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Laparoscopic pancreaticoduodenectomy and laparoscopic pancreaticoduodenectomy with robotic reconstruction: single-surgeon experience and technical notes

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Purpose: Despite the increasing number of robotic pancreaticoduodenectomies, laparoscopic pancreaticoduodenectomy (LPD) and LPD with robotic reconstruction (LPD-RR) are still valuable surgical options for minimally invasive pancreaticoduodenectomy (MIPD). This study introduces the surgical techniques, tips, and outcomes of our experience with LPD and LPD-RR.

Methods: Between March 2014 and July 2021, 122 and 48 patients underwent LPD and LPD-RR respectively, at CHA Bundang Medical Center in Korea. The operative settings, procedures, and trocar placements were identical in both approaches; however, different trocars were used. We introduced our techniques of retraction methods for Kocherization and uncinate process dissection, pancreatic reconstruction, pancreatic division, and protection using the round ligament. The perioperative surgical outcomes of LPD and LPD-RR were compared.

Results: Baseline demographics of patients in the LPD and LPD-RR groups were comparable, but the LPD group had older age (65.5 ± 11.6 years vs. 60.0 ± 14.1 years, $p = 0.009$) and lesser preoperative chemotherapy (15.6% vs. 35.4%, $p = 0.008$). The proportion of malignant disease was similar (LPD group, 86.1% vs. LPD-RR group, 83.3%; $p = 0.759$). Perioperative outcomes were also comparable, including operative time, estimated blood loss, clinically relevant postoperative pancreatic fistula (LPD group, 9.0% vs. LPD-RR group, 10.4%; $p = 0.684$), and major postoperative complication rates (LPD group, 14.8% vs. LPD-RR group, 6.2%; $p = 0.082$).

Conclusion: Both LPD and LPR-RR can be safely performed by experienced surgeons with acceptable surgical outcomes. Further investigations are required to evaluate the objective benefits of robotic surgical systems in MIPD and establish widely acceptable standardized MIPD techniques.

Keywords: Laparoscopy, Robotics, Minimally invasive surgical procedures, Pancreaticoduodenectomy

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INTRODUCTION

Minimally invasive approaches have been employed in most general surgical fields [1]. However, one of its slowest-growing areas is minimally invasive pancreaticoduodenectomy (MIPD) which still accounts for a small portion of all pancreaticoduodenectomy (PD) procedures [1]. The majority of MIPDs have been performed by a few expert surgeons in high-volume centers [1]. However, with a growing body of literature supporting the feasibility and oncologic safety of MIPD, great interest has emerged among enthusiastic surgeons. Although a multicenter randomized phase 2/3 trial (LEOPARD-2 trial) failed to show the safety of laparoscopic PD (LPD) compared to open PD (OPD) [2], other randomized controlled trials (RCTs) (PADULAP [3] and PLOT [4]) illustrated that LPD was associated with comparable postoperative complications and shorter length of hospital stay than OPD; a recent RCT also mirrored these results [5].

There are several options for MIPD, including LPD, LPD with open reconstruction, LPD with robotic reconstruction (LPD-RR), and robotic PD (RPD) [6]. Recently, some studies have advocated the advantages of RPD over OPD [7,8]. Despite technological advancements and surgeon-oriented advantages of the robotic surgical system, a meta-analysis of RCTs and matched studies demonstrated no differences in perioperative outcomes between LPD and RPD [9]. Therefore, many surgeons perform LPD or LPD-RR instead of RPD alone [8]. Aside from cost-effectiveness, the two phases of resection and reconstruction in MIPD involve different surgical environments. Moreover, the resection phase covers a wide operative field, that requires frequent changes in surgical targets and instruments. However, during the reconstruction phase, the surgical field of view is fixed, for which a more static and delicate technique is required. The laparoscopic approach has fluidity of movement for a wide range of operative fields, whereas the robotic approach has the advantage of high-fidelity motion with increased instrument dexterity. Therefore, the tailored use of minimally invasive modalities according to each phase would be helpful for the surgeon's adaptation to MIPD. A recent European multicenter study evaluated the learning curves of LPD, RPD, and LPD-RR and demonstrated that LPD-RR had a shorter learning curve than the other methods [10].

In this article, we describe techniques and tips for LPD and LPD-RR and report the outcomes of both surgical approaches.

METHODS

Patients and methods

In total, 122 and 48 consecutive patients underwent LPD and LPD-RR, respectively, for periampullary pathologies performed by a single surgeon from March 2014 to July 2021 at CHA Bundang Medical Center; their medical records were retrospectively reviewed. Patients with RPDs were excluded from the study. Perioperative surgical outcomes of LPD were compared with those of LPD-RR.

MIPD was contraindicated based on the following criteria: (1) poor general health assessed by an American Society of Anesthesiologists physical status classification of >III; (2) uncertain safety of surgical margins regarding the proximity to major arterial structures, pancreatic resection margins, and upper bile duct margins; (3) locally advanced malignancies with invasion of other organs; and (4) risk of tumor rupture during the procedure. Independent surgeons informed all patients on the benefits and disadvantages of each surgical approach, including open surgery, allowing patients to voluntarily select the surgical method.

Definitions for the study

Postoperative complications were graded using the Clavien-Dindo classification system [11]. Postoperative pancreatic fistula (POPF) [12], delayed gastric emptying [13], and postpancreatectomy hemorrhage (PPH) [14] were graded according to the International Study Group of Pancreatic Surgery, and bile leakage was defined according to the International Study Group of Liver Surgery [15]. Furthermore, pancreatic textures were categorized as soft (normal, friable) or hard (fibrotic, sclerotic), as determined by the surgeon's intraoperative assessment using instrumental touch sensation and visual judgment [16]. Pancreatic duct size was measured at the cut surface of the remnant pancreas during the operation. These data were recorded in operative notes.

Surgical techniques

Operative setting

In our basic operative setting, the patient is positioned in the supine and reversed Trendelenburg positions with slight right-side elevation. We use three 12-mm and two 5-mm trocars (Fig. 1). Port no. 1, the main camera port, is placed at the umbilicus, and the incision is used for the extraction of the specimen and extracorporeal anastomosis of the duodenojejunostomy using

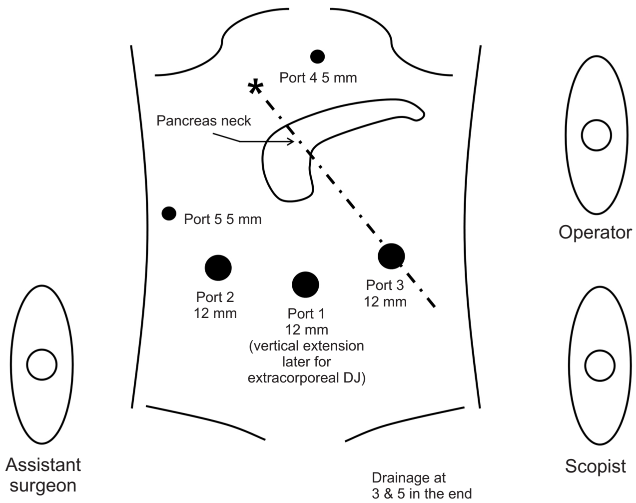

Fig. 1. Basic operative setting. The patient is positioned in the supine and reversed Trendelenburg positions with slight right-side elevation. Three 12-mm and two 5-mm trocars are used in laparoscopic pancreaticoduodenectomy. In laparoscopic pancreaticoduodenectomy with a robotic reconstruction approach, port 5 is replaced with an 8-mm robotic trocar, and two robotic working arms are docked to port 3 (using the double-docking technique) and port 5. The operator and scopist stand on the left side of the patient, and the assistant surgeon stands on the right side. *Pancreatic neck resection line.

a small extension. Thus, the positioning of ports no. 2 and 3 is important. Port no. 2 is placed at the right midclavicular line at the same level as the umbilical port in the axial plane. This port is used as the laparoscopic camera during the dissection of the uncinate process [17]; if it is placed too far laterally, the laparoscopic view will be too low, and if placed more medially, the operative view will be too close to the target organ with a narrow angle. Then, port no. 3 is placed at the left midclavicular line, slightly cranial to the umbilical port. This port is used to transect the pancreatic neck and reconstruct the remnant pancreas and hepatic duct. We obliquely transect the pancreatic neck to better visualize the cut surface during pancreatic reconstruction; therefore, this port is placed in a straight line with the oblique pancreatic neck resection plane (asterisk in Fig. 1). It would be difficult for the operator to manipulate the instrument through port no. 3 if the port is placed at the same level or lower than the umbilical port. Thus, the operator and scopist stand on the left side of the patients, while the assistant surgeon stands on the right side.

Laparoscopic resection phase

This procedure was described in detail in previous publication [17]. Before the procedure, the abdominal cavity is explored to confirm the presence of metastases or abnormalities. The round ligament is then retracted upward to expose the liver hilum by needling it with a 2-0 monofilament-straight needle and tying it up extracorporeally. We prefer pylorus-preserving PD in most patients, except when tumors are close to the pylorus or in the presence of gastric pathology. The resection consisted of three phases: mobilization, portal dissection, and uncinate dissection.

• Mobilization phase

1) Division of the gastrocolic ligament: The gastrocolic ligament is opened below the gastroepiploic vessels using ultrasonic shears, and the anterior aspect of the pancreas is completely exposed, detaching the adhered connective tissues.
2) Dissection of the inferior border of the pancreatic neck: The mesocolon is detached from the pancreatic head, and the superior mesenteric vein (SMV) is identified and exposed. The gastrocolic trunk is gently isolated and divided after Hem-o-Loc clipping.
   Complete exposure of the pancreatic head: The hepatic flexure of the colon is dissected along the anatomical plane between the pancreatic head and mesocolon. This step is performed with upward traction of the stomach prior to division of the first portion of the duodenum. This helps in the upward traction of the pancreatic head and duodenal unit, allowing better visualization of the inferior portion of the pancreatic head.
3) Control of the right gastrocolic vessels and right gastric artery: These are ligated using Hem-o-Loc clips and then divided.
4) Transection of the first portion of the duodenum: The first portion of the duodenum is transected using a laparoscopic linear stapler, and the pancreatic head and hepatoduodenal ligament are fully exposed.

• Portal dissection phase

1) Control of the gastroduodenal artery: Lymph node dissection around the superior border of the pancreatic neck helps expose the common hepatic and gastroduodenal arteries and remove the regional lymph nodes. The gastroduodenal artery is safely isolated and ligated using Hem-o-Loc clips.
2) Dissection of the hepatoduodenal ligament: After the division of the gastroduodenal artery, the common hepatic artery is easily looped. Moreover, traction of the hepatic artery can help clear the regional lymph nodes.
3) Creation of the pancreatic neck window: The SMV and por-

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tal vein (PV) were completely exposed, allowing for the window of the pancreatic neck to be easily created and taped.

4) Mobilization of the duodenum and pancreatic head complex: The assistant surgeon uses a surgical gauze to wrap the duodenum for medial traction (Fig. 2). This protects it from injury by the assistant grasper during traction, avoiding spillage of bowel contents. Then, the ligament of Treitz is opened, and the posterior aspect of the pancreatic head is dissected up to the root of the superior mesenteric artery (SMA) and celiac trunk.

5) Division of the proximal jejunum: The proximal jejunum is transected using a laparoscopic linear stapler, and the resected proximal jejunum is moved to the right side of the pancreatic head through the mesocolon.

• Uncinate dissection phase

This procedure was also described in detail in our previous publication [17].

1) Division of the pancreas: The gallbladder is detached from the liver bed, and the common hepatic duct is isolated. Then, the pancreatic neck is transected using an ultrasonic shear and divided obliquely from the bottom to the top and from the anterior to the posterior aspect of the pancreas; this is to make pancreatic reconstruction easier through better visualization of the pancreatic cut surface. Approaching the deep and posterior aspect of the pancreatic neck, the pancreatic parenchyma is carefully dissected using the ultrasonic vibration energy of the acting blade of the ultrasonic shears to identify the pancreatic duct and facilitate duct-to-mucosa anastomosis.

2) Application of the self-traction method for uncinate process dissection: The pancreatic head and duodenal unit are encircled using a long nylon tape and fastened with Hem-o-Loc clips. The encircling nylon tape is retracted laterally using an elastic rubber band, which was then extracted and fixed externally.

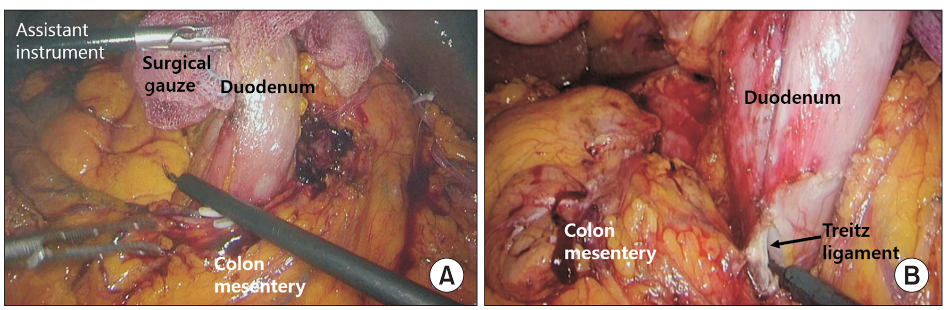

Fig. 2. Mobilization of the duodenum. (A) Surgical gauze is used to wrap the duodenum to protect it from injury using an assistant grasper during medial traction of the duodenum. (B) With medial retraction of the duodenum, the ligament of Treitz is completely opened, and dissection of the posterior aspect of the pancreatic head proceeds to the root of the superior mesenteric artery and the celiac trunk.

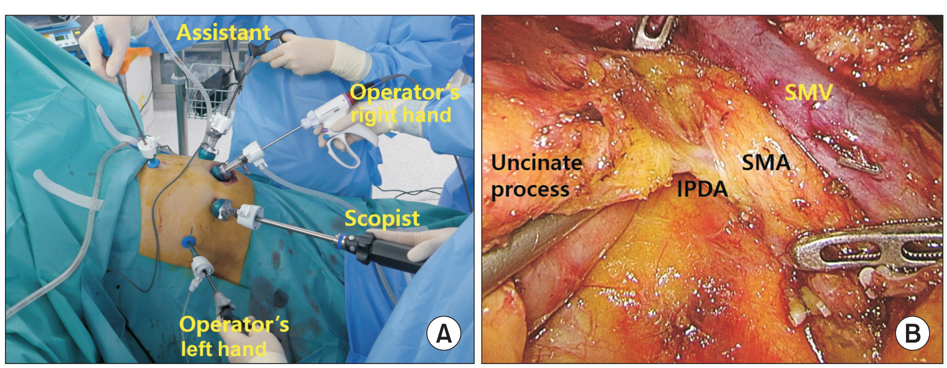

Fig. 3. Operative setting and intraoperative view during the uncinate process dissection. (A) After applying our self-traction method to the uncinate process dissection, the operator moves from the left side to the right of the patient. The laparoscopic camera is also moved from the umbilical trocar to the right side 12-mm trocar for better visualization of the uncinate process. (B) With this operative setting, an appropriate operative view for uncinate process dissection could be obtained (B). SMA, superior mesenteric artery; SMV, superior mesenteric vein; IPDA, inferior pancreaticoduodenal artery.

3) Surgeon position change: After setting up the retraction method, the operator moves from the left to the right side of the patient. The laparoscopic camera is also moved from the umbilical trocar to the right side 12-mm trocar for better visualization of the uncinate process (Fig. 3A).
4) Dissection of the uncinate process (Fig. 3B): The superior border of the uncinate process is dissected first, which allowed for further exposure of the retroperitoneal margin, freeing of the SMV-PV and easy identification of the SMA branches, including the inferior pancreaticoduodenal artery. Neural tissues around the SMA and celiac trunk were dissected, and the regional lymph nodes were dissected *en bloc*.
5) Division of the bile duct: The positions of the operator and laparoscope are returned to the left side of the patient. The hepatic duct was divided using a laparoscopic linear stapler to avoid bile spillage. Then, the specimens are placed in plastic bags. For reconstruction, the distal jejunal limb was placed on the right side of the remnant pancreas through a new opening in the mesocolon.

Laparoscopic reconstruction phase (Supplementary Video 1)

Our procedure of pancreatic reconstruction is an end-to-side pancreaticojejunostomy (PJ) with a conventional interrupted suture technique, duct-to-mucosa anastomosis, and internal short stent insertion (Fig. 4). The outer serosal layers of the pancreas and jejunum are sutured using interrupted sutures with a 5-0 nonabsorbable monofilament. A duct-to-mucosa anastomosis is also performed with a 5-0 absorbable monofilament instead of a short silicone catheter, using four stitches for the small duct and six to eight stitches for the large duct. Furthermore, hepati-

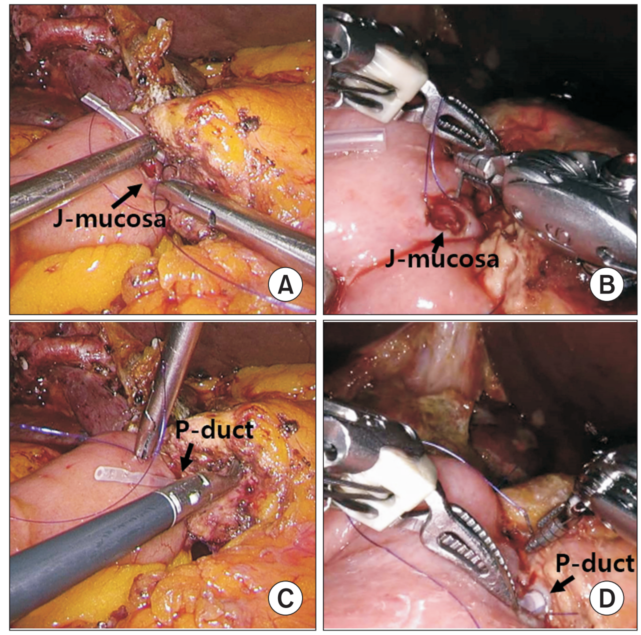

Fig. 4. Laparoscopic and robotic pancreatic reconstructions. Pancreatic reconstruction is made by a basic principle of end-to-side pancreaticojejunostomy with conventional interrupted sutures, duct-to-mucosa anastomosis, and internal short catheter insertion. Suturing views of the posterior side of the pancreatic duct in laparoscopic (A) and robotic (B) reconstructions, and the superior side of the pancreatic duct in laparoscopic (C) and robotic (D) approaches.

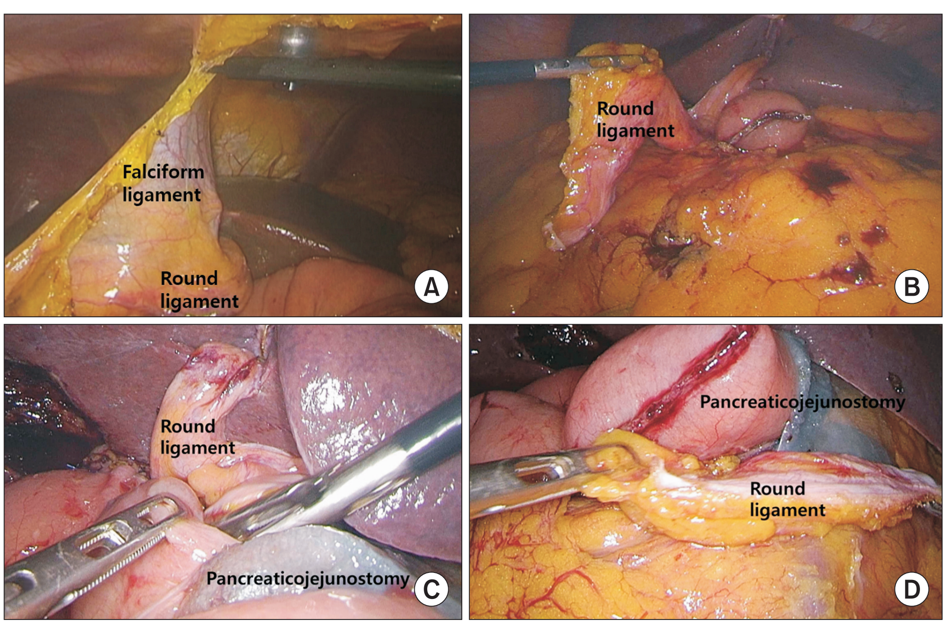

Fig. 5. Protection method using the round ligament. (A) The round ligament is widely harvested, including nearby fat tissues and falciform ligament. The harvested round ligament (B) is inserted into the superior space of the pancreaticojejunostomy (C) and pulled out underneath it (D). The wide round ligament automatically covered the stump of the gastroduodenal artery and the confluence of the superior mesenteric-portal vein.

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cojejunostomy is performed using a posterior continuous suture with a 4-0 barbed suture device, and an anterior interrupted suture with a 5-0 absorbable monofilament. After completing these procedures, the round ligaments are widely harvested, including nearby fat tissues, and placed below the PJ site, covering the gastroduodenal artery and SMV-PV confluence (Fig. 5). Two-armed drain tubes are placed bilaterally via trocars 3 and 5. Finally, the specimen is retrieved through a small extension of the vertical transumbilical wound, and duodenojejunostomy is performed by extracorporeal anastomosis through the same wound.

Robotic reconstruction phase (Supplementary Video 2)

After preparing for reconstruction, the robotic surgical system is docked to the patient's head. In the LPD-RR, we use an 8-mm robotic trocar instead of a 5-mm trocar on the right flank (port 5 in Fig. 1), and a robotic camera is introduced through the umbilical port. We used only two robotic working arms: a Maryland dissector through the right side of an 8-mm trocar (port 5 in Fig. 1) and a needle driver through a 12-mm trocar on the left side (port 3 in Fig. 1). Furthermore, a double-docking method is used for the left 12-mm trocar, which means that a robotic 8-mm trocar is directly inserted through the 12-mm trocar. We prefer using a Maryland dissector and needle driver instead of two needle drivers. Because robotic surgical systems currently do not provide haptic sensations. Therefore, the weak grasping power of the Maryland dissector can compensate for the strong power of the needle driver during tying-up, while an assistant surgeon can assist with the right 12-mm trocar (port 2 in Fig. 1). The surgical procedures are identical to those used for laparoscopic reconstruction (Fig. 4).

Statistical analysis

Continuous data were reported as mean ± standard deviation and range, whereas categorical data were reported as the number and percentage of cases. Categorical variables were compared using the chi-square test or the Fisher exact test, and differences between continuous variables were analyzed using the Student *t*-test. Statistical significance was set at $p < 0.05$. All analyses were performed using IBM SPSS version 28.0 (IBM Corp.). The description of the analysis was based on the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement [18].

RESULTS

The baseline demographics of the patients in the two groups are presented in Table 1. Most characteristics were comparable between them, except for age and history of chemotherapy. The LPD group had a tendency to older age than the LPD-RR group (65.5 ± 11.6 years vs. 60.0 ± 14.1, $p = 0.009$), and fewer patients received previous chemotherapy prior to surgery in the LPD group (15.6% vs. 35.4%, $p = 0.008$). However, the proportion of malignant disease in final pathology was comparable (LPD group, 86.1% vs. LPD-RR group, 83.3%; $p = 0.759$).

Perioperative outcomes presented no statistically significant differences between the LPD and LPD-RR groups, including operative time (431.8 ± 68.8 minutes vs. 424.3 ± 83.7 minutes, $p = 0.547$), estimated blood loss (411.4 ± 309.0 mL vs. 394.9 ± 380.4 mL, $p = 0.770$), clinically relevant POPF (9.0% vs. 10.4%, $p = 0.684$), and major postoperative complication rates (14.8% vs. 6.2%, $p = 0.082$) (Table 2). Three open conversions occurred in patients who planned to undergo LPD, all of which were decided upon during the resection phase. There were four (3.3%) and two PPHs (4.2%) in the LPD and LPD-RR groups, respectively; four patients with PPH underwent radiological interventions or endoscopic hemostasis. However, there was one reoperation case in each group due to PPH, unsuitable for interventional treatment. Furthermore, postoperative 90-day readmission rates were also comparable; postoperative hospital stay was shorter in the LPD-RR group (15.1 ± 7.5 days vs. 13.1 ± 5.0 days, $p = 0.039$), and there was one postoperative 90-day mortality in the LPD group. Nine patients in the LPD group (7.4%) and one in the LPD-RR group (2.1%) were failed to achieve a complete resection margin.

DISCUSSION

This study introduced several technical tips for LPD and LPD-RR learned from 170 consecutive MIPD cases, including the operative setting, traction methods during the resection phase, pancreatic neck division, reconstruction techniques, and protection methods around the PJ. Laparoscopic surgery has the fundamental limitation of using non-articulating instruments and is dependent on proper port placement based on the target organ for operation success. Therefore, LPD involving a broad surgical field and multiple organs has many concerns regarding port placement and operator position, while also being technically demanding and time and labor-consuming. However, our data demonstrated that both LPD and LPD-RR can be safely

Table 1. Demographics of LPD and LPD-RR group

Demographic	LPD group	LPD-RR group	*p*-value
No. of patients	122	48	
Age (yr)	65.5 ± 11.6	60.0 ± 14.1	<0.050
Sex			0.204
Female	39 (32.0)	21 (43.8)	
Male	83 (68.0)	27 (56.2)	
Body mass index (kg/m^2)	23.4 ± 4.0	24.0 ± 3.7	0.436
ASA PS classification			0.268
I, II	98 (80.3)	44 (91.7)	
≥III	24 (19.7)	4 (8.3)	
Diabetes mellitus	26 (21.3)	10 (20.8)	>0.999
Cancer history	6 (4.9)	4 (8.3)	0.624
Previous upper abdominal operation	15 (12.3)	4 (8.3)	0.640
Previous chemotherapy	19 (15.6)	17 (35.4)	<0.050
Preoperative biliary drainage	81 (66.4)	30 (62.5)	0.763
Disease entity			0.759
Benign	17 (13.9)	8 (16.7)	
Malignancy	105 (86.1)	40 (83.3)	
Pathologic diagnosis			0.387
Pancreatic cancer	18 (14.8)	5 (10.4)	
Distal bile duct cancer	51 (41.8)	18 (37.5)	
Ampullary carcinoma	24 (19.7)	14 (29.2)	
Duodenal cancer	6 (4.9)	2 (4.2)	
IPMN	9 (7.4)	2 (4.2)	
Pancreatic NET	2 (1.6)	3 (6.2)	
Duodenal GIST	2 (1.6)	0 (0)	
Choledochal cyst	2 (1.6)	1 (2.1)	
Others	8 (6.5)	3 (6.3)	
Pancreatic texture			0.520
Hard	33 (27.0)	10 (20.8)	
Soft	89 (73.0)	38 (79.2)	
Pancreatic duct size (mm)			0.634
<3	80 (65.6)	34 (70.8)	
≥3	42 (34.4)	14 (29.2)	

Values are presented as number only, mean ± standard deviation, or number (%).
LPD, laparoscopic pancreaticoduodenectomy; LPD-RR, laparoscopic pancreaticoduodenectomy with robot-assisted reconstruction; ASA PS, American Society of Anesthesiologist physical status; IPMN, intraductal papillary mucinous neoplasm; NET, neuroendocrine tumor; GIST, gastrointestinal stromal tumor.

performed with acceptable complication rates.

The first step in MIPD is the proper selection of indications. Many conversions to open laparotomy are due to bleeding or difficult dissection during the resection phase, usually associated with pancreatitis and locally advanced diseases [19,20]. In our series, there were three conversions in patients with chronic pancreatitis or pancreatic head cancer. The first summit of International Expert Consensus on Minimally Invasive Pancreatico-Biliary-Surgery recommended that case selection for the initial period of the learning curves includes periampullary pathologies

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Table 2. Comparison of perioperative outcomes between two groups

Variable	LPD group (n = 122)	LPD-RR group (n = 48)	*p*-value
Open conversion	3 (2.5)	0 (0)	0.653
Gastro- or duodeno-jejunostomy			0.327
Intracorporeal	12 (9.8)	8 (16.7)	
Extracorporeal	110 (90.2)	40 (83.3)	
Operative time (min)	431.8 ± 68.8	424.3 ± 83.7	0.547
Estimated blood loss (mL)	411.4 ± 309.0	394.9 ± 380.4	0.770
Intraoperative RBC transfusion	17 (13.9)	5 (10.4)	0.718
Postoperative complication[a)]			0.290
Minor	43 (35.2)	17 (35.4)	
Major	18 (14.8)	3 (6.2)	
CR-POPF			0.684
Grade B	9 (7.4)	5 (10.4)	
Grade C	2 (1.6)	0	
PPH	4 (3.3)	2 (4.2)	>0.999
Bile leak	2 (1.6)	0 (0.0)	0.919
Delayed gastric emptying	8 (6.6)	2 (4.2)	0.815
Wound infection	6 (4.9)	1 (2.1)	0.683
Incisional hernia	6 (4.9)	0 (0.0)	0.270
Postoperative length of hospital stay (day)	15.1 ± 7.5	13.1 ± 5.0	<0.050
Postoperative 90-day outcome			
Reoperation	1 (0.8)	1 (2.1)	>0.999
Readmission	15 (12.3)	6 (12.5)	0.823
Mortality	1 (0.8)	0 (0)	>0.999

Values are presented as number (%) or mean ± standard deviation.
LPD, laparoscopic pancreaticoduodenectomy; LPD-RR, laparoscopic pancreaticoduodenectomy with robot-assisted reconstruction; RBC, red blood cell; CR-POPF, clinically relevant postoperative pancreatic fistula; PPH, post-pancreatectomy hemorrhage.
[a)]Minor, Clavien-Dindo (CD) grade of <III; major, CD grade of ≥III.

with healthy tissue structures without vascular involvement, no history of previous upper abdominal surgery, lower body mass index of ≤25.0 kg/m^2, pancreatic duct size of ≥3 mm, and bile duct size of ≥10 mm [5]. In addition to the proper patient selection, novice surgeons considering the MIPD should be prepared with enough experience in various minimally invasive biliary and pancreatic surgeries as well as OPD. Furthermore, recently there are many available educational programs including the experts' lectures and the procedure or task-specific training curriculums, which might be helpful to minimize the trial and error in the initial period of MIPD.

Port placement and surgeon position differ according to the surgeon's preference; several surgeons preferred to stand on the right side of the patient. In this setting, a 12-mm trocar for the laparoscopic camera was placed on the right side of the umbilicus. This position is advantageous for better visualization of the pancreatic cut surface and excellent exposure of the SMA. However, the ergonomic position of the surgeon via "co-axial setup" is unattainable because the main operative targets are in the right upper quadrant. Therefore, our left-sided position is not only more ergonomic for the operator but also provides a more familiar anatomical view for hepatobiliary and pancreatic surgeons. Meanwhile, changing the position of the operator to the right side of the patient is more advantageous for the dissection of the uncinate process, where the operator can use the dominant right hand for major manipulation around the SMA.

There is no standard technique for reconstruction, and the best PJ method remains controversial. Although evidence has shown that pancreaticogastrostomy is associated with lower POPF [21], PJ is the preferred method because it is more suitable for MIPD in terms of manageability and exposure of the operative target compared to pancreaticogastrostomy. However, a large body of literature has demonstrated no difference in POPF rates between the duct-to-mucosa and invagination PJ techniques [22,23]. In this study, we adopted a conventional two-layered duct-to-mucosa anastomosis using a short silicone internal pancreatic duct stent [24]. Duct-to-mucosa PJ is technically challenging, especially in patients with a soft pancreatic texture and small pancreatic duct, even though these are good indications for MIPD. Furthermore, some studies have revealed that the invagination PJ technique is associated with postoperative pancreatic duct obstruction, which might result in pancreatic endocrine and exocrine insufficiency, as well as complications, such as pancreatic stones, acute pancreatitis, and abdominal pain [25]. Bai et al. [26] showed that duct-to-mucosa PJ was superior to invagination in maintaining anastomotic patency. Our previous animal experimental research also illustrated that PJ without duct-to-mucosa anastomosis frequently induces pancreatic duct obstruction and fibrosis [27]. During this series, we performed duct-to-mucosa PJ in all cases except for one where the pancreatic duct could not be found. Our clinically relevant-POPF rates were comparable with those of previous studies [3].

One of our preferred methods for preventing postoperative complications is covering the stump of the gastroduodenal artery and the posterior aspect of the PJ using a round ligament flap. Tani et al. [28] and Meng et al. [29] reported that this wrapping technique did not decrease the rate of POPF; however, it may reduce postoperative complications, such as PPH. In our study, none of the patients developed PPH from the gastroduodenal artery, but the protective effect of gastroduodenal artery against PPH could not be confirmed; however, we speculate it is possible. There were six cases of PPH, four of which occurred in jejunal branches. Three patients were treated with angiographic embolization and one patient underwent reoperation, which was controlled by suturing and clipping under laparoscopy. Another PPH occurred in the inferior epigastric artery at the trocar site and was managed using laparoscopic suturing. The last case involved bleeding at the duodenojejunostomy site, which was managed using endoscopic hemostasis. Furthermore, Mañas-Gómez et al. [30] reported many sites could be the origins of PPH. Bleeding from the proximal jejunal branch is very difficult to manage using angiographic embolization because these vessels are very small in diameter and have short branches at a right angle around the SMA root. Although we have always applied individual clip ligation to the jejunal mesenteric vessels, we emphasize that the proximal jejunal arteries are a risk factor for PPH.

Unfortunately, we frequently experienced a positive resection margin, especially in patients who had bile duct cancer in the initial period. Therefore, recently we routinely perform the preoperative cholangioscopy (SpyGlass, Boston Scientific) that provides direct visualization of the biliary tree during endoscopic retrograde cholangiopancreatography to check the safety margin.

This study did not investigate the advantages of LPD-RR over LPD. The robotic surgical system provides a superior environment and fidelity in the reconstruction phase. However, it is difficult to prove the benefits of objective data. Operative time was also comparable between the LPD and LPD-RR groups. However, we plan to evaluate the actual advantages of the robotic system in MIPD by analyzing our video database in the future.

This study aimed to share some technical tips on LPD and LPD-RR, and the perioperative outcomes of our MIPD experience; our data showed acceptable surgical outcomes for both techniques. However, future investigation is required to evaluate the objective benefits of robotic surgical systems in MIPD and establish widely acceptable standardized MIPD techniques.

NOTES

Ethical statements

This study was approved by the Institutional Review Board and Ethics Committees of the CHA Bundang Medical Center of the CHA University in Seongnam, Korea (No. 2023-01-014), and it was conducted according to the ethical standards of each institutional committee on human experimentation, and Declaration of Helsinki. The need for patient consent was waived, and anonymized data were collected and analyzed.

Authors' contributions

Conceptualization, Data curation, Formal analysis: All authors
Methodology, Visualization: JYJ, ECH, SHC
Project administration: JYJ, ECH, SHC
Writing–original draft: All authors
Writing–review & editing: JYJ, EHC, IK, SJY, SHL, SHC
All authors read and approved the final manuscript.

Conflicts of interest

All authors have no conflicts of interest to declare.

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Supplementary materials

Supplementary Videos 1 and 2 can be found via https://doi.org/10.7602/jmis.2023.26.2.72.

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