows for the real-time detection and prevention of bile duct injuries.

With the advancement of medical technology and the increasing popularity of minimally invasive procedures, the use of single-port laparoscopy is becoming more widespread in surgical practice. In comparison to traditional multiport laparoscopy, single-port laparoscopy offers several benefits, such as the potential for better outcomes, reduced loss of hemoglobin during surgery, impressive cosmetic results, and a lower risk of postoperative complications (10,11). Single-incision laparoscopic surgery (SILS) has become popular due to its favorable clinical outcomes and positive cosmetic results. Prior studies have shown that single-port appendectomy, cholecystectomy, and bariatric surgery are performed worldwide (12,13). However, the restricted space for manipulating instruments and mutual interference increase operative complexity, leading to limited use of single-port laparoscopic procedures, especially in pancreatic surgery (14,15). In this instance, an added 12-mm trocar is used as the primary operating port (known as "+1") to facilitate the execution of this intricate surgical procedure. To our knowledge, this is the first study to compare surgical outcomes between single-incision plus one port LDPPHR (SILDPPHR+1) and five-port conventional LDPPHR (cLDPPHR). We present this article in accordance with the STROBE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-24-200/rc).

Highlight box

Key findings

- Single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection (SILDPPHR+1) appears to be a reliable and safe procedure for certain patients.

What is known and what is new?

- For benign tumors located in the head of the pancreas, duodenum-preserving pancreatic head resection is safe and feasible.
- We report for the first time of SILDPPHR+1 and confirm its safety and feasibility.

What is the implication, and what should change now?

- SILDPPHR+1 appears to be a reliable and safe procedure with no increase in operating time or complications, and also has the advantage of a better cosmetic result. It can be performed discreetly in high-volume centers for specific populations.

Methods

Study population

From October 15, 2021 to October 30, 2023, 43 patients with masses in the pancreatic head who underwent SILDPPHR+1 or cLDPPHR at Sichuan Provincial People's Hospital were enrolled in this study. The inclusion criteria comprised patients aged between 18 and 75 years, patients diagnosed with a benign pancreatic head tumor, and patients with complete clinical information. The exclusion criteria encompassed patients with malignant pancreatic tumors and patients with an American Society of Anesthesiologists (ASA) score of four or higher. The study collected data on relevant demographics, laboratory examinations, peri-surgical conditions, and clinical outcomes. If there was a high suspicion of tumor malignancy or lymph node metastasis, we do not perform DPPHR. All surgeries were conducted by the same doctor (Y.Z.) using a standard surgical technique and facility. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics board of Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China (No. 2023-189) and informed consent was taken from all the patients.

SILDPPHR+1 surgical procedure

Before surgery

Before surgery, 20 mg ICG was injected through the central vein. The patient was placed in the supine position with the arms abducted and legs spread. The operating surgeon stood at the patient's left side during the entire surgical phase, the assisting surgeon stood at the patient's right side, and the laparoscope assistant stood between the patient's legs. The anesthesiologist and the assisting nurse were located on the head side and near the assisting surgeon, respectively.

Trocars layout

A transverse incision measuring 3–5 cm was made in the paraumbilical region. Then, a commercial multichannel port (Beijing Hang Tian KaDi Technology R&D Institute, Beijing, China) was inserted into the established incision to provide the instruments with an adequate range of motion. An additional 12-mm trocar was inserted in the region of the lower 3 cm of the coastal arch along the middle clavicular line on the left side. The surgeon employed an ultrasonic scalpel for separation, resection, and anatomical procedures using their right hand through the additional trocar. Additionally, for stretching, laparoscopic instruments were utilized with the left hand via the 5-mm trocar in the homemade or commercial multichannel port. The laparoscopic assistant used a 30-degree rigid laparoscope for maximal visualization through the 10 mm trocar.

Surgical procedure

We first explored the abdominal cavity to rule out tumor metastasis and dissected the gastrocolic ligament. If suspicious lymph nodes are discovered during intraoperative exploration, we will change the surgical approach based on the frozen section pathology results. The stomach was then suspended from the falciform ligament using rubber tubing and Hem-o-Lok clips. The gastrocolic ligament is opened during the initial stages of the procedure. This involves dissecting the gastrocolic ligament to access the lesser sac and fully expose the pancreatic head and duodenum. By carefully cutting through the gastrocolic ligament, we can mobilize the stomach and create an optimal surgical field. The transverse mesenteric anterior lobe and hepatic flexure of the colon were dissected to fully expose the pancreatic head and duodenum without dissection using the Kocher's maneuver. Henle's trunk and the right gastroepiploic vein (RGV) were located and ligated. To reveal the superior mesenteric vein (SMV), the capsule of the pancreas was incised at the lower extremities of the pancreatic neck. A retro-pancreatic tunnel was subsequently formed, and the pancreatic neck was amputated using an ultrasonic scalpel, followed by meticulous transection of the main pancreatic duct using cold scissors.

Pancreatic head dissection was performed from the duodenal inner edge and right and ventral edges of the common bile duct (CBD). The main branch of the inferior pancreaticoduodenal artery (IPDA) was carefully identified and preserved along with the posterior superior pancreaticoduodenal artery (PSPDA) identified at the dorsal edge of the CBD. The branches of the PSPDA entering the distal CBD and the ampulla were also carefully preserved. When approaching the area around the CBD, the fluorescent laparoscope was opened to avoid damaging the CBD. Identification of the CBD proved relatively easy, aided by a fluorescence guide. We can expose the CBD starting from the ampulla of the duodenum or from the angle between the gastroduodenal artery (GDA) and the portal vein, as the bile duct positions in these two locations are relatively fixed. The primary artery supplying the pancreatic portion of the CBD is the PSPDA. There is usually a portion of pancreatic tissue between the PSPDA and the CBD. Therefore, most domestic experts recommend preserving this portion of pancreatic tissue to protect the blood supply from the PSPDA to the CBD. However, some domestic experts suggest completely removing this portion of pancreatic tissue, including only the vascular network on the surface of the CBD. This is currently the most controversial aspect of LDPPHR. Indeed, preserving this portion of pancreatic tissue may increase the incidence of pancreatic fistula, but whether completely suspending and exposing the CBD will lead to long-term bile duct stricture requires studies with larger sample sizes to confirm. The space between the pancreatic parenchyma and the CBD was then examined by moving the pancreatic parenchyma to the right. The CBD was then separated by dissection, working closely with the dorsal pancreatic parenchyma. The sphincters of the CBD and the ampulla were carefully explored. After identifying the pancreatic duct surrounding the ampulla, the primary and secondary pancreatic ducts were dissected, ligated, and transected. After completing the resection of the pancreatic head, we administered 10 mg ICG through the central vein to confirm the blood supply of the duodenum and CBD. *Figures 1*,*2* show the results.

Data collection and definitions

Data on patient demographics, tumor characteristics,

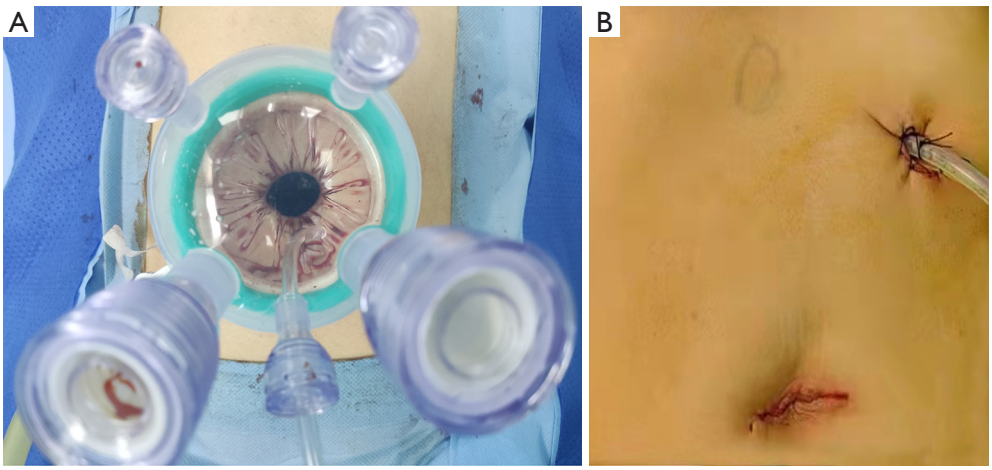

Figure 1 Demonstration of the patient's abdominal surgical site with postoperative incisions. (A) The single-port's position. The principal operating apertures are through which the left-hand instruments for the lead surgeon. The laparoscopic lens, and the right-hand instruments for the assistant are introduced. (B) The incision and drainage tubes post operation, which showed minimally invasive incisions.

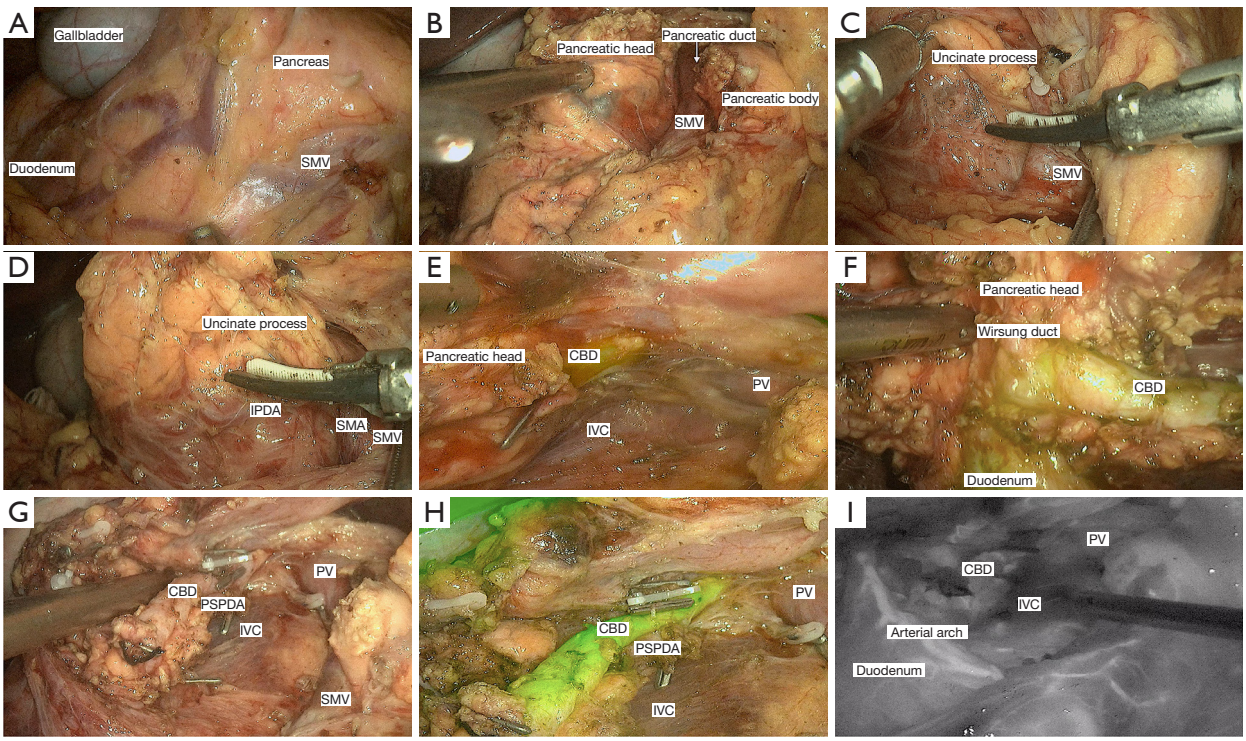

Figure 2 Representative procedure of SILDPPHR+1. (A) Exposure of the pancreas and SMV. (B) Transect the pancreatic neck and main pancreatic duct. (C) Dissect the dorsal pancreatic head. (D) Dissect the uncinate process. (E) Dissect the pancreatic head from the CBD. (F) Dissect, ligate, and cutoff the Wirsung duct. (G-I) Images of the CBD and arterial arch after completion of laparoscopic total pancreatic head resection. SMV, superior mesenteric vein; IPDA, inferior pancreaticoduodenal artery; SMA, superior mesenteric artery; CBD, common bile duct; PV, portal vein; IVC, inferior vena cava; PSPDA, posterior superior pancreaticoduodenal artery; SILDPPHR+1, single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection.

perioperative outcomes, and clinicopathological factors were collected for analysis. Patient demographics included age, sex, body mass index (BMI), ASA score, comorbidities, and preoperative laboratory test results. Tumor characteristics comprised tumor type and tumor diameter. Perioperative outcomes included the following: operative time, estimated blood loss, the visual analog scale (VAS) score at baseline, postoperative day (POD) 3 and POD 7, postoperative pancreatic fistula (POPF), and the delayed gastric emptying (DGE), postpancreatectomy hemorrhage (PPH), transfusion, conversion, postoperative recovery, bile leakage, and abdominal infection rates.

For the definitions and criteria for POPF (16), DGE (17), and PPH (18), we adopted those set out by the International Study Group of Pancreatic Surgery (ISGPS). Complications were assessed based on the Clavien-Dindo classification system (19). Pain intensity was evaluated using the VAS with a score range of 0–10, where 0 indicated no pain and 10 indicated the worst possible pain (20). The textbook outcome was defined as surviving hospitalization, radical resection, no further interventions, no colostomy, no negative outcomes, and discharge within 14 days of hospitalization (21). The cosmetic score was evaluated by the doctor based on specific criteria. A score of 1 indicated no cosmetic problems, while a score of 5 indicated easy detection of such problems. Notably, a lower score indicated fewer cosmetic issues.

Statistical analysis

To compare the different variables between the SILDPPHR+1 and cLDPPHR groups, we performed Fisher's exact test, the χ^2 test, and the Wilcoxon test. Statistical significance was considered at a two-tailed P<0.05. The statistical analyses were performed using SPSS version 25.

Results

A total of 43 patients were enrolled in the study, included 19 who underwent SILDPPHR+1 {median [interquartile range (IQR)] age, 54 [43–61] years and 9 (47.4%) male} and 24 who underwent cLDPPHR {median [IQR] age, 56 [47.8–65.3] years and 11 (45.8%) male}. *Table 1* summarizes the demographics and characteristics of all patients. There were no significant differences between the two groups in age and sex distribution, tumor size, BMI, or ASA score. Hypertension, diabetes mellitus, and a history of previous surgery were present in both groups of patients, but there was no significant difference between the two groups. Leukocyte, hemoglobin, platelet, serum albumin, total bilirubin, and prothrombin time values were within the normal range in both groups. The data from the two groups were comparable. The two most common cases comprised IPMN and SCA.

The perioperative outcomes are shown in *Table 2*. The groups displayed similar median operative times {median [IQR], 290 [265–320] *vs.* 285 [260–311.3] min, P=0.59}, estimated blood loss {median [IQR], 80 [57.5–100] *vs.* 100 [90–140] mL, P=0.16}, conversion rates [1 (5.3%) *vs.* 2 (8.3%)], and postoperative hospital stays (POHSs) {median [IQR], 14 [11–16.5] *vs.* 14 [12–15] days, P=0.91}. No statistically significant differences were observed between the two groups regarding postoperative recovery, the bile leakage rate, the DGE rate, the PPH rate, the abdominal infection rate or the textbook outcome. Both patients with POPF had grade B pancreatic fistulas and experienced symptoms such as fever and abdominal pain. Postoperative computed tomography (CT) scans indicated abdominal fluid collections, and CT-guided catheter drainage was performed. However, a statistically significant difference in cosmetic scores existed between the two groups {median [IQR], 2 [1–2] *vs.* 3 [3–3], P<0.001}.

In terms of patient-reported outcomes, pain reported using the VAS {1 [0–2] *vs.* 1 [0–2], P=0.77} and the change from baseline were similar between the groups on POD 3 {3 [2–3.5] *vs.* 3.5 [3–5], P=0.10} and POD 7 {2 [1–2] *vs.* 2 [1–3], P=0.23] (*Figure 3*). Moreover, we compared the amylase levels in the drainage fluid of the two groups. *Figure 4* indicates the absence of any significant differences between the two groups in the amylase levels in drainage fluid on POD 1 (P=0.67) and POD 3 (P=0.17).

The rate of conversion to open surgery was also determined. For one patient (1/19, 5.3%) in the SILDPPHR+1 group, the procedure was converted to five-port laparoscopic surgery (cLDPPHR) due to bleeding and was based on intention-to-treat (ITT) principles for the SILDPPHR+1 group. Similarly, for two patients (2/24, 8.3%) in the cLDPPHR group, the procedure was converted to open surgery based on ITT principles for the cLDPPHR group.

Discussion

Since minimally invasive surgery was first introduced, surgeons have sought to perform safe procedures with

Table 1 Demographic characteristics of the two groups

Parameters	SILDPPHR+1 (n=19)	cLDPPHR (n=24)	P
Age (years)	54 [43–61]	56 [47.8–65.3]	0.53
Sex			0.76
Female	10 (52.6)	13 (54.2)	
Male	9 (47.4)	11 (45.8)	
BMI (kg/m^2)	22.5 [20.4–24.4]	23.3 [21.3–24.5]	0.24
ASA score			0.92
I	2 (10.5)	3 (12.5)	
II	13 (68.4)	15 (62.5)	
III	4 (21.1)	6 (25.0)	
Comorbidities			
HTN	6 (31.6)	7 (29.2)	>0.99
DM	2 (10.5)	3 (12.5)	>0.99
History of abdominal surgery	2 (10.5)	1 (4.2)	0.58
Laboratory examination			
WBCs (×10^9/L)	7.7 [5.3–8.9]	7.7 [5.7–8.7]	0.97
HGB (g/L)	125 [113.5–134.5]	119.5 [111.3–131.8]	0.47
PLTs (×10^9/L)	152 [132–173]	135.5 [110.5–162.5]	0.20
ALB (g/L)	38 [37–41]	37 [35–41]	0.26
TBIL (μmol/L)	21 [16.5–23]	19.5 [16–23.5]	0.76
PT (s)	11.3 [11–21.1]	11.8 [11–12.3]	0.66
Diagnosis			0.91
IPMN	6 (31.6)	8 (33.3)	
SCA	6 (31.6)	6 (25.0)	
MCN	2 (10.5)	5 (20.8)	
pNEN	3 (15.8)	3 (12.5)	
SPN	2 (10.5)	2 (8.3)	
Diameter of tumor (cm)	3.1 [2.4–3.5]	3.2 [2.5–3.9]	0.49

Data are presented as median [IQR] or n (%). SILDPPHR+1, single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection; cLDPPHR, conventional laparoscopic duodenum-preserving pancreatic head resection; BMI, body mass index; ASA, American Society of Anesthesiologists; HTN, hypertension; DM, diabetes mellitus; WBCs, white blood cells; HGB, hemoglobin; PLTs, platelets; ALB, albumin; TBIL, total bilirubin; PT, prothrombin time; IPMN, intraductal papillary mucinous neoplasm; SCA, serous cystadenoma; MCN, mucinous cystic neoplasm; pNEN, pancreatic neuroendocrine neoplasm; SPN, solid pseudopapillary neoplasm; IQR, interquartile range.

less trauma (22). To achieve this, instruments and imaging systems have been developed to make smaller incisions while maintaining anatomical quality comparable to or better than that of traditional surgery. Single-incision surgery and natural orifice transluminal endoscopic surgery are not only desirable due to their less invasive nature but also because they result in less scarring. If the procedure of SILDPPHR+1 is deemed safe and reliable, then it could be

Table 2 Intraoperative and postoperative outcomes of the two groups

Parameters	SILDPPHR+1 (n=19)	cLDPPHR (n=24)	P
Operative time (min)	290 [265–320]	285 [260–311.3]	0.59
Estimated blood loss (mL)	80 [57.5–100]	100 [90–140]	0.16
Conversion	1 (5.3)	2 (8.3)	>0.99
POHS (days)	14 [11–16.5]	14 [12–15]	0.91
Postoperative recovery			
Time to ambulation (POD)	3 [3–4]	3 [3–4.3]	0.70
Time to first flatus (POD)	2 [2–3.5]	2.5 [2–4]	0.65
Time to first liquid intake (POD)	4 [3–4]	4 [3–4.3]	0.73
Time to first solid intake (POD)	6 [6–6.5]	6 [5–6]	0.53
POPF	1 (5.3)	1 (4.2)	>0.99
Bile leakage	1 (5.3)	2 (8.3)	>0.99
DGE	1 (5.3)	1 (4.2)	>0.99
PPH	1 (5.3)	1 (4.2)	>0.99
Transfusion	1 (5.3)	1 (4.2)	>0.99
Abdominal infection	1 (5.3)	2 (8.3)	>0.99
Postoperative complications			
I–II	9 (47.4)	9 (37.5)	0.55
≥III	1 (5.3)	1 (4.2)	>0.99
VAS score			
Baseline	1 [0–2]	1 [0–2]	0.77
POD 3	3 [2–3.5]	3.5 [3–5]	0.10
POD 7	2 [1–2]	2 [1–3]	0.23
Cosmetic score	2 [1–2]	3 [3–3]	<0.001
Textbook outcome	13 (68.4)	17 (70.8)	>0.99

Data are presented as median [IQR] or n (%). SILDPPHR+1, single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection; cLDPPHR, conventional laparoscopic duodenum-preserving pancreatic head resection; POHS, postoperative hospital stays; POD, postoperative day; POPF, postoperative pancreatic fistula; DGE, delayed gastric emptying; PPH, postpancreatectomy hemorrhage; VAS, visual analog scale; IQR, interquartile range.

a feasible alternative for aesthetically aware patients who place importance on a cosmetic outcome with minimal scarring. Previous meta-analyses and randomized controlled trials have reported better cosmetic results and patient satisfaction with minimally invasive surgery compared to open surgery (23,24). Moreover, Bulut *et al.* found that the median levels of C-reactive protein were significantly lower in a single-port surgery group than in a multiport surgery group, indicating that the former had positive effects on the acute phase response to trauma-induced immunomodulation (25).

SILS has obvious advantages in terms of minimal invasiveness and postoperative pain relief, but it also has obvious limitations due to the obvious "chopstick" effect and the small manipulation angle of the instruments, which is a challenge in pancreatic surgery. Single-port laparoscopic surgery may not provide an adequate visual field during the surgical process; however, our updated protocol addresses this challenge by introducing an additional 12-mm port. This modification allows the

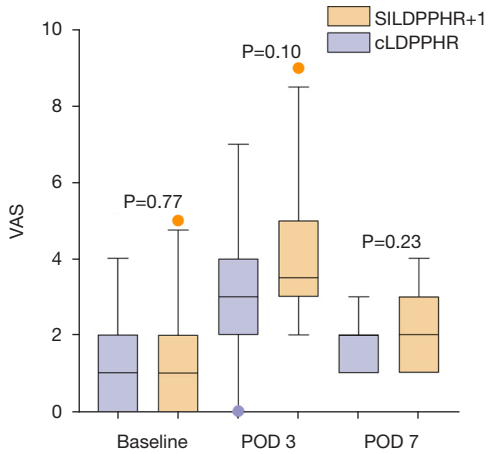

Figure 3 Postoperative pain VAS. On the VAS, 0 point indicates no pain and 10 points indicates the most severe pain. The horizontal line in the middle of each box indicates the median, while the upper and lower boundaries of the box indicate the 90th and 10th percentile respectively. The horizontal lines above and below each vertical line represent the 95% confidence interval. VAS, visual analog scale; POD, postoperative day; SILDPPHR+1, single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection; cLDPPHR, conventional laparoscopic duodenum-preserving pancreatic head resection.

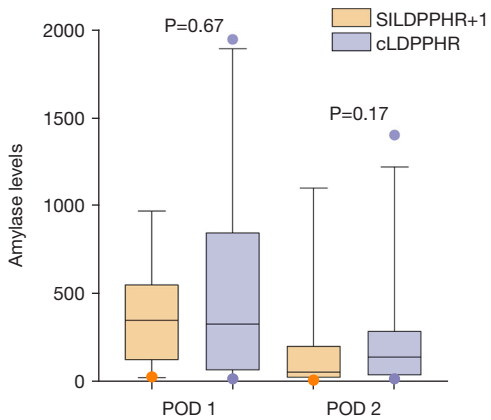

Figure 4 Amylase level in drainage fluid. The horizontal line in the middle of each box indicates the median, while the upper and lower boundaries of the box indicate the 90th and 10th percentile respectively. The horizontal lines above and below each vertical line represent the 95% confidence interval. The vertical axis indicates the logarithmic normalization of the amylase level. POD, postoperative day; SILDPPHR+1, single-incision plus one-port laparoscopic duodenum-preserving pancreatic head resection; cLDPPHR, conventional laparoscopic duodenum-preserving pancreatic head resection.

surgeon to gain an appropriate visual field by utilizing the supplementary port. cLDPPHR requires an extra incision for specimen extraction, whereas the SILDPPHR+1 technique does not. The specimen could be eliminated through the sole incision, with the additional port utilized for drainage purposes. In contrast, the SILDPPHR+1 method offers a simpler and more replicable alternative to the total single-incision technique. Safety is guaranteed after a brief pre-learning process of cLDPPHR.

Our study demonstrated that SILDPPHR+1 possesses several advantages over cLDPPHR, including no increase in operative time and reduced hemoglobin and blood loss. Moreover, there were no significant distinctions in postoperative recovery, the bile leakage, DGE, PPH, and abdominal infection rates or the textbook outcome. The operation time of the SILS was reduced, and the estimated blood loss was lower because of the operator's previous experience in performing five-port LDPPHR. SILS was exclusively executed after the operator had surpassed the learning curve. As a result, the surgical outcomes of SILDPPHR+1 could be superior to those of cLDPPHR. Compared to conventional five-port laparoscopic surgery, SILS is distinguishable by its "no scar" feature, aesthetically pleasing incision, higher patient satisfaction, quicker postoperative recovery, and other advantages. This is due to the naturally formed skin folds in the navel concealing the surgical incision.

The Beger procedure maintains blood supply to the distal CBD, Vater's ampulla, and the duodenum by performing a partial resection of the pancreatic head in the duodenum. Then it developed into Frey's procedure, Berne's procedure, Takada's procedure (26,27), and others. The Takada procedure fully excises the pancreatic head while preserving the duodenal blood supply. This reduces the occurrence of POPF as well as the risk of positive margins (28). However, the procedure has a relatively high incidence of biliary complications. Previous studies have shown that the incidence of bile leakage after LDPPHR ranges from 4.5% to 16.7%. This may be attributed to bile duct injury and ischemia during surgery (5,6,29). The identification and protection of bile ducts during surgery is of the utmost importance. Cai *et al.* reported that the incidence of bile duct injury can be minimized by employing real-time ICG fluorescence imaging during surgery, resulting in a bile leakage rate of only 12.5% (3/24) (29). The use of an ICG fluorescence imaging system for bile duct protection has also been reported by Hong *et al.*, showing a low bile leakage incidence rate of 4.5% (1/22) (6).

Lu *et al.* reported the use of preoperative endoscopic nasobiliary drainage (ENBD) and ICG fluorescence imaging to protect the bile ducts (30). However, they did not report the incidence of bile leakage. In contrast, Wu *et al.* found that the preoperative ENBD increased the risk of POPF (21).

The employment of LDPPHR for pNENs is still a matter of debate and is carefully assessed at our center. As the biological behavior of pNENs is highly variable, ranging from benign to severe (31), we typically resect the head of the pancreas rather than enucleate and perform laparoscopic pancreaticoduodenectomy (LPD) in neuroendocrine tumors larger than 2 cm. In addition, we always take a sample of the nearby lymph nodes during surgery and analyze them by frozen section to rule out malignancy.

There are various limitations in this study. The first limitation is the retrospective method of data collection, which may lead to selection bias. The second limitation is that this was a single-center study, and both groups had a relatively small number of patients. The third limitation is that the long-term follow-up effect was not assessed.

From our initial experience, SILDPPHR+1 is a safe and feasible procedure with few postoperative complications and good recovery outcomes. However, it is a complex procedure that requires careful preoperative evaluation and intraoperative technique and skill. Due to limited case numbers, further randomized controlled trials are needed to accurately assess the efficacy and safety of SILDPPHR+1, and it is suggested that further studies will be performed in centers with extensive experience in cLDPPHR.

Conclusions

SILDPPHR+1 appears to be a reliable and safe procedure for specific patients. Additionally, real-time ICG imaging significantly assists in the prevention and identification of biliary tract injuries, without any increase in operation time or complications, which is comparable to the results achieved using cLDPPHR. Furthermore, SILDPPHR+1 provides the added advantage of better cosmetic outcomes.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://gs.amegroups.com/article/view/10.21037/gs-24-200/rc

Data Sharing Statement: Available at https://gs.amegroups.com/article/view/10.21037/gs-24-200/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-24-200/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics board of Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China (No. 2023-189) and informed consent was taken from all the patients.

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