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# Laparoscopic pancreaticoduodenectomy: Single-surgeon experience

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## ABSTRACT

**Introduction:** Pancreaticoduodenectomy is a technically demanding surgical procedure with an incidence of postoperative complications ranging from 30% to 61%. Pancreatic surgery and associated complications pose challenges for clinicians. Adenocarcinoma of the pancreas is one of the most aggressive malignant neoplasms. Patients who undergo an R0 resection have significantly better survival than those with R1/R2 resection. This article describes the use of laparoscopic pancreaticoduodenectomy in 9 cases.

**Materials and Methods:** Nine patients underwent a laparoscopic pancreaticoduodenectomy in the department of gastroenterology of a city hospital between April 2018 and August 2018. The demographic characteristics, perioperative details, and pathological results of 5 female and 4 male patients were retrospectively reviewed.

**Results:** The mean age of the patients was 64.5±14 years. The average operative time was 593 minutes (range: 480–797minutes) and the intraoperative blood loss was 207 mL (range: 110–500 mL). None of the patients required a blood transfusion, but 1 patient required conversion to an open pancreaticoduodenectomy procedure due to uncontrolled bleeding. Prophylactic abdominal drainage was performed for all patients.

**Conclusion:** Based on the results of this initial study, laparoscopic pancreaticoduodenectomy appears to be safe and feasible, producing satisfactory results when performed by experienced surgeons in carefully selected patients. However, long-term outcome data and a learning curve analysis should be fully demonstrated. Further studies from multiple centers are needed to support our conclusions.

**Keywords:** Laparoscopic pancreaticoduodenectomy; laparoscopy; pancreatic surgery.

## Introduction

Pancreaticoduodenectomy is a complex surgical procedure with an incidence of postoperative complications varying from 30% to 61%. Pancreatic surgery and associated complications pose challenges for clinicians. Adenocarcinoma of the pancreas is one of the most aggressive malignant neoplasms. Patients who undergo an R0 resection have a better survival those with R1/R2 resection and therefore, achieving R0 resection is the major goal of surgery for patients with this tumor. Approaching pancreaticoduodenectomy laparoscopically is more demanding owing to the inherent complexity of dissection and reconstruction as well

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as the requirement for creating critical anastomoses.[1] The procedure necessitates extensive experience, and surgical expertise is essential to minimize postoperative complications and mortality.[2] Recently, minimally invasive techniques have been used increasingly, which have expanded to involve pancreaticoduodenectomy. Minimally invasive surgery has gained worldwide recognition in a wide range of areas, but pancreatic surgery remains one of the most complex fields in general surgery.[3] More complex operations including laparoscopic pancreaticoduodenectomy also be beneficial with a minimally invasive approach but are less frequently used.[4] Laparoscopic pancreaticoduodenectomy has been reported to be a safe, feasible and effective procedure in the hands of an experienced surgeon, but laparoscopic experience is a must. Pancreas surgery poses challenges because of the anatomic location of the organ and its proximity to vital organs. Consequently, its evolution has been slower compared to other surgical procedures. The first minimally invasive pancreas surgery was reported in 1994. During the development of initial laparoscopic procedures, close dissection was performed with anastomoses created using minimal laparotomy or hybrid approach.[5] The use of a mini-laparotomy and hand-port for the creation of the anastomosis is particularly helpful in difficult situations.

## Materials and Methods

From April 2018 to August 2018, nine patients were selected to undergo laparoscopic pancreaticoduodenectomy at the Department of Gastroenterology Surgery, City Hospital. All surgical operations were performed laparoscopically in our clinic. The demographic characteristics, perioperative details, and pathological results were retrospectively reviewed. All patients underwent preoperative workup including laboratory investigations on blood samples, tumor markers and imaging studies including computed tomography of the abdomen and chest and magnetic resonance imaging of the pancreas. Only patients with the following specific characteristics were deemed eligible for a laparoscopic pancreaticoduodenectomy: Eastern Cooperative Oncology Group performance status 0, body mass index (BMI) less than 30 kg/m$^2$, a small neoplastic lesion (<4 cm) confined to the pancreas, the absence of infiltration to any organs and/or blood vessels (T1 or T2). In one patient, the reconstruction (gastrojejunostomy) was done through a small incision which was also used for collecting sample extruction.Treatment included partial or complete parenteral or enteral nutrition. Liquid diet (soups) is better than solid diet in the treatment of patients with delayed gastric emptying. Promotility agents were used for management of these patients including metoclopramide or domperidone. Our study patients met the American Society of Anesthesiologists grade 1–2–3 criteria. Proximity of the tumor to the vasculature (and invasion, if any) was determined in accordance with established criteria for pancreas surgery.

### Surgical Technique And Intraoperative Steps

A total of 9 patients underwent this procedure. A single surgeon performed laparoscopic pancreaticoduodenectomy for all patients. The patients were placed in the modified lithotomy, reverse Trendelenburg position (French position). The surgeon stood between the legs of the patient. Six ports were used for the surgery. The camera was placed at on the left side of the patient while the assistant surgeon stood on the right side of the patient. The port positions are shown in Figure 1. We developed stages to standardize the operation. The step-by-step surgical technique for laparoscopic pancreaticoduodenectomy is shown in Table 5. Here, we used the standardized 14-step technique that we developed. One of the factors affecting the technique for creation of anastomosis is the port position. Placing the port according to the laparoscopic surgical rules provides ease of anastamosis. End-to-side pancreaticojejunostomy was performed with 4 large needles (3/0) trans-pancreatic sutures and 4 to 6 duct-to-mu-


**Figure 1.** The port positions.

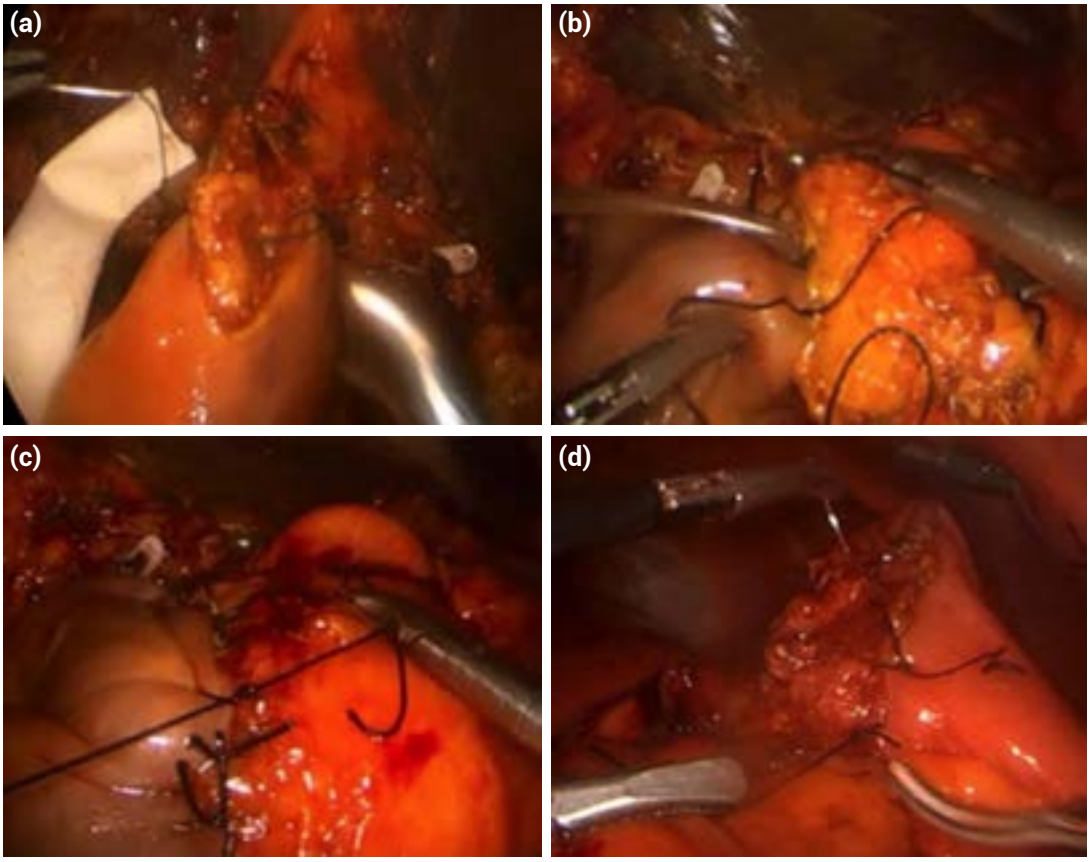


**Figure 2.** Pancreatic and biliary reconstructions. **(a)** Hepaticojejunostomy, **(b)** pancreaticojejunostomy placing the stent, **(c)** pancreaticojejunostomy, **(d)** duodenojejunostomy.

cosa sutures using 4/0 absorbable multifilament combined with a 12 cm, 6 or 7 Fr internal stent, guided by 3D laparoscopy. Two surgical drains were placed alongside the pancreaticojejunostomy (Fig. 2).

## Results

Five female and four male patients with a mean age of 64.5 years underwent laparoscopic pancreaticoduodenectomy. The average operative time and intraoperative blood loss were 593 min and 207 mL, respectively. The mean body mass index was 26.7 kg/m$^2$ (range, 24–30) and a median American Society of Anesthesiologists Classification score was 2 (Table 1). Routine early postoperative enteral nutrition (through the nasogastric suction tube) was not preferred. However, recovery from -anesthesia was prolonged in one patient. The mean length of postoperative hospital stay was 21 (9–36) days (Table 2). Of note, the overall incidence of clinically relevant postoperative grade B pancreatic fistula was 22% (Table 3). The mean number of lymph nodes harvested was 14. In all patients, a R0 resection (curative resection) was achieved. One patient died due to pulmonary embolism in the third postoperative day. No other patients died during 90 days after the operation. Final pathologic examination revealed four malignant pancreatic ductal adenocarcinoma, one adenocarcinoma of the ampulla of Vater, two ampullary neuroendocrine tumors and two benign lesions (Table 4).

The mean diameters of the pancreatic duct and bile duct were 4 mm (3–6 mm) and 12 mm (10–16 mm), respectively. The mean tumor size was 2.1 cm (1.5–4 cm), and the mean number of lymph nodes harvested was 14 (6–24).

## Discussion

Minimally invasive pancreatic resections are technically complex procedures but rapidly gaining popularity.[6] Though initially slow to gain acceptance, the minimally invasive approach to pancreatic resection has recently been adopted by an increased number of surgeons and pancreatic surgeries are now frequently performed laparoscopically. Regarding oncological considerations, despite initial concerns, laparoscopic resection seems to be non-inferior to an open procedure in terms of lymph node harvesting, negative margin rates, and long-term survival.[4]

Zhang YH al. suggested that minimally invasive pancreaticoduodenectomy is as safe and feasible as open pan-

**Table 1. Patient demographics and surgical data, n (%)**

| Characteristic | Median (range) |
|---|---|
| Patients, n | 9 |
| Age, Mean±SD (years) | 64.5±14 |
| Body mass index (kg/m$^2$) | 26.7 (26–30) |
| ASA score | 2 (1–3) |
| Sex, female/male | 5/4 |
| Tumor status | |
| Benign | 2 (22) |
| Malignant | 7 (78) |
| Parenchymal background, n | |
| Soft | 2 |
| Intermediate | 4 |
| Solid | 3 |
| Type of procedure | |
| Pylorus-preserving | 6 (78) |
| Operative time, mean (range), (min) | 593 (480–797) |
| Estimated blood loss, mean (range) (mL) | 207 (110–500) |
| Conversion rate, mean (range) | 2 (22) |
| Number of lymph nodes harvested, mean (range) | 14 (6–24) |

creaticoduodenectomy, and shows some benefit, such as less intraoperative blood loss and shorter hospitalization.[7] Wang et al.[8] reviewed 32 articles representing 2209 patients to evaluate the current status of minimally invasive pancreaticoduodenectomy and concluded that minimally invasive pancreaticoduodenectomy is technically feasible and safe in carefully selected patients and can provide acceptable oncologic outcomes. However, concerns such as long-term outcomes, cost-effectiveness and learning curve must be fully addressed.

Nigri et al.[9] conducted a meta-analysis on 8 eligible studies including 204 patients undergoing minimally invasive pancreaticoduodenectomy and 419 patients undergoing open pancreaticoduodenectomy. They found no significant differences between minimally invasive pancreaticoduodenectomy and open pancreaticoduodenectomy in overall mortality and rates of repeat surgery and concluded that the minimally invasive pancreaticoduodenectomy procedure is safe and effective in selected cases. They also reported that minimally invasive pancreaticoduodenectomy may be associated with a number of potential advantages over undergoing open pancreaticoduodenectomy such as improved negative margin status and

**Table 2. Patient demographics and surgical data**

| N | Age | Gender | Body mass index | ASA | Mortality 30 first the days | Pancreas leak | Bile leak | Estimated blood loss (mL) | Tumor size (cm) | Pathological diagnosis | Operative time (min) | Length of hospital stay (days) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 63 | Male | 28 | 2 | Yes | No | No | 150 | 2 | Neuroendocrine tumor | 660 | 9 |
| 2 | 65 | Male | 27 | 2 | No | Yes | No | 110 | 2 | Ampulla adenocarcinoma | 645 | 9 |
| 3 | 64 | Male | 26 | 2 | No | No | No | 130 | 1.5 | Ductal adenocarcinoma | 480 | 21 |
| 4 | 49 | Female | 26 | 1 | No | No | No | 160 | 1.8 | Neuroendocrine tumor | 627 | 19 |
| 5 | 75 | Female | 28 | 3 | No | No | Yes | 120 | 2 | Pancreatic adenoma | 797 | 30 |
| 6 | 65 | Female | 30 | 2 | No | Yes | Yes | 500 | 2 | Ductal adenocarcinoma | 555 | 36 |
| 7 | 62 | Female | 26 | 2 | No | No | No | 220 | 1.6 | Ductal adenocarcinoma | 612 | 16 |
| 8 | 78 | Male | 26 | 2 | No | No | No | 180 | 4 | Polycystic pancreas | 480 | 24 |
| 9 | 60 | Female | 24 | 2 | No | No | No | 300 | 4 | Ductal adeno carcinoma | 480 | 24 |

ASA: American Society of Anaesthesiologists.

**Table 3. Surgical outcomes and complications**

| | n | % |
|---|---|---|
| Number of all patients | 9 | 100 |
| Pancreatic anastomotic leak | 2 | 22 |
| Delayed gastric emptying | 2 | 22 |
| Postoperative pneumonia | 1 | 11 |
| Surgical site infection | 1 | 11 |
| Bile leak | 2 | 22 |
| Mortality (postoperative on the third day due to pulmonary embolism) | 1 | 11 |
| 90 day mortality rate | 1 | 11 |

**Table 4. Final diagnosis and histologic findings**

| | n | % |
|---|---|---|
| Diagnosis | | |
| Pancreatic ductal adenocarcinoma | 4 | |
| Ampullary neuroendocrine tumor | 2 | |
| Ampullary adenocarcinoma | 1 | |
| Pancreatic adenoma and Polycystic pancreas | 2 | |
| Characteristics of surgical specimen | | |
| Tumor size, median (range) (cm) | 2.1 (1.5–4.0) | |
| Margin-negative, R0 resection | 9 | 100 |
| Regional lymph node metastases | 3 | 33 |

**Table 5. Step-by-step operative technique of LPD**

**Dissection**

1. Gastrocolic ligament opening
2. Right colonic flexure mobilization
3. Right gastroepiploic artery division
4. Kocher maneuver
5. Gastroduodenal artery dissection and transection
6. Common bile duct dissection with suspensio and transection after 10 steps
7. Cholecystectomy
8. Jejunal loop transection (at the Treitz ligament)
9. Duodenum division
10. Uncinate process dissection with pancreas suspension
11. Pancreatic neck transection

**Reconstruction**

12. Hepaticojejunostomy
13. Pancreatojejunostomy following pylorojejunostomy or gastrojejunostomy
14. Specimen extraction and closure

**Standardized 14-step technique**

lower rates of post-operative complications but it should be performed and developed through use in selected patients in highly experienced medical centers.

In Liang et al.'s[10] study, minimally invasive pancreaticoduodenectomy and open pancreaticoduodenectomy showed comparable safety and cost in their preliminary patient series. Nevertheless, the trend toward a higher rate of repeat surgery with a pancreatic leakage suggests the need for caution when implementing this new technique. Almost fifty years later, minimally invasive pancreatoduodenectomy is still controversial. As Pędziwiatr et al.[11] suggested, it can be argued whether a surgical procedure of 5 to 8 hours can actually be called a "minimally invasive" procedure? On the one hand, minimally invasive pancreaticoduodenectomy does not require a long incision, and for this reason it can really be called "less invasive". Numerous systematic reviews compared the results of minimally invasive (manual, laparoscopic or manual) and open pancreatoduodenectomy. However, many of them include studies involving pure minimally invasive pancreaticoduodenectomy and hybrid procedures, where dissection was performed using a minimally invasive approach, but anastomoses were created manually with minilaparotomy. Appropriate patient selection is a critical factor before considering laparoscopic pancreas surgery Comorbid conditions may render surgical operation more challenging. The earliest series of minimally invasive pancreaticoduodenectomy involved patients with small, benign or low-grade tumors of the pancreatic head, duodenal ampulla, and distal common bile duct, in the absence vascular or extrabiliary involvement.[5]

Pancreatic fistulas are the most common complications following Whipple's procedure. In our series, the rate of grade B pancreatic fistula meeting International Study Group of Pancreatic Fistula (ISGPF) criteria was 22%. Our patients who developed fistula were treated conservatively. There was no need for interventional or surgical treatment. The oncological outcomes following a laparoscopic procedure have not been fully described in comparison to the open surgery. The safety of laparoscopic pancreas surgery has been clearly demonstrated in several studies in published literature. All of the patients in our series had negative resection margin. The number of

lymph nodes removed was adequate owing to the magnification with the 3D imaging system. Preoperative use of imaging modalities and diagnostic laparoscopy may improve surgical outcomes.[12]

Chen et al.[13] conducted a literature review and meta-analysis to compare outcomes of minimally invasive pancreaticoduodenectomy versus open pancreaticoduodenectomy. One hundred studies were included for systematic review and of these, 26 (3402 cases in total; 1064 for minimally invasive pancreaticoduodenectomy, 2338 for open pancreaticoduodenectomy) were included in the meta-analysis. minimally invasive pancreaticoduodenectomy was found to be associated with less blood loss, longer operation time, faster postoperative recovery, and shorter length of hospitalization However, they cautioned that their results need to be confirmed through comparative studies and randomized clinical trials. There are many factors affecting the operative time. Patient-related factors include the location and size of the tumor. Surgical experience is also important. Unfortunately, there is no clear explanation about the learning curve. In ou study, we found that the learning curve was associated with decreased operative time and blood loss.

Some studies have shown that laparoscopic pancreaticoduodenectomy is better than open pancreaticoduodenectomy.[14] However, some studies reported that laparoscopic pancreaticoduodenectomy is a difficult procedure associated with a high morbidity. They concluded that laparoscopic pancreaticoduodenectomy should not be used routinely for resection of periampullary tumors.[14] Meng et al.[14] reported that laparoscopic pancreaticoduodenectomy is a feasible, effective and safe method for the treatment of nonpancreatic periampullary adenocarcinoma which may be used as an alternative to open pancreaticoduodenectomy. In our study, dissection was easier in a patient with an ampullary tumor.

Surgeons should have gained some experience in other laparoscopic surgeries before advancing to laparoscopic pancreaticoduodenectomy. While little skill is required for sutures used in laparoscopic operations, laparoscopic pancreas surgery requires technically challenging intracorporeal anastomoses and takes more time.[15] Therefore, some authors suggest that it should be performed in high-volume pancreatic surgery centers in selected patients.[16]

Recently, minimally invasive robotic pancreaticoduodenectomy emerged as a new technique. Despite its potential benefits and encouraging results, robotic pancreaticoduodenectomy use is limited and controversial. In a study by Wang et al.,[18] robotic pancreaticoduodenectomy was reported as a safe and feasible technique, with acceptable oncological outcomes for highly selected patients in the hands of experienced surgeons.[17] Guerra et al.[19] studied on 59 patients who underwent robotic pancreaticoduodenectomy. Median hospital stay was 9 days and overall morbidity and mortality were 37% and 3%, respectively. R0 resections were achieved in 96% of patients and 3-year disease-free and overall survival rates were 37.2% and 61.9%, respectively. They concluded that robotic pancreaticoduodenectomy can be performed reliably and it satisfies all requirements of oncological adequacy. Despite promising results, global acceptance of robotic pancreaticoduodenectomy as the 'gold standard' is still work in progress. This is because a limited number of centers specialize in pancreatic minimally invasive surgery and adequately powered randomized controlled trials are difficult to conduct. However, the results of many studies show that robotic pancreatic surgery is safe and feasible for a highly selected group of patients.[20,21]

None of the patients in our series received neoadjuvant chemotherapy and the expert council decided on surgical treatment for their condition. Newer neoadjuvant treatment protocols offer the possibility to downstage advanced tumors, potentially increasing candidates for curative surgery. Conversely, the benefits of neoadjuvant therapy in patients with technically resectable tumors have not been unequivocally demonstrated and its optimal indications are highly controversial.[22]

Given today's global economic climate where careful allocation of limited healthcare resources is essential, cost is an important consideration for minimally invasive surgery. In a study by Gerber et al.,[23] the cost of laparoscopic pancreaticoduodenectomy for initial hospitalization was equivalent to open pancreaticoduodenectomy and total operating room costs were higher in the laparoscopic pancreaticoduodenectomy group in comparison to the open pancreaticoduodenectomy group (median $12,290 versus $11,299; p=0.05). The authors concluded that total costs of care per episode may favor laparoscopic pancreaticoduodenectomy by reducing post-hospital requirements for qualified nursing and rehabilitation. The average cost in our study per patient was $3500.

Laparoscopic pancreatoduodenectomy represents one of the most advanced laparoscopic procedures involving difficult anatomy and meticulous dissection around ma-

jor blood vessels. However, only a few studies exist in literature focusing on this complex procedure. In our study, anastomosis technique for laparoscopic pancreaticoduodenectomy was associated with favorable outcomes and a low risk of pancreatic fistula. All patients in our series underwent pancreaticojejunostomy with an internal stenting.

## Conclusion

Based on this initial study, laparoscopic pancreaticoduodenectomy is safe and feasible, producing acceptable results when performed in highly selected patients by experienced surgeons. However, evidence for long-term outcomes and learning curve should be demonstrated. Further studies from multiple centers are needed to support our conclusions.

### Disclosures

**Ethichs Committee Approval:** The study was approved by the Local Ethics Committee.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

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