**Original Article**

# A Non-Randomized Comparative Study of Laparoscopy-Assisted Pancreaticoduodenectomy and Open Pancreaticoduodenectomy

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**Running title: Laparoscopy-assisted pancreaticoduodenectomy**

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**ABSTRACT**

**Background/Aims:** Laparoscopic surgery for periampullary disease is still a challenging operation. The aim of this study was to compare the perioperative outcomes of patients undergoing conventional pancreaticoduodenectomy (PD) with the outcomes of those undergoing laparoscopy-assisted PD.

**Methodology:** A retrospective analysis was conducted on 51 consecutive patients who underwent laparoscopy-assisted or open PD for periampullary disease.

**Results:** There were no significant differences in the preoperative demographic or clinical data of the two study groups. Although there were no significant differences in the operative time between the two study groups, blood loss in the laparoscopy-assisted PD group was significantly smaller than that in the open PD group. There were no significant differences in the occurrence of postoperative complications between the two groups.

**Conclusions:** Laparoscopy-assisted PD is a feasible and safe surgical procedure that provides the advantages expected from a minimally invasive surgery including less blood loss.

**KEYWORDS**: laparoscopy-assisted, pancreaticoduodenectomy, minimally invasive.

**ABBREVIATIONS:** Pancreaticoduodenectomy (PD); Pylorus-preserving PD (PPPD); Subtotal stomach-preserving PD (SSPPD); International Study Group on Pancreatic Fistula (ISGPF); International Study Group of Pancreatic Surgery (ISGPS); Superior mesenteric artery (SMA); Superior mesenteric vein (SMV); Portal vein (PV); American Society of Anesthesiologists (ASA); Body mass index (BMI); Hemoglobin A1c (HbA1c); *N*-benzoyl-tyrosyl-*p*-aminobenzoic acid (BT-PABA); Intraductal papillary mucinous neoplasm (IPMN)

## Introduction

Although minimally invasive approaches to gastrointestinal surgery are performed routinely, laparoscopic pancreaticoduodenectomy (PD) is uncommon. The first report of laparoscopic PD was published by Gagner and Pomp in 1994 (1). Despite several improvements in surgical devices and techniques that have allowed surgeons to approach the pancreas laparoscopically, laparoscopic PD remains challenging, and the performance of successful laparoscopic PD has been limited. Kimura et al. (2) report that hand-assisted laparoscopic PD is less invasive than conventional open surgery and presents no technical difficulties. Palanivelu et al. (3) report complete laparoscopic PD in 45 patients for varying indications, including periampullary malignancies. Additionally, robot-assisted PD is one of the most advanced and newest surgical innovations for minimally invasive surgery (4-8). Thus, a variety of laparoscopic procedures have been used for PD. We performed laparoscopy-assisted PD, in which pancreaticoduodenal resection was performed laparoscopically and reconstruction of the digestive tract was performed through a midline minilaparotomy. The aim of the present study was to compare

the perioperative outcomes of patients undergoing conventional open PD with the outcomes of those undergoing laparoscopy-assisted PD.

**Patients and Methods**

We carried out a retrospective analysis on 51 consecutive patients who underwent laparoscopy-assisted or open PD for pancreatic and periampullary disease at Nagasaki University Hospital between January 2008 and December 2010. The subjects included 32 men and 19 women with a mean age of 72.9 years (range 54 to 86 years). The patients were divided into 2 groups according to surgical procedure. Patients who underwent reconstruction of the portal vein and/or extended lymph node dissection were excluded. The pancreatic resection of the PD consisted of a pylorus-preserving PD (PPPD) and a subtotal stomach-preserving PD (SSPPD). Laparoscopy-assisted PD was performed by one of the authors (T.K.) and open PD was performed by two of the authors (T.K., T.A.). Demographics, and intraoperative and postoperative outcome data were analyzed. Continuous data are expressed as mean ± SD. The 8 preoperative and 7 intraoperative parameters were registered as presumed risk factors for postoperative pancreatic complications. The diagnosis was based on postoperative histopathological diagnosis. The pancreatic fistula was defined according to the International Study Group on Pancreatic Fistula

(ISGPF) definition (9). Delayed gastric emptying was defined according to the International Study Group of Pancreatic Surgery (ISGPS) definition (10). Statistical analysis was carried out using either the Mann-Whitney *U* test or Fisher's exact test. Differences were considered significant at $P < 0.05$.

**Technique for Laparoscopy-Assisted PD**

The patients were placed in the lithotomy position. Under general anesthesia, the first 12-mm laparoscopic trocar was inserted at the umbilicus using an open technique, and pneumoperitoneum was set at 8 mm Hg. Five additional trocars were inserted: 2 12-mm trocars level with the right and left midclavicular lines, 1 12-mm trocar level with the subxiphoid, and 2 5-mm trocars level with the right and left anterior axillary lines. The first step was to expose the head and body of the pancreas by opening the lesser sac. The right gastroepiploic vessels were divided. In the PPPD, the first part of the duodenum was transected with a linear stapler 2-4 cm distal to the pyloric ring. In the SSPPD, the stomach was transected 2 cm proximal to the pyloric ring. The edge of the transecting duodenum/stomach was grasped and retracted to employ the Kocher maneuver. An upper

portion of the jejunum was transected beyond the ligament of Treitz with a linear stapler, and the jejunum proximal to the fourth part of the duodenum was delivered posterior to the superior mesenteric artery (SMA) and the superior mesenteric vein (SMV) from left to right. A tunnel was developed between the SMV and the pancreas. The pancreatic parenchyma was transected anterior to the portal vein (PV) using ultrasonic shears. The gastroduodenal artery and the right gastric artery were divided. The common hepatic duct was transected just above the entrance of the cystic duct with a linear stapler following the removal of the gallbladder. At this point, the specimen, including the pancreas head and uncinate process, was connected to the neural plexuses and connective tissue of the right lateral aspect of the SMV and SMA. Next, dissection between the pancreas head including the uncinate process and the superior mesenteric vessels was performed using a 5-mm LigaSure V vessel sealing instrument (Covidien, Norwalk, CT, USA) and ultrasonic shears using a pancreas-hanging maneuver as described in the literature (11). The specimen was removed by extending the subxiphoid port site by 5 to 8 cm. The reconstruction was performed following Child’s method through a midline

minilaparotomy, as in open surgery, through which the tumor was removed. For reconstruction, the proximal jejunum was brought up behind the transverse colon by the retrocolic route. End-to-side pancreaticojejunostomy using a mucosa-to-mucosa two-layer technique was performed, followed by an end-to-side hepaticojejunostomy, and an end-to-side single-layer duodenojejunostomy or gastrojejunostomy using an open method as conventional open PD. The reconstruction of the enterojejunostomy was performed by the antecolic route. Two closed suction drains were routinely placed near the biliary and pancreatic anastomoses.

**Results**

In the laparoscopy-assisted PD group, no patients needed to be converted to open PD. The preoperative demographic and clinical data of the two study groups are compared in Table 1; there were no significant differences in patient age, gender, American Society of Anesthesiologists (ASA) physical status score, body mass index (BMI), or preoperative serum bilirubin between the groups. The groups were also similar in hemoglobin A1c (HbA1c) levels, and *N*-benzoyl-tyrosyl-*p*-aminobenzoic acid (BT-PABA) test results. In the laparoscopy-assisted PD group, 8 patients had bile duct carcinoma, 6 patients had intraductal papillary mucinous neoplasm (IPMN) of the pancreas, 5 patients had ampullary carcinoma, and 1 patient had an islet cell tumor. In the open PD group, 18 patients had bile duct carcinoma, 7 patients had IPMN of the pancreas, 4 patients had pancreatic carcinoma, 1 patient had ampullary carcinoma, and 1 patient had chronic pancreatitis. There was no significant difference in diagnosis between the groups. The intraoperative data for the two study groups are shown in Table 2. No significant differences were seen in the type of pancreatic resection, lymphadenectomy, texture of the pancreas,

main pancreatic duct size, or operative time between the two groups. In contrast, there were significant differences in intraoperative bleeding, and red blood cell transfusion requirements between the groups. The postoperative complications of the patients in the two study groups are compared in Table 3. Postoperative pancreatic fistula was identified in 9 patients in the laparoscopy-assisted PD group, and was classified in 6 patients as grade A, being transient and asymptomatic with only elevated drain amylase values, and as grade B in 3 patients, who required percutaneous drainage of an amylase-rich or infected peripancreatic intra-abdominal collection. In the open PD group, pancreatic fistula occurred in 12 patients, grade A in 7 and grade B in 5. There were no cases of grade C pancreatic fistula in this study. Postoperative delayed gastric emptying was identified in 3 patients in each group, in both groups as grade A in 2 and grade B in 1. Three patients developed bile leakage in the open PD group. There were no significant differences in the occurrence of postoperative complications between the two study groups.

**Discussion**

Laparoscopic surgical procedures can be used for several operations and provide the advantages of minimally invasive surgery. Although laparoscopic PD has been slow to be developed in the field of operation under laparoscopy, the effort of many surgeons and progress in surgical techniques and laparoscopic instruments have made laparoscopic PD possible in recent years (1-3, 12-18). Recent reports note that complete laparoscopic PD including laparoscopic resection and reconstruction is both technically feasible and safe (3-8, 19). In some cases a minilaparotomy of a few cm is necessary to remove the resected specimen. Therefore, we chose laparoscopy-assisted PD rather than complete laparoscopic PD. The reconstruction, including pancreaticojejunostomy, choledochojejunostomy and gastrojejunostomy can be performed through a midline minilaparotomy of approximately 5 cm through which the resected specimen is removed. An important point in the midline minilaparotomy of laparoscopy-assisted PD is to place the incision exactly above the resected end of the pancreas in order to obtain a favorable surgical view of the reconstruction of the

pancreaticojejunostomy because this reconstruction is associated with the development of postoperative complications (20, 21). In the present study, there were no significant differences between the two groups in terms of complications, including pancreatic fistula. On the other hand, although there was no significant difference in operative time, laparoscopy-assisted PD was associated with less blood loss, which is one of the advantages of minimally invasive surgery. Several reports have pointed out that laparoscopic surgery is associated with lower blood loss in pancreatic surgery (22, 23). A randomized prospective study of laparoscopy-assisted PD versus open PD should be considered for further conclusive evidence.

Recently, Giulianotti et al. (8) reported the usefulness of robotic surgery for laparoscopic PD. Robotic technology allows the surgeon to perform the sophisticated needle manipulations for precise and safe reconstruction, especially in pancreaticojejunostomy. Laparoscopy-assisted PD may thus play an important role as a bridge between the conventional open PD and complete laparoscopic PD using the robotic technology.

In conclusion, laparoscopy-assisted PD is a feasible and

safe surgical procedure that provides the advantages expected from minimally invasive surgery including less blood loss. A prospective study involving a large series and long follow-up evaluation is needed to reach definitive conclusions.

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Table 1. Demographic and clinical data of the patients

| | Laparoscopy-assisted PD (n=20) | Open PD (n=31) | P value |
|---|---|---|---|
| Age (y) | 71.2 ± 8.8 | 73.5 ± 7.3 | NS |
| Sex (M/F) | 11 / 9 | 21/ 10 | NS |
| ASA status | 1.5 ± 0.6 | 1.6 ± 0.7 | NS |
| Preoperative BMI (kg/m2) | 21.9 ± 4.0 | 22.9 ± 3.4 | NS |
| Preoperative serum bilirubin (mmol/L) | 1.7 ± 3.7 | 2.4 ± 3.3 | NS |
| HbA1c (%) | 5.5 ± 0.5 | 6.0 ± 1.6 | NS |
| BT-PABA test (%) | 57.7 ± 14.9 | 60.2 ± 17.7 | NS |
| Diagnosis | | | NS |
| Bile duct carcinoma | 8 | 18 | |
| IPMN of the pancreas | 6 | 7 | |
| Ampullary carcinoma | 5 | 1 | |
| Islet cell tumor | 1 | 0 | |
| Pancreatic carcinoma | 0 | 4 | |
| Chronic pancreatitis | 0 | 1 | |

ASA, American Society of Anesthesiologists; BMI, body mass index; HbA1c, hemoglobin A1c; BT-PABA, N-benzoyl-tyrosyl-p-aminobenzoic acid; IPMN , intraductal papillary mucinous neoplasm; NS, not significant.

Table 2. Intraoperative data of the patients

| | Laparoscopy-assisted PD (n=20) | Open PD (n=31) | P value |
|---|---|---|---|
| Type of pancreatic resection | | | NS |
| PPPD | 16 | 26 | |
| SSPP | 4 | 5 | |
| Lymphadenectomy | | | NS |
| Non | 6 | 5 | |
| Regional | 14 | 26 | |
| Texture of the pancreas | | | NS |
| Soft | 18 | 26 | |
| Hard | 2 | 5 | |
| Main pancreatic duct size (mm) | 3.0 ± 1.5 | 3.0 ± 1.4 | NS |
| Operative time (min) | 656.6 ± 191.4 | 554.6 ± 119.4 | NS |
| Intraoperative bleeding (ml) | 376.6 ± 291.4 | 1509.5 ± 1000.2 | < 0.01 |
| Red blood cell transfusion | 0 | 13 | < 0.01 |

Table 3. Postoperative complications of the patients

| | Laparoscopy-assisted PD (n=20) | Open PD (n=31) | P value |
|---|---|---|---|
| Pancreatic fistula, ISGPF | | | NS |
| Grade A | 6 | 7 | |
| Grade B | 3 | 5 | |
| Grade C | 0 | 0 | |
| Delayed gastric emptying, ISGPS | | | NS |
| Grade A | 2 | 2 | |
| Grade B | 1 | 1 | |
| Grade C | 0 | 0 | |
| Bile leakage | 0 | 3 | NS |

ISGPF ,International Study Group on Pancreatic Fistula; ISGPS, International Study Group on Pancreatic Surgery.