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A novel surgical approach for en-bloc resection laparoscopic total pancreatectomy

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Abstract

Laparoscopic total pancreatectomy (LTP) is technical challenging and rarely reported in the literature. Herein, we introduced a safe and feasible approach to perform LTP basing on our own experience.

Over the period of July 2015 to August 2018, we performed 13 cases of LTP at our institution. Demographic characteristics, intraoperative and postoperative variables, and follow-up outcomes were prospectively collected. The surgical procedures were also described in this study.

Seven male and six female patients were included in this study. The median age of the patients was 51 years (range 29–79 years). The median operative time was 355 minutes (range 300–470 minutes). The median estimated blood loss was 200 mL (range 50–1000 mL). The median postoperative hospital stay was 17 days (range 12–23 days). One patient suffered from bile leakage and another patient suffered from delayed gastric emptying. Both patients cured with conservative therapy.

Laparoscopic total pancreatectomy can be safely and feasibly performed in well-selected patients.

Abbreviations: BMI = body mass index, CP = chronic pancreatitis, EBL= estimated blood loss, HA = hepatic artery, HALTP = hand-assisted laparoscopic total pancreatectomy, IPMN = intraductal papillary mucinous neoplasia, LTP = laparoscopic total pancreatectomy, LTPIAT = laparoscopic total pancreatectomy and islet auto-transplantation, MRCC = metastasis of renal cell carcinoma, NET = neuroendocrine tumor, PD = pancreaticoduodenectomy, PDCA = pancreatic ductal adenocarcinoma, PV = portal vein, SMA = superior mesenteric artery, SMV = superior mesenteric vein, SSA = stump of splenic artery, TP = total pancreatectomy.

Keywords: laparoscopic, minimal invasive surgery, pancreatectomy, vascular resection

1. Introduction

Total pancreatectomy (TP) is a complex procedure that combines the pancreaticoduodenectomy and distal pancreatectomy.[1] The first case of TP was reported by Rockey in 1943.[2] However, TP was rarely performed after the first enthusiasm period due to limited oncologic advantages and the metabolic problems resulted from TP.[3,4] In last decade, along with the improvement in perioperative management, including better pancreatic enzyme formula and long-acting insulin, TP became a viable choice in the treatment of several pancreatic diseases in selected patients.[5]

During the past decade, laparoscopic surgeries have rapidly evolved to include a variety of pancreatectomy procedures. Laparoscopic distal pancreatectomy became the first choice in setting of benign or low-grade malignant tumors located at distal pancreas.[6] Laparoscopic pancreaticoduodenectomy is also safe and feasible in well-selected patients.[7,8] From a technical point of view, total pancreatectomy stands just in between pancreaticoduodenectomy and distal pancreatectomy. However, only a few case reports and small size case series of full laparoscopic and/or laparoscopic-assisted total pancreatectomy have been reported to date.[9–13] In setting of malignant disease, it is critical to keep the specimen intact. Herein, we reported 13 cases of en-bloc resection laparoscopic total pancreatectomy (LTP) and shared our operative experience from a technical point of view.

2. Methods

Over the period of July 2015 to August 2018, we performed 13 cases of planned LTP at our institution. The planned pancreaticoduodenectomies that converted to a total pancreatectomy due to positive transected pancreatic neck margin were excluded in this study. Data on the demographic characteristics (age, sex, body mass index, American Society of Anesthesiology, and histopathologic diagnosis), intraoperative outcomes (operative time, estimated blood loss, spleen preservation, major vessels resection, and surgical approaches), and postoperative results (length of hospital stay, recovery of bowel function, complications, and mortality) of the cases were prospectively collected and retrospectively analyzed. All patients were informed about the possible advantages and disadvantages of laparoscopic surgery. Informed consent was obtained from the patients associated in

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The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are publicly available.

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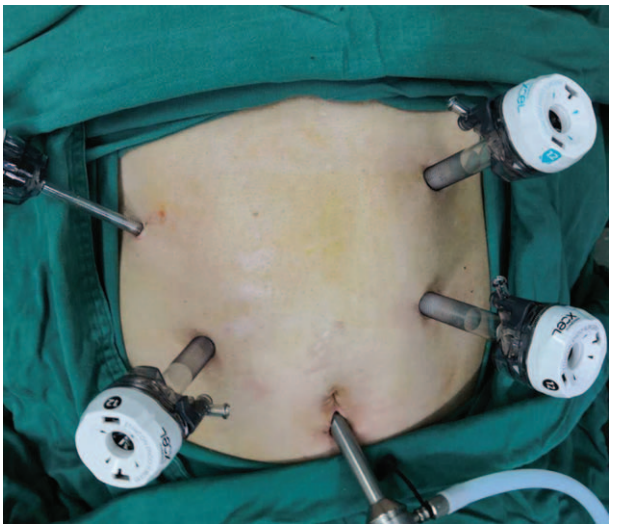

Figure 1. Trocars distribution.

this study, and this study was permitted by the Ethics Committee of Sichuan University.

3. Operative procedure

3.1. Patient positioning and trocar distribution

All patients were placed in the supine position with their legs separated, in a 30° Trendelenburg position. Generally, 5 trocars were used. A 10 mm trocar was place below the umbilicus for 30° laparoscope. Another 4 trocars were placed symmetrically at flank of rectus abdominis and midclavicular. The trocars distributions were shown in Fig. 1. The surgeon stood at the right side of the patient; the first assistant stood at the left side of the patient, and the scope assistant stood between the legs of the patient.

3.2. Exploration

The operation began with the careful exploration of the whole abdominal cavity to exclude tumor metastasis or dissemination. Then the great omentum was widely opened by a harmonic scalpel from left to right. The hepatic flexure of the colon and the mesentery of the transverse colon were fully taken down to expose the head of pancreas and the ring of duodenum. A wide Kocher maneuver was performed. The common hepatic artery was identified and hanged with a rubber band at the upper edge of pancreas. The gastroduodenal artery was clipped with hem-o-lock and dissected with cold scissor. The superior mesenteric vein (SMV) and portal vein (PV) were identified and hanged with rubber band. The post pancreatic neck tunnel was explored to identify SMV/PV involvement.

3.3. Dissection

The first part of the duodenum or distal stomach was transected with an endoscopic stapler. The gallbladder and the common hepatic duct were transected with the ultrasonic scalpel. Then, the jejunum was also transected at a site 15 cm from the Treitz ligament with endoscopic stapler. The proximal jejunum was

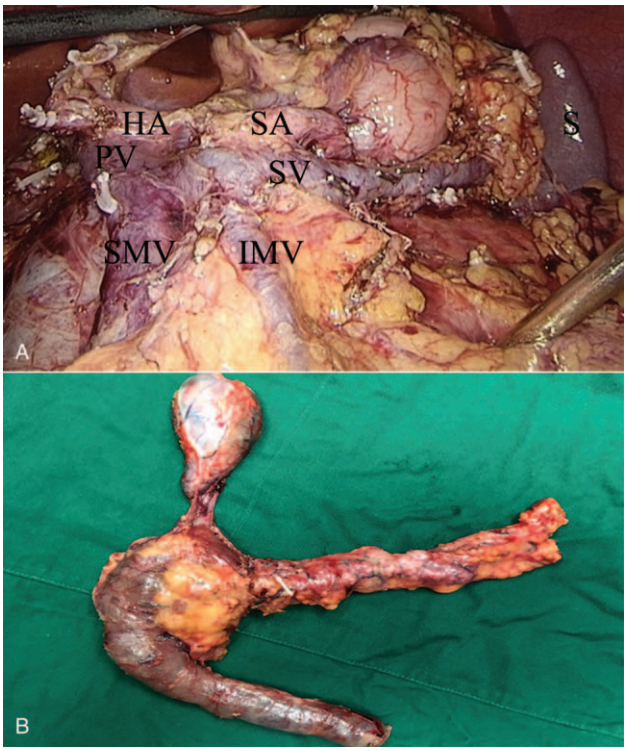

Figure 2. A. Operative field after total pancreatectomy without splenectomy.B. Gross specimen of total pancreatectomy without splenectomy. HA = hepatic artery; IMV = inferior mesenteric vein; PV = portal vein; SA = splenic artery; SMV = superior mesenteric vein; SV = splenic vein.

retracted to right side from the tunnel behind the mesenteric vessels.

For patient without SMV/PV involvement, "Head approach" was applied. The SMV was retracted to left side. Then, the space between uncinate process of pancreas and SMV/superior mesenteric artery (SMA) was extended. The right semicircular dissection of all soft connective tissues surrounding SMA was performed. After the mesentery of uncinate process of pancreas was completely dissected, the head of pancreas and duodenum were retracted to the left. Then the splenic vein and artery were revealed. For benign/low grade malignant lesions, we preserved the spleen using "Kimura" maneuver[14] (Fig. 2). For pancreatic adenocarcinoma, we transect the splenic vein and artery from the root. The total pancreas and spleen were removed together (Fig. 3).

For patients with SMV/PV involvement, "tail approach" were applied. In order to reduce the volume of spleen, the distal splenic artery was identified and clipped or sutured at the upper edge of pancreas. The lower edge of pancreas was freed and the Toldt space was identified. The body and tail of pancreas were dissected to the hilum of spleen in Toldt space. Then, the peri-splenic ligaments were dissected. The tail of pancreas and spleen were retracted to the right side. The splenic artery was dissected from the root. The whole pancreas, spleen, and the SMV/PV axis were retracted to the right and the SMA/celiac trunk axis were revealed. The right semicircular dissection of all soft connective tissues surrounding the SMA was performed and standard lymphadectomy were carried out. Then, the splenic vein was sutured approximately 1 cm far away from tumor to occlude the blood from spleen. SMV/PV were clipped with bull-dog clips and

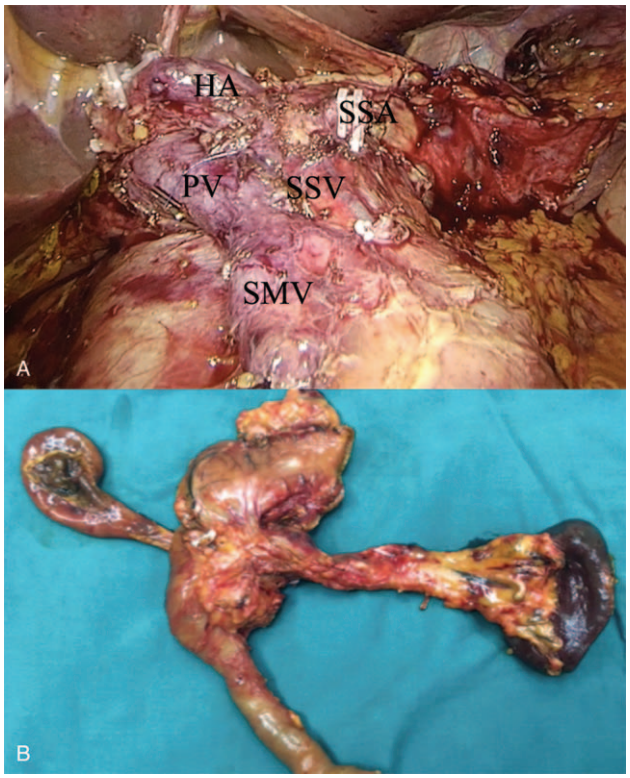

Figure 3. A. Operative field after total pancreatectomy with splenectomy. B. Gross specimen of total pancreatectomy with splenectomy. HA = hepatic artery; PV = portal vein; SMV = superior mesenteric vein; SSV = stump of splenic vein; SSA = stump of splenic artery.

dissected and the specimen was put into a retrieval bag. The SMV/PV were reconstructed by end-to-end anastomosis or with an artificial graft basing on the length of venous resected (Fig. 4).

3.4. Digestive reconstruction

A window was created in the mesenteric of transverse colon and the jejunum was passed through the window and an end-to-side hepaticojejunostomy was performed with 4-0 absorbable sutures. Generally, a single layer running suturing was applied. End-to-side duodenojejunostomy or side-to-side gastrojejunostomy was performed at a site 45 cm from the hepaticojejunostomosis.

3.5. Specimen retrieval and drainage

The specimen was retrieved from the enlarged umbilicus incision. Generally, 3 drainages were used. These drainages located at the vicinity of hepaticojejunostomy, splenic recess, and the hepatorenal recess, respectively.

3.6. Postoperative management

Nasogastric tubes were removed and all patients began to orally consume water on the first postoperative day. Patients began to intake liquid food after the first passage of flatus. Drainages were removed on the third to fifth postoperative day. Low-molecular heparin (2500–5000 IU/d for 7 days) was administered to patients with venous resection and reconstruction. Blood glucose

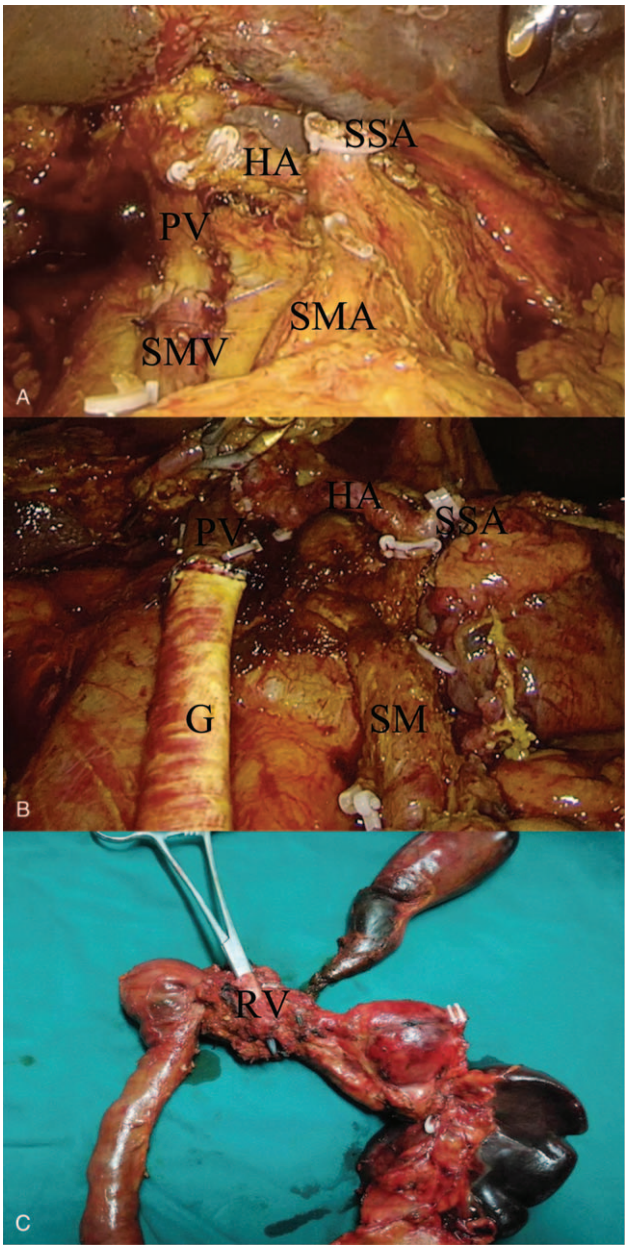

Figure 4. A. Operative field after total pancreatectomy with venous resection and end-to-end anastomosis. B. Operative field after total pancreatectomy with venous resection and reconstruction with artificial graft. C. Gross specimen of total pancreatectomy with venous resection. G = artificial graft; HA = hepatic artery; PV = portal vein; RV = resected venous; SSA = stump of splenic artery; SMA = superior mesenteric artery; SMV = superior mesenteric vein.

monitored 4 times a day. The blood glucose maintained approximately 10 mmol/L by subcutaneous injection of insulin or insulin pump. All patients began to take pancreatin preparation after resuming oral liquid food.

4. Outcomes

The demographic characteristics of patients were shown in Table 1. Seven male and six female patients were included in this study. The median age of the patients was 51 years (range 29–79 years). The median body mass index was 23.7 kg/m^2 (range 19.2–

Table 1

Demographic characteristics of patients.

Variables	
No. of patients	13
Male/female	7/6
Mean age, yrs	51 (range 29–79)
BMI, kg/m^2	23.7 (range 19.2–25.3)
Pathological diagnosis	
Pancreatic ductal adenocarcinoma	6
Intraductal papillary mucinous neoplasm	5
Multiple tumors	1
Chronic pancreatitis	1

Table 3

Postoperative outcomes.

Variables	
POHS, d	17 (range 12–23)
Intensive care unity stay, d	1.2 (range 1–2)
90-days mortality (n, %)	0, 0%
Liquid food intake, d	2.6 (range 2–4)
Complications (n, %)	
Bile leakage	1, 7.7%
Delayed gastric emptying	1, 7.7%
Chylous fistula	2, 15.4%

POHS = Postoperative hospital stay.

25.3 kg/m^2). Nine patients (69.2%) suffered from diabetes mellitus preoperatively. Three patients (23.1%) suffered from fatty diarrhea. The postoperative pathological diagnosis included pancreatic ductal adenocarcinoma (6 cases), intraductal pancreatic mucinous neoplasm (5 cases), multiple tumors (1 case), and chronic pancreatitis (1 case).

The operative outcomes were shown in Table 2. One patient (7.7%) required converting to hand-assisted laparoscopic total pancreatectomy due to tearing of spleen. Eleven patients (84.6%) preserved pylorus and 6 patients (46.2%) preserved spleen. The median operative time was 355 minutes (range 300–470 minutes). The median estimated blood loss was 200 mL (range 50–1000 mL). Two patients (15.4%) required blood transfusion.

The postoperative outcomes were shown in Table 3. The median postoperative hospital stay was 17 days (range 12–23 days). In terms of complications, no patient suffered from postoperative bleeding. One patient suffered from bile leakage, 2 patients suffered from chylous fistula and another patient suffered from delayed gastric emptying. All patients were cured with conservative therapy. There was no 90-days mortality in our series. All patients were followed up regularly in the outpatient department. They were followed-up once every 3 months in the first 2 years and once every half a year after 2 years. All patients received insulin and pancreatin replacement therapy. All patients had normal blood glucose level after insulin treatment except one. Despite pancreatin replacement therapy, 2 patients developed long-term diarrhea and weight loss. Two patients with pancreatic cancer died of tumor liver metastasis at 12 and 17 months after surgery.

Table 2

Operative outcomes.

Variables	
Operative time, min	355 (range 300–470)
Estimated blood loss, mL	200 (range 50–1000)
Conversion to hand-assisted surgery (n, %)	1, 7.7%
Conversion to open surgery (n, %)	0
Transfusion (n, %)	2, 15.4%
R0 resection	13, 100%
Pylorus preserved (n, %)	11, 84.6%
Head approach (n, %)	11, 84.6%
Spleen preserved (n, %)	7, 63.6%
Spleen resected (n, %)	4, 36.4%
Tail approach	2, 15.4%
SMV/PV resection and reconstruction (n, %)	2, 15.4%
End-to end anastomosis	1
Artificial grafts	1

5. Discussion

Compared with pancreaticoduodenectomy, TP may provide several potential advantages. First of all, TP can avoid the pancreatic fistula, which is the crucial complication and the main cause of mortality among patients who underwent PD.[15] Secondly, due to pancreatic adenocarcinomas might develop multi-centrically in the pancreas, TP was considered as an extension of oncologic radicality in setting of pancreatic adenocarcinoma. However, the expected clinical advantages after TP were limited in the literature. Several studies reported that the complications associated with TP were equal to those of PD, but no advantages in long-term survival.[4] Furthermore, TP caused several major metabolic problems, such as insulin-dependent diabetes mellitus and malabsorption, which contributed to significant morbidity and decreased quality of life and physical activity in the long-term follow-up.[16–18]

In last decade, major improvements in pancreatic enzyme formula and long-acting insulin, as well as advances in nutrition and critical care may overcome the problems associated with TP.[19] TP should be considered in selective cases for treatment of pancreatic neoplasm if it allows complete clearance.[16,20] The indications for TP were the diseases affecting the whole pancreas, including pancreatic ductal adenocarcinomas,[21] chronic pancreatitis,[11] intraductal papillary mucinous neoplasia (IPMN),[10] and multifocal neuroendocrine tumors, which were consistent with the indications in this study.

Compared with open surgery, laparoscopic surgery can provide several advantages, such as faster recovery, less complications, and cosmetic outcomes. However, Berger et al[22] performed a case-matched study of pediatric patients who underwent laparoscopic-assisted or open total pancreatectomy and islet auto-transplantation and found that the operative time, estimated blood loss (EBL), blood transfusions, morbidity, and hospital length-of-stay were comparable between 2 groups. Due to the technical challenging, only a few cases of LTP and laparoscopic-assisted total pancreatectomy were available in the literature. We performed a literature review of laparoscopic total pancreatectomy and the results were shown in Table 4. The median estimated blood loss of patients in the literature was 483 mL (range 100–1300 mL). The median operative time was 456 minutes (range 270–779 minutes). The postoperative morbidity of LTP ranged from 0% to 100%.[12] Only 2 patients required converting to open surgery due to vein resection and reconstruc-

Table 4

Current studies of laparoscopic total pancreatectomy.

	Year	No. of patients	Pathologic diagnosis	Operative type	Operative time, min	EBL, mL	Morbidity (n, %)
Kim et al[13]	2011	1	IPMN (1)	LTP	300	800	1, 100%
Kitasato et al[23]	2011	1	IPMN (1)	HALTP	779	1300	1, 100%
Dallemagne et al[24]	2013	2	IPMN (1), NET (1)	LTP	390 (360–420)	400 (200–600)	0
Dokmak et al[25]	2013	2	IPMN (1), NET (1)	HALTP	315 (270–360)	250 (200–300	1, 50%
Blair et al[11]	2016	20	CP (20)	LTPIAT	NA	NA	NA
Chapman et al[10]	2017	1	IPMN (1)	LTP	270	150	0
Wang et al[1]	2017	3	IPMN (2), NET (1)	LTP	480 (450–540)	300 (100–400)	2, 67%
Fan et al[28]	2017	22	CP (22)	LTPIAT	493	627	NA
Choi et al[9]	2017	1	MRCC	LTP	441	150	0
Gumbs et al[26]	2018	4	IPMN (1), PDCA (1) CP (1)	LTP	NA	NA	NA
Wu, et al[27]	2019	1	IPMN (1)	LTP	NA	NA	0
Berger, et al[22]	2020	21	CP (21)	LTPIAT	310	612	12, 61.8%

CP = chronic pancreatitis, EBL = estimated blood loss, HALTP = hand-assisted laparoscopic total pancreatectomy, IPMN = intraductal papillary mucinous neoplasm, LTP = laparoscopic total pancreatectomy, LTPIAT = laparoscopic total pancreatectomy and islet auto-transplantation, MRCC = metastasis of renal cell carcinoma, NA = not available, NET = neuroendocrine tumor, PDCA = pancreatic ductal adenocarcinoma.

tion.[12] No 30-days surgery related mortality after LTP was reported in the literature. Some surgeons may dissect the pancreatic neck during LTP,[11,28] dividing the LTP into 2 independent procedures: laparoscopic pancreaticoduodenectomy and laparoscopic distal pancreatectomy. This maneuver might facilitate the LTP, however, it violated the principle of en-bloc resection, especially in setting of diffuse malignant tumors. We introduced 2 different approaches to perform LTP in this study, named "head approach" and "tail approach," respectively. We did not dissect the pancreatic neck during operation; therefore, we called this technique en-bloc resection LTP. Our surgical outcomes were comparable with those reported in literature. The en-bloc resection did not compromise the safety or feasibility of LTP compared with traditional approach. For tumors without SMV/PV involvement, it is feasible to create the post-pancreas tunnel. In our experience, it is important to enlarge the tunnel as much as possible. It is also critical to hang the SMV and PV with a rubber band and retract them to the left side. This technique can extend the space between uncinate process of pancreas and SMV and facilitate the dissection of uncinate process of pancreas. Additional attention should be paid to the branches of SMV/PV to pancreas in this approach, such as posterior superior pancreaticoduodenal vein. It is much easier to dissection the body and tail of pancreas after completely mobilization of pancreas head.

For pancreas neck tumors with SMV/PV involvement, it is difficult to create the post-pancreas tunnel. It is also difficult to dissect the pancreas from head to tail in this situation. We presented another approach, called "tail approach," for LTP with SMV/PV involvement. In this approach, we dissected the tail of pancreas and spleen and reversed them to the right side. Then the SMA/celiac trunk axis was revealed. The right semicircular dissection of all soft connective tissues surrounding the SMA was performed. There were several key points in this approach. Firstly, we did not create the post pancreas neck tunnel in order to prevent bleeding from SMV or tumor rupture. Secondly, we clipped or sutured the splenic artery before dissecting the tail of pancreas and spleen in order to decrease the volume of spleen and facilitate to reverse them to the right. Thirdly, in order to decrease the duration of blood occlusion, we did not occlude the SMV/PV until we have dissected the uncinate of process and performed the lymphadectomy.

We proposed a new surgical approach to perform en-bloc resection laparoscopic total pancreatectomy in this study. This is the first study that reported LTP from a technical point of view. However, there were several limitations associated with this study. We just discuss the perioperative outcomes of LTP. The long-term oncological outcomes and the quality of life and physical activity of patients were not available. Furthermore, this is a surgical experience from a single surgical team. More data from different institutions should be required to establish the safety and long-term efficiency of LTP.

6. Conclusions

Laparoscopic total pancreatectomy can be safely and feasibly performed in well-selected patients. Further studies from different institutions are required to establish the safety and long-term efficiency of en-bloc resection laparoscopic total pancreatectomy.

Author contributions

Yunqiang Cai, Pan Gao, Bing Peng designed of the work; Yunqiang Cai and Pan Gao collected and analyzed the data for the work; Yunqiang Cai drafted the manuscript; Pan Gao and Bing Peng revised the manuscript. All authors approved the final version of the manuscript to be published and agreed to be accountable for all aspects of the work.

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