



Original Article

Short and long-term outcomes of minimally invasive central pancreatectomy: Comparison with minimally invasive spleen-preserving subtotal distal pancreatectomy



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ARTICLE INFO

Article history:

Received 9 June 2022

Accepted 24 August 2022

Available online 8 September 2022

Keywords:

Central pancreatectomy

Minimally invasive surgery

Pancreas

Pancreatic fistula

ABSTRACT

Background: Central pancreatectomy (CP) is more complex surgery and higher complication rate than distal pancreatectomy (DP). However, with the development of minimally invasive surgery, CP has become a safer surgery technique. In this study, we compare minimally invasive CP (MI-CP) and Minimally invasive spleen-preserving subtotal DP (MI-SpSTDP) to figure out the short-term and long-term outcomes of MI-CP.

Methods: From March 2007 to June 2020, 36 cases of MI-SpSTDP and 23 cases of MI-CP were performed for benign and borderline malignant pancreatic tumors in Severance hospital. The occurrence of post-operative pancreatic fistula (POPF) and Clavian-Dindo classification grade 3 or more in the two group was investigated, and the Controlling nutritional status scores (CONUT score) before and 1-year after surgery were compared to determine the long-term outcomes of exocrine function.

Results: There was no difference in postoperative complications including POPF between the two groups (17.4% vs 5.1%, $p = 0.294$). And there were no statistical differences in either the MI-CP group (0.74 ± 0.75 vs. 0.78 ± 0.99 , $p = 0.803$) or the MI-SpSTDP group (0.86 ± 0.83 to 0.61 ± 0.59 , $p = 0.071$). **Conclusions:** MI-CP had longer operation time and hospital stay and is safe and effective in preserving endocrine and exocrine functions in treatment of benign or borderline tumors located at the neck or proximal body of the pancreas.

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1. Introduction

Central pancreatectomy (CP) was first performed in 1982.¹ For tumors in the pancreas neck or proximal body, CP has been established as an alternative to subtotal distal pancreatectomy (STDP). Benign and borderline tumors located at the neck or proximal body of the pancreas are considered a potential indication for the procedure.^{2,3} CP can reliably preserve normal pancreatic and spleen tissue and has the advantage of preserving the integrity of gastrointestinal (GI) bile flow continuity.⁴

CP is not performed as frequently as STDP for several reasons. The first reason is that the pancreatic surgery involves two cut surfaces. This increases the risk of postoperative pancreas fistula (POPF).⁵ There is also fear of complications due to complicated procedures and increased operation time.⁶ However, with the remarkable development of minimally invasive surgery techniques in the late 20th century and the development of perioperative management methods such as interventional radiology, CP again has become popular.^{7–10}

There have been many studies comparing CP and DP,¹¹ although most focused on comparison with STDP. We think that the true counterpart of CP is spleen-preserving STDP (SpSTDP), and that comparison with such a group is necessary to determine the clinical significance of CP. However, there are few such studies in the literature.

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<https://doi.org/10.1016/j.asjsur.2022.08.084>

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Therefore, in this study, we compare the differences in outcomes and incidence of pancreatic diabetes mellitus(PDM) in minimally invasive CP (MI-CP) and minimally invasive SpSTDP (MI-SpSTDP) to determine a difference in quality of life.¹²

2. Materials and methods

From March 2007 to June 2020, 36 cases of MI-SpSTDP and 23 cases of MI-CP were performed for benign and borderline malignant pancreatic tumors in Severance hospital. MI-CP and MI-SpSTDP were considered for lesions located at the neck or proximal body of the pancreas. In all cases, the pancreas was divided at the pancreatic neck above the superior mesentery-splenic vein-portal vein confluence.^{7,13,14} All surgeries performed during this study period used either a robotic or laparoscopic approach. Patients with diabetes were excluded from the study.

The medical records of these patients were retrospectively reviewed, and data were collected. Preoperative data collected were age, sex, weight, height, body mass index (BMI), presence of symptoms, and presence of diabetes mellitus. Operative data were type and duration of surgery and estimated intraoperative blood loss. Postoperative data collected were lesion size, perioperative transfusion, final pathology, and BMI. The 30-day postoperative morbidity was also reviewed and classified according to the Clavien–Dindo system of surgical complications.¹⁵ Postoperative pancreatic fistula (POPF) was classified according to the International Study Group of Pancreatic Surgery (ISGPS).¹⁶ Postoperative HbA1c and blood glucose levels were measured at an outpatient visit and were used to identify new onset pancreatogenic DM (PDM).¹⁷ The measures required for blood glucose control included dietary restriction, oral hypoglycemic medication, and insulin injection. In order to identify nutritional status before and after surgery, albumin, cholesterol, and lymphocyte levels were measured before and 1 year after surgery, and controlling nutritional status score (CONUT score) was calculated([Table 1](#)).¹⁸ Patients are divided into 4 groups according to total score as 0–1 is normal, 2–4 is light, 5–8 is moderate, and 9–12 is severe malnutrition.

Statistics: Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Somers, NY). Continuous variables were expressed as mean ± standard deviation, and nominal variables were expressed as frequency with percentage. Categorical data were compared with χ^2 test, and continuous data with Student's *t*-test and paired *t*-test. Median follow-up and risk of post-operative new-onset DM were estimated using Kaplan–Meier curves and compared with the log-rank test. A *p*-value less than 0.05 was considered statistically significant. This study was approved by our institutional review board (#-4-2021-1242).

3. Results

3.1. General characteristics of the patients

A total of 59 patients underwent MI-CP or MI-SpSTDP at our institution during the study period. Among them, 12 were male and 47 were female, and the average age was 50.7 ± 15.23 years. The most common postoperative diagnosis was NET, the average tumor

size was 2.3 ± 1.51 cm, and the average length of hospitalization was 11.3 ± 7.32 days. The complication rate was about 23.7%, and no mortality was reported.

A total of 23 patients underwent MI-CP ([Table 2](#)). Mean age was 54.9 ± 13.5 years. Diagnosis was solid pseudopapillary tumor (SPT) in 8 cases, neuroendocrine tumor (NET) in 11 cases, renal cell carcinoma metastasis in 2 cases, intraductal papillary mucinous neoplasm (IPMN) in 1 case, and pancreatic ductal adenocarcinoma (PDAC) in 1 case. The average length of hospital stay was 14.7 ± 9.3 days, and complications were found in 7 cases. Among all cases, PDM occurred in 1.

In contrast, a total of 36 patients with an average age of 48.0 ± 15.8 years underwent MI-SpSTDP during the same period. The diagnosis was SPT in 8 cases, NET in 7 cases, MCN in 6 cases, IPMN in 6 cases, chronic pancreatitis in 4 cases, SCN in 3 cases, simple cyst in 1 case, and pDAC in 1 case. The average length of hospital stay was 9.2 ± 4.6 days, and complications were found in 7 cases. A total of 9 cases experienced PDM.

3.2. Comparative analysis of perioperative outcomes between MI-CP and MI-SpSTDP

We compared MI-CP and MI-SpSTDP for short-term perioperative outcomes and found larger tumor size (1.4 ± 0.5 cm vs. 2.9 ± 1.6 cm, *p* < 0.001) and shorter operation time (362.3 ± 80.8 min vs. 256.3 ± 103.9 min, *p* < 0.001) with subtotal distal pancreatectomy. There was no difference in bleeding, but hospital stay was slightly longer in the MI-CP group (14.7 ± 9.3 days vs. 9.2 ± 4.6 days, *p* = 0.004); There was no difference in post-operative complications including POPF between the two groups.

3.3. Comparative analysis of long-term outcomes of endocrine function between MI-CP and MI-SpSTDP

In all cases, new onset DM was detected within 12 months after surgery. Comparing the incidence of new onset DM between the two groups, 9 cases of MI-CP (39.1%) were identified as IFG, and 1 case (4.3%) was newly diagnosed as diabetes. On the other hand, in the STDP group, 21 cases (58.3%) were confirmed as IFG, and 9 cases (25.0%) were newly diagnosed as diabetes. These differences in incidence of impaired endocrine function were significant between the two groups (*p* = 0.039, [Table 3](#)). When analyzing time-dependent incidence of new onset DM after surgery, diabetes was diagnosed at an earlier time in the STDP group (74.94 months [95% confidence interval: 67.2–82.6] vs. 73.11 months [95% confidence interval:60.1–86.0], *p* = 0.081)[Fig. 1](#).

3.4. Comparative analysis of long-term outcomes of exocrine function between MI-CP and MI-SpSTDP

The postoperative follow-up period was similar between the two groups, at 28.33 ± 25.4 months and 25.4 ± 23.36 months for MI-CP and MI-SpSTDP, respectively (*p* = 0.665). When comparing the preoperative and 1-year postoperative CONUTS values of the MI-CP group and MI-SpSTDP group, there were no statistical differences in either the MI-CP group (0.74 ± 0.75 vs. 0.78 ± 0.99, *p*-

Table 1
Assessment of undernutrition degree by CONUT.

	Normal	Score	Light	Score	Moderate	Score	Severe	Score
Serum albumin (g/dl)	3.5–4.5	0	3.0–3.49	2	2.5–2.9	4	<2.5	6
Total lymphocytes (/ml)	>1600	0	1200–1599	1	800–1199	2	<800	3
Cholesterol (mg/dl)	>180	0	140–180	1	100–139	2	<100	3

Table 2
Comparison of characteristics of MI-CP and MI-SpSTDP patients.

	MI-CP (n = 23)	MI-SpSTDP (n = 36)	P-value
Age (years, mean ± SD)	54.9 ± 13.5	48.0 ± 15.8	0.092
Sex			
Male	5 (21.7%)	7 (19.4%)	0.831
Female	18 (78.3%)	29 (80.6%)	
Symptoms			
No	14 (60.9%)	25 (69.4%)	0.497
Yes	9 (39.1%)	11 (30.6%)	
Tumor size (cm, mean ± SD)	1.4 ± 0.5	2.9 ± 1.6	0.001
Diagnosis			
SPT	8 (34.8%)	8 (22.2%)	<0.001
NET	11 (47.8%)	7 (19.4%)	
MCN	0	6 (16.7%)	
SCN	0	3 (8.3%)	
IPMN	1 (4.3%)	6 (16.7%)	
Chronic pancreatitis	0	4 (11.1%)	
Cyst	0	1 (2.8%)	
PDAC	1(4.3%)	1 (2.8%)	
Metastasis	2(8.7%)	0	
Surgical approach			
Laparoscopic	7 (30.4%)	28 (77.8%)	
Robotic	16 (69.6%)	8 (22.2%)	
Operation time (min, mean ± SD)	362.35 ± 80.8	256.33 ± 103.9	
Bleeding (ml, mean ± SD)	193.3 ± 176.5	175.5 ± 231.4	0.74
Hospital stay (days, mean ± SD)	14.7 ± 9.3	9.2 ± 4.6	0.004
Complication			
No	16 (69.6%)	29 (80.6%)	0.333
Yes	7 (30.4%)	7 (19.4%)	
Clinically relevant POPF			
No or grade A	19 (82.6%)	33 (91.7%)	0.294
Grade B or C	4 (17.4%)	3 (5.1%)	

Table 3
Incidence rates of IFG and new onset PDM.

	MI-CP (n = 23)	MI-SpSTDP (n = 36)	P-value
IFG			
No	14 (60.9%)	15 (41.7%)	0.15
Yes	9 (39.1%)	21 (58.3%)	
New onset PDM			
No	22 (95.7%)	27 (75.0%)	0.039
Yes	1 (4.3%)	9 (25.0%)	

value = 0.803) or the MI-SpSTDP group (0.86 ± 0.83 to 0.61 ± 0.59, p-value = 0.071) Fig. 2.

4. Discussion

The recent trend in function-preserving approaches for pancreatic surgery—especially for benign and low-grade cancers, for which oncological outcomes are generally not compromised and where quality of life must be considered due to longer expected survival—has resulted in many pancreatic parenchymal-sparing techniques.¹⁹ However, each of these techniques has its own set of benefits and limitations.

CP and SpSTDP are considered when enucleation is not feasible for a tumor occurring in the proximal body or neck of the pancreas.²⁰ The CP technique is more technically challenging and

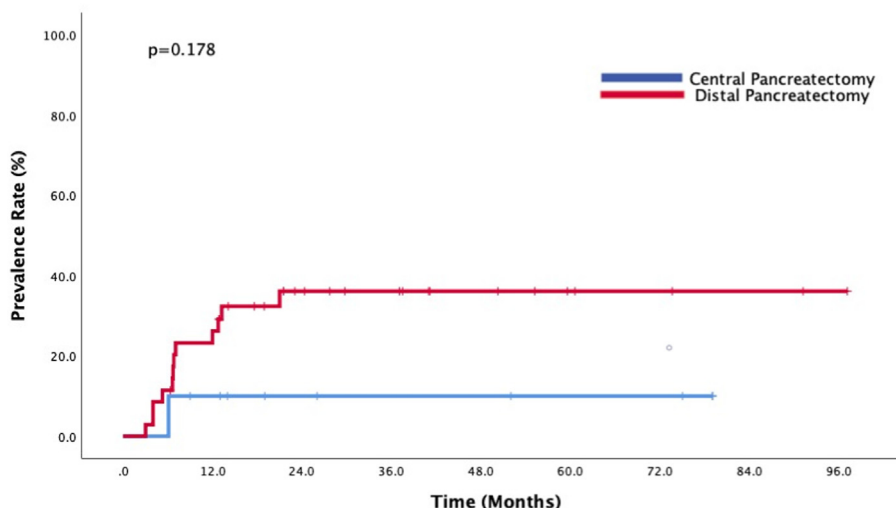


Fig. 1. Probability of new onset DM.

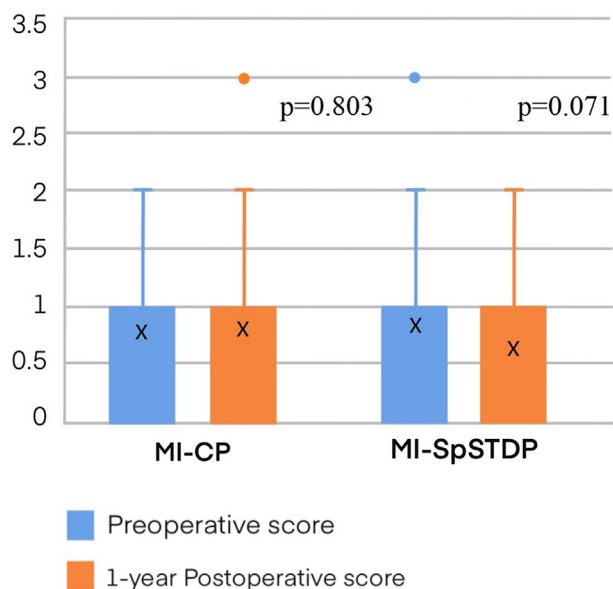


Fig. 2. CONUT score of MI-CP and MI-SpSTDP. CONUT score: controlling nutritional status score. MI-CP: minimally invasive central pancreatectomy. MI-SpSTDP: minimally invasive spleen-preserving subtotal distal pancreatectomy.

has been associated with increased POPF^{5,21–23} and longer hospital stay and operative time^{2,24–26} compared with SpSTDP. With the development of current surgical techniques and minimally invasive surgery, research on the occurrence of complications is needed. To date, few studies have compared CP and SpSTDP,^{1,19} specifically with regard to minimally invasive approaches (either robotic or laparoscopic), and there are no comparative data available.

In our institution, many studies on CP have been conducted. In addition to research on open CP,²⁶ there has been study of MI-CP, especially using a robotic approach.^{7,27} Recently, a study comparing open CP and MI-CP argued that MI-CP was safer and more effective than open CP.¹⁰

Lee et al compared pancreatic volumetry in CP, DP, and pancreateoduodenectomy (PD).²⁸ It was shown that CP resulted in worse overall morbidity, Clavien-Dindo complication grade, POPF grade, and hospital stay compared to DP. In addition, DP showed superior remnant pancreas volume and lower morbidity than CP, and POPF was more frequent in the CP group. These results suggest a lower effectiveness of volumetry for CP than the other procedures. The study did not mention spleen preservation with respect to DP. In addition, there was no specific mention of the pancreatic division line in DP (extent of distal pancreatectomy). For these reasons, DP might not be the exact counterpart to be compared with CP.

On the other hand, the complication rate of CP is significantly different from that of historical CP surgery due to development of the surgical technique and of standardized surgery and postoperative management.⁸

Iacono et al performed meta-analysis between CP and DP.²⁹ A total of 350 cases for CP and 480 cases for DP were compared. The CP group was inferior in postoperative morbidity and POPF but superior in endocrine function.

However, in present study, all subjects underwent a minimally invasive surgery, and only SpSTDP was compared as the control group. The results showed that MI-CP was beneficial in preserving endocrine function of the pancreas and reducing incidence of postoperative morbidity and POPF.

Comparison between the MI-CP and MI-SpSTDP groups showed

longer operation time and longer hospital stay in the MI-CP group but no difference in bleeding. In addition, unlike previous studies^{28,29} showing no differentiation of the minimally invasive approach from open surgery, the complication rate and POPF rate did not show any significant difference between the two groups. This suggests that MI-CP is feasible as safe and effective function-preserving pancreatectomy for benign or low-grade malignant pancreatic tumor in the proximal body or neck of the pancreas.

Regarding new onset of PDM and IFG, MI-CP provided an appropriate capacity for glucose metabolism as illustrated by the lower incidence of new onset DM and IFG compared with MI-SpSTDP. In addition, MI-CP showed a tendency to delay impairment in glucose metabolism. The volume of the normal parenchyma of the pancreas has a large effect on glucose metabolism. This indirectly infers that the MI-CP group has better quality of life than the MI-SpSTDP group. In addition, based on cases in which PDM occurs in SpSTDP, better results are expected if the patients predict diabetes well and selects the surgical method.¹²

In the present study, exocrine function was determined based on patient CONUT score. There was no significant difference in CONUT score before and 1-year after surgery in the two groups. Also, there was no significant difference in CONUT score before and after surgery in each group. Weidong Xiao et al performed meta-analysis to confirm exocrine insufficiency after CP confirmed by pancreatic enzyme supplementation, steatorrhea, weight loss, fecal chymotrypsin level, or pancreolauryl test.³⁰ They found that patients who underwent CP had less frequent exocrine insufficiency than those who underwent DP. Although the present study confirmed nutritional status based only on CONUT data, CP did not result in a decrease of nutrition status compared to DP. Exocrine function is affected by many external factors, such as amount of food eaten, use of a digestive agent, and balanced intake of nutrients. Therefore, it is not easy to explain changes in function based on a single factor. Since there was no difference between the two groups in CONUT score, which is an index of nutritional influence before and after surgery, it seems possible to manage patient nutrition with appropriate postoperative measures.

The strength of this study is that it does not simply compare CP and DP, but also includes Sp-STDP, which is thought to be a more exact counterpart of CP. We tried to homogenize the target group and draw practical conclusions based on only those who underwent minimally invasive surgery, which has been widely applied in clinical practice. However, this is a retrospective study of the uncommon central pancreatectomy procedure, resulting in a small number of cases. Also, there is need for a more specific and direct method of measuring exocrine function than using only CONUT score. These factors limit the strength of our findings.

In conclusion, MI-CP had longer operation time and hospital stay and is safe and effective in preserving endocrine and exocrine functions in treatment of benign or borderline tumors located at the neck or proximal body of the pancreas. Based on the long life expectancy of patients with benign or borderline tumor of the pancreas, MI-CP should be the first option considered.

Compliance with ethical standards

Disclosures This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Also, all authors Dawn Jung, Hassaan Bari, Ho Kyoung Hwang, Woo Jung Lee, and Chang Moo Kang, the corresponding author have no conflict of interest.

Declaration of competing interest

None.

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