

# Laparoscopic total pancreatectomy

## Case report and literature review

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### Abstract

**Rationale:** Laparoscopic total pancreatectomy is a complicated surgical procedure and rarely been reported. This study was conducted to investigate the safety and feasibility of laparoscopic total pancreatectomy.

**Patients and Methods:** Three patients underwent laparoscopic total pancreatectomy between May 2014 and August 2015. We reviewed their general demographic data, perioperative details, and short-term outcomes. General morbidity was assessed using Clavien–Dindo classification and delayed gastric emptying (DGE) was evaluated by International Study Group of Pancreatic Surgery (ISGPS) definition.

**Diagnosis and Outcomes:** The indications for laparoscopic total pancreatectomy were intraductal papillary mucinous neoplasm (IPMN) (n=2) and pancreatic neuroendocrine tumor (PNET) (n=1). All patients underwent laparoscopic pylorus and spleen-preserving total pancreatectomy, the mean operative time was 490 minutes (range 450–540 minutes), the mean estimated blood loss was 266 mL (range 100–400 minutes); 2 patients suffered from postoperative complication. All the patients recovered uneventfully with conservative treatment and discharged with a mean hospital stay 18 days (range 8–24 days). The short-term (from 108 to 600 days) follow up demonstrated 3 patients had normal and consistent glycated hemoglobin (HbA1c) level with acceptable quality of life.

**Lessons:** Laparoscopic total pancreatectomy is feasible and safe in selected patients and pylorus and spleen preserving technique should be considered. Further prospective randomized studies are needed to obtain a comprehensive understanding the role of laparoscopic technique in total pancreatectomy.

**Abbreviations:** CHA = common hepatic artery, DGE = delayed gastric emptying, GDA = gastroduodenal artery, HbA1c = glycated hemoglobin, IPMN = intraductal papillary mucinous neoplasm, ISGPS = International Study Group of Pancreatic Surgery, PNET = pancreatic neuroendocrine tumor, PPPD = pylorus preserving pancreaticoduodenectomy, PpSpTPD = pylorus- and spleen-preserving total pancreatectomy, PV = portal vein, SMA = superior mesenteric artery, SMV = superior mesenteric vein, SV = splenic vein.

**Keywords:** laparoscopic techniques, literature review, total pancreatectomy

## 1. Introduction

Total pancreatectomy is a complicated surgical procedure that combines the operative steps of pancreaticoduodenectomy and distal pancreatectomy, but facilitates reconstruction and lowers the risk of pancreatic fistula by avoiding the need for a pancreatic anastomosis. In brief, the development of total pancreatectomy

could be divided into 3 major periods. Since the first report of total pancreatectomy for pancreatic adenocarcinoma performed by Rockey in 1943,<sup>[1]</sup> it was considered as a radical surgery in terms of oncology due to the extent of resection.<sup>[2]</sup> However, after the first enthusiasm over total pancreatectomy, the disadvantages and limited long-term outcome of this surgical strategy became more obvious, which made it seldom performed. Several centers indicated perioperative morbidity and mortality of total pancreatectomy were similar to those of Whipple procedure, but without significant improvement in terms of long-term survival.<sup>[3–5]</sup> In addition, the metabolic problems resulted from total pancreatectomy made it rarely performed.<sup>[6]</sup> In recent years, with the development of modern techniques and enzyme preparations, total pancreatectomy could achieve good long-term outcomes and quality of life.<sup>[7–9]</sup> These improvements made it possible to reappraise total pancreatectomy as a choice of treatment in selected patients in which partial resection is impossible due to the spread of the disease.<sup>[10–12]</sup>

Nowadays, laparoscopic surgeries have rapidly evolved to include a variety of complex surgical procedures with the advantages of recovery and cosmetic outcomes.<sup>[13,14]</sup> Laparoscopic distal pancreatectomy is the most safe and feasible pancreatic procedure, for which there is limited resection and without reconstruction.<sup>[15]</sup> However, due to the complexity, only a few cases of full laparoscopic and laparoscopic-assisted total pancreatectomy have been reported to date. Here, we report 3 cases of laparoscopic total pancreatectomy with spleen and

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pylorus preservation and review the current data in terms of this procedure.

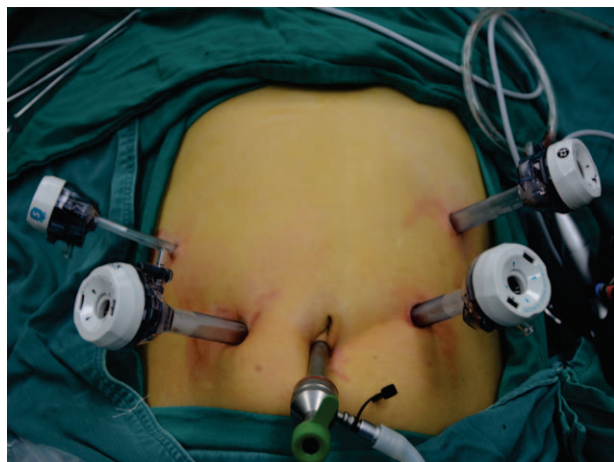
## 2. Materials and methods

This study was approved by the Institutional Ethic Committee of West China Hospital, Sichuan University. Between May 2014 and August 2015, 2 patients underwent laparoscopic pylorus- and spleen-preserving total pancreatectomy (PpSpTPD) for IPMN; the other patient underwent robotic-assisted PpSpTPD for neuroendocrine tumor and laparoscopic ultrasound-guided liver tumor ablation at West China Hospital, Sichuan University. All the diagnoses were confirmed by CT and postoperative pathology. We reviewed their general demographic data, perioperative details, and short-term outcomes. Outcomes were followed by telephone interview and Internet questionnaire ranged from 108 to 600 days after surgery. General morbidity was assessed using the Clavien–Dindo classification and delayed gastric emptying (DGE) was evaluated by International Study Group of Pancreatic Surgery (ISGPS) definition.<sup>[16,17]</sup>

### 2.1. Operative technique

**2.1.1. Patient positioning and ports placement.** Patients were placed in a supine position with legs split, in a 20° Trendelenburg position. The robotic-assisted system was only applied in the anastomosis part of one patient, therefore there is no difference in terms of Trocar position between the laparoscopic and robotic-assisted technique. At the beginning of surgery, a first 10 mm trocar for 30° of laparoscope was introduced below the umbilicus at the beginning. Four additional trocars were placed to the left and right of the laparoscope trocar: 2 trocars on the right were for the surgeon and the other 2 trocars on the left were for the assistant (Fig. 1). Besides, a small incision (2–3 mm) at the subxiphoid area was created for the retraction of the liver or stomach.

**2.1.2. Entrance into the lesser sac and division of the duodenum.** One patient comorbid with liver tumor underwent laparoscopic ultrasound-guided liver tumor ablation at the beginning of surgery. After the initial exploration, the gastrocolic omentum was widely opened by a harmonic scalpel. Then the posterior stomach was freed from the anterior surface of the pancreas and the right gastroepiploic vessels are identified and



**Figure 1.** Trocar placement: 2 trocars on the right for surgeon and 2 trocars on the left for assistant.

divided. The duodenum was transected 3 to 4 cm from pylorus with a laparoscopic linear cutting stapler.

### 2.2. Mobilization of the pancreatic head and duodenum

The hepatic flexure attachments of the right colon were divided down to the terminal ileum; an extended Kocher maneuver was performed to mobilize the first and second portion of the duodenum, this maneuver also allowed the jejunum to be pulled into the right upper quadrant. The jejunal mesenteric vessels were divided with the LigaSure (Covidien, MA, USA) and the jejunum was transected with a linear cutting stapler approximately 10 cm from the ligament of Treitz.

**2.2.1. Division the bile duct and Mobilization of the pancreatic neck.** Using the harmonic scalpel, the superior border of the pancreas and the common hepatic artery (CHA) were exposed. Then we routinely cleared lymph nodes and tissue around CHA to aid exposure of the underlying vessel; gastroduodenal artery (GDA) was isolated and divided. A standard cholecystectomy was performed and the bile duct was transected. A tunnel was created underneath the pancreatic neck and through a gentle dissection with tangential movements in relation to the vascular axis. The splenic vein (SV) proximal to the portal vein (PV) was isolated and encircled with a vessel loop, which could facilitate further mobilization of pancreatic body and tail. Another vessel loop was applied to the superior mesenteric vein (SMV) to facilitate the mobilization of pancreatic head.

**2.2.2. En bloc mobilization of total pancreas.** With the help of retraction on the SMV, the dissection was performed from the lateral border of SMV–PV in a caudal to cephalic direction. Small branches were divided by the LigaSure system. The pancreaticoduodenal veins were clipped and divided. Once the pancreatic head and duodenum were retracted medially to the left, the superior mesenteric artery (SMA) was identified posteriorly. Dissection was proceeded along the plane and small branches were served with clips. Then the inferior border of the pancreas was dissected; the dissection began at the inferior margin of the body moving towards the tail. Under the help of splenic vein retraction, small branches were easily isolated and divided. With this maneuver, the specimen was fully detached from the retroperitoneum. Then the specimen was retrieved through a 5-cm periumbilical incision.

**2.2.3. Reconstruction and drainage.** During the reconstruction, the jejunum was brought up behind the transverse mesocolon and an end-to side hepaticojejunostomy was performed in running suture. Then the duodenojejunostomy was performed in a 2-layer antecolic fashion 50 cm distal to the previous hepaticojejunal anastomosis. Three drainage tubes were left in the vicinity of hepaticojejunostomy, duodenojejunostomy, and hepatorenal recess, respectively.

## 3. Results

Between May 2014 and August 2015, total pancreatectomy was performed in 3 patients; 2 patients with fully laparoscopic total pancreatectomy, the other patient with laparoscopic total pancreatectomy and robotic-assisted anastomosis. Table 1 demonstrates the demographics and indications. Their mean age was 63 years (range 49–78 years); mean BMI was 23 (range 22–24); All the 3 patients were ASA classification grade II; The third patient with comorbidity of liver tumor (1 cm) was

**Table 1****Patients demographics and indications for TP.**

Patients	Age	Sex	BMI	ASA classification	Comorbidity	Indications
1	68	Female	22	II	Chronic pancreatitis, Type 2 diabetes	IPMN
2	74	Male	24	II	—	IPMN
3	49	Male	24	II	Liver tumor (1 cm), Type 2 diabetes	Neuroendocrine tumor

ASA = American Society of Anesthesiologist, BMI = body mass index, IPMN = intraductal papillary mucinous neoplasm.

underwent laparoscopic ultrasound-guided tumor ablation at the beginning of surgery. The indications for total pancreatectomy included IPMN (n=2) and neuroendocrine tumor (n=1). All the patients underwent pylorus- and spleen-preserving total pancreatectomy. As shown in Table 2, the intraoperative data indicate mean operative time was 490 minutes (range 450–540 minutes), mean estimated blood loss was 266 mL (range 100–400), there is no transfusion during the surgery. In terms of postoperative outcomes, all the patients require 1-day ICU monitoring after surgery. Two patients suffered from postoperative complications (66%): 1 patient suffered from grade A DGE, which required prokinetic medications; the other patient suffered from grade A DGE and melena, which required both prokinetic medications and blood transfusion. All the patients recovered uneventfully and the mean hospital stay was 18 days (range 8–24 days). There is no 90-day mortality and readmission in this study. In terms of the postoperative follow up (range 108–600 days), our study demonstrated 3 patients had normal and consistent glycated hemoglobin (HbA1C) level, although 1 patient had slight weight loss and hypoglycemic episodes, all of them had acceptable quality of life.

#### 4. Discussion

Because of the absence of pancreatic anastomosis and its radical resection, total pancreatectomy was favored in many surgeons decades ago. But the emerging evidence rapidly mitigated this enthusiasm: although pancreatic fistula was avoided, further quality was worsened because of brittle diabetes. Besides this, it does not improve the cancer-free survival.<sup>[19]</sup> However, new formulations of endocrine medication and improved understanding of pancreatic disease have made total pancreatectomy an increasingly viable option in the treatment of selected patients. Since the advent of laparoscopic surgery, the advantages were so evident that it quickly became the standard for many surgical indications; however, laparoscopic total pancreatectomy represents one of the most challenging fields in surgery, the reports related laparoscopic total pancreatectomy are still scarce. In our study, we will share our early experience of laparoscopic total pancreatectomy in terms of indication, surgical technique, and postoperative complication.

The indications for total pancreatectomy include a variety of disease. *Chronic pancreatitis*: Warren first performed total

pancreatectomy in patients with recurrent pancreatitis and proposed that this procedure is indicated for patients with intractable pain and intraductal obstruction not amenable to a drainage procedure.<sup>[18]</sup> At that time, the long-term effect is questionable. Nowadays, several center published their excellent pain relief effect of total pancreatectomy for chronic pancreatitis, which made it a reasonable indication for total pancreatectomy.<sup>[19,20]</sup> *Pancreatic adenocarcinoma*: historically, sporadic pancreatic cancer was considered as an indication for total pancreatectomy, however, given the recent evidence showing that pancreatic fistulas are now better managed, only 0% to 6% tumors are multicentric<sup>[21,22]</sup> and this procedure did not provide an increased long-term survival, there is no role for routine consideration of total pancreatectomy as an indication for sporadic pancreatic cancer. On the contrary, in family member with 3 or more first-degree relatives affected by pancreatic cancer, there is a 57-fold increase in the risk of developing familial pancreatic cancer.<sup>[23]</sup> The susceptibility to pancreatic cancer is inherited in an autosomal dominant fashion.<sup>[24]</sup> Evidence showed that surveillance and total pancreatectomy had the potential to avert the development of familial pancreatic cancer and should be considered as a prophylactic procedure in some patients.<sup>[25]</sup> *Neuroendocrine tumors*: more and more recent analyses suggest that endocrine tumors always do not have a benign course as previously thought, radical surgery, including total pancreatectomy, to remove locally advanced and metastatic neuroendocrine tumors can improve the duration and quality of life.<sup>[26]</sup> Therefore, as our understanding of the natural history of pancreatic neuroendocrine tumors (PNETs) has improved, it is clear that total pancreatectomy could be applied in selected patients suffering from PNETs. *IPMN*: it is an intraductal mucin-producing cystic neoplasm of the pancreas with overt malignant potential. In borderline IPMN, a partial pancreatectomy may be considered.<sup>[27]</sup> However, lesions involving the main pancreatic duct usually have a higher rate of malignancy than those arising from branch duct,<sup>[28]</sup> about two-thirds of malignant IPMNs become invasive.<sup>[29]</sup> Therefore, total pancreatectomy should be considered for selected patients with diffuse lesion involving the whole pancreas. There is no difference in terms of indications between laparoscopic and open approaches. In addition, as shown in Table 3, the results from several centers and our present study indicate that IPMN (n=25) is the primary indication for laparoscopic total pancreatectomy, which comprising 53%

**Table 2****Intraoperative data.**

Patients	OT, min	Estimated blood loss, mL	Intraoperative transfusion	ICU stay, d	Morbidity	LOS, d	90-d readmission
1	450	300	N	1	Clavien–Dindo II (grade A DGE)	24	N
2	480	400	N	1	Clavien–Dindo II (Grade A DGE, melena)	23	N
3	540	100	N	1	N	8	N

DGE = delayed gastric emptying, LOS = length of hospital stay, OT = operative time.



**Table 3****Current studies of laparoscopic/robotic-assisted total pancreatectomy.**

	No. of patients	Indication	Operation approach	Spleen preserving	EBL (range), mL	OT, min	Conversion	Morbidity	Mortality
Boggi et al <sup>[32]</sup>	11	IPMN (8), PDCA (2), CP (1)	Robotic TP	3 (27.2%)	220 (100–450)	600 (400–800)	0	7 (63.6%)	0
Zureikat et al <sup>[31]</sup>	10	IPMN (6), PDCA (1), CP (3)	Robotic TP + AIT	2 (20%)	650 (400–1000)	560 (461–592)	1 (10%)	10 (100%)	0
Galvani et al <sup>[33]</sup>	6	CP (6)	Robotic TP + AIT	4 (66%)	630 (500–800)	717 (612–835)	0	2 (33%)	0
Giulianotti et al <sup>[34]</sup>	5	IPMN (1), PDCA (2), CP (1), NET (1)	Robotic TP	2 (40%)	310 (50–650)	456 (300–560)	0	2 (40%)	0
Choi et al <sup>[28]</sup>	3	IPMN (3)	LTP	3 (100%)	483 (160–800)	423 (410–450)	0	1 (20%)	0
Dallemagne et al <sup>[49]</sup>	2	IPMN (1), NET (1)	LTP	1 (50%)	400 (200–600)	390 (360–420)	0	0	0
Dokmak et al <sup>[35]</sup>	2	IPMN (1), NET (1)	HALTP	0	250 (200–300)	315 (270–360)	0	1 (50%)	0
Kim et al <sup>[50]</sup>	1	IPMN (1)	LTP	1 (100%)	800	300	0	1 (100%)	0
Kitasato et al <sup>[36]</sup>	1	IPMN (1)	HALTP	0	1300	779	0	1 (100%)	0
Marquez et al <sup>[51]</sup>	1	CP (1)	Robotic TP + AIT	0	1200	900	0	1 (100%)	0
Our current series	3	IPMN (2), NET (1)	Robotic TP (1), LTP (2)	3	266 (100–400)	490 (450–540)	0	2 (60%)	0

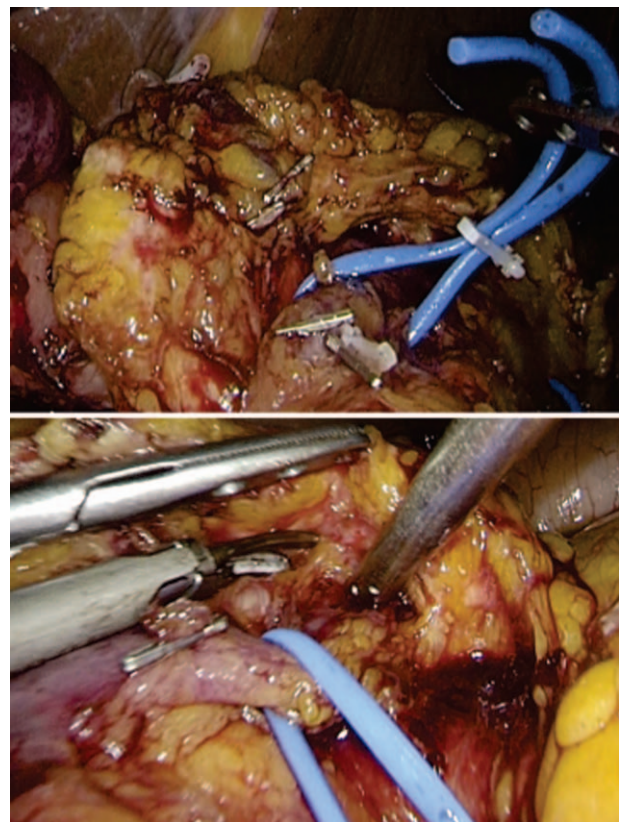
AIT = autologous islet transplantation, CP = chronic pancreatitis, EBL = estimated blood loss, HALTP = hand-assisted laparoscopic total pancreatectomy, IPMN = intraductal papillary mucinous neoplasm, LTP = laparoscopic total pancreatectomy, NET = neuroendocrine tumor, OT = operative time, PDCA = pancreatic ductal adenocarcinoma.

patients underwent laparoscopic total pancreatectomy, followed by chronic pancreatitis (n = 12, 27%), pancreatic cancer (n = 5, 11%), and neuroendocrine tumor (n = 4, 9%).

Since the advent of laparoscopy, the advantages of laparoscopic surgery have led it to be the standard for many procedures. However, the pancreatic surgery, especially for total pancreatectomy, is the most challenging technique in laparoscopic surgeries. Therefore, the intraoperative safety is an important concern in terms of laparoscopic total pancreatectomy. To address this problem, several centers<sup>[30–33]</sup> introduced the robotic-assisted system, which could provide surgeons with precisely dissection of vessels and dexterous reconstruction. Besides, other centers<sup>[34,35]</sup> used the hand assisted laparoscopic technique or mini-laparotomy to address the limitations of laparoscopy. In our study, robotic system was only applied in one patient for the reconstruction procedure and it is not superior to the laparoscopic technique in terms of anastomosis because the absence of pancreatic anastomosis. In the dissection part, we had 2 strategies to facilitate the fully laparoscopic procedure. As shown in Fig. 2, the first strategy was the application of vascular loops encircled SMV and SV. Because the elasticity of vascular loops, the surgeon could get a perfect retraction without fear of vascular laceration. Besides, the small branches of SMV and SV could be easily spared and clipped. The other strategy, as shown in Fig. 1, is the position of trocars. There are 2 operating trocars on each side, which will facilitate the surgeon and the assistant on each side of patient to cooperate to complete some complicated procedures. For instance, when the major bleeding occurs, assistant could compress the vascular by one hand and expose the bleeding site by the other hand, which would let the surgeon focus on the suture procedure. Therefore, these strategies not only speed up our procedure but also reduce the avoidable bleeding.

Pylorus preserving is a concern in pancreatic surgery such as Whipple or total pancreatectomy. In a prospective, randomized, multicenter study, Tran et al<sup>[36]</sup> demonstrated that there was no difference in terms of operation time, blood loss, and morbidity between the pylorus preserving pancreaticoduodenectomy (PPPD) and standard Whipple procedure. In another system review, Karanicolas et al<sup>[37]</sup> suggested that PPPD was a faster procedure with less intraoperative blood loss compared with standard Whipple procedure. In addition, several early studies<sup>[38,39]</sup> indicated that pylorus-preserving technique might have

an improved nutritional recovery and a better maintenance of the capacity for glucose metabolism. Therefore, pylorus preserving might be beneficial for patients if surgeons could avoid distal gastrectomy in cases of total pancreatectomy without compromising long-term survival. Another issue is whether preserving spleen in total pancreatectomy. In some instance, distal pancreatectomy with simultaneous splenectomy was the surgical choice for tumors located in pancreatic tail because of the



**Figure 2.** Vascular loop encircled major vein for better retraction and expose: SMV (the upper picture), SV (the lower picture). SMV = superior mesenteric vein, SV = splenic vein.

anatomic intimacy between the pancreas and the spleen. However, growing understanding in the immunological role of the spleen,<sup>[40]</sup> along with the long-term complication of splenectomy,<sup>[41]</sup> led more and more surgeons to avoid splenectomy during pancreatectomies for benign to borderline tumors. Preservation of spleen with distal pancreatectomy can be accomplished in either of 2 ways: by resecting the main splenic artery and vein en bloc with the pancreas but preserving the collateral blood supply of the spleen from short gastric and left gastroepiploic vessels, named Warshaw technique,<sup>[42]</sup> or by carefully dissecting the pancreas off the splenic vessels, named Kimura technique.<sup>[43]</sup> Although the Warshaw technique is judged to be safe, fast and associated with reduced intraoperative blood loss, concerns still exist due to the possibility of postoperative splenic infarct and development of gastric varices after division of the splenic vessels.<sup>[44]</sup> However, there is no significant difference between the 2 techniques in terms of long-term consequence. Therefore, it is worth to attempt spleen preserving total pancreatectomy in selected patients; which technique used for spleen conservation depends on the condition of patient and experience of surgeon.

Due to the absence of pancreatic anastomosis, DGE is one of the most common postoperative complications after total pancreatectomy. The ISGPS developed an objective and generally applicable definition and classification of DGE: the inability to return to a solid diet by the end of the first postoperative week and includes prolonged nasogastric intubation of the patient; 3 grades were defined based on the impact on the clinical course and postoperative management.<sup>[17]</sup> The mechanism of developing postoperative DGE is poorly understood because of the complex process of gastric emptying. Duodenal resection, leading to decrease of cholecystokinin and other hormones, might be an important factor for DGE<sup>[45]</sup>; other proposed factors including the occurrence of complications, anatomic alteration, and so on. DGE occurs after both standard (with antrectomy) and pylorus-preserving technique without significant difference.<sup>[46]</sup> Various strategies have been proposed to reduce the incidence of DGE; in a random, prospective study, Tani et al<sup>[47]</sup> published that an antecolic duodenojejunostomy might have a lower the occurrence of DGE compared with that of retrocolic method. Moreover, John et al<sup>[48]</sup> suggested that laparoscopic total pancreatectomy approach lowered length of stay and need for prokinetic medications postoperatively, which indicates a role of laparoscopy in reducing the incidence of DGE. Therefore, standardization of surgical technique and postoperative management are needed to improve the incidence of DGE.

In conclusion, our results are in keeping with a few current studies: laparoscopic total pancreatectomy is feasible and safe in well-selected patients with reasonable indications. In addition, pylorus and spleen preserving should be considered during the operation. Further prospective randomized studies are needed to obtain an objective assessment of laparoscopic total pancreatectomy.

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