Original Article

Laparoscopic Left Posterior Superior Mesenteric Artery First Approach Pancreaticoduodenectomy: Experience, Outcome and Critical Steps

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Background: Pancreaticoduodenectomy is a standard treatment for periampullary carcinoma. Currently, morbidity of this surgery is still high. Even though laparoscopic pancreaticoduodenectomy was successfully done more than 20 years ago, the adoption of this minimally invasive surgery is very slow. Recent development of superior mesenteric artery first pancreaticoduodenectomy increased the complexity of the procedure. The technique of laparoscopic left posterior superior mesenteric artery first pancreaticoduodenectomy was successfully developed in our center in 2013.

Objective: To describe technique of laparoscopic left posterior superior mesenteric artery first pancreaticoduodenectomy with peri-operative outcomes and pathologic result. The appropriate patient selection for this technique and the critical step that may lead to conversion are also identified.

Materials and Methods: All patients who underwent this procedure were retrospectively reviewed. Demographic data, peri operative and operative results including morbidity and mortality were collected. The detailed technique of laparoscopic left posterior superior mesenteric artery first pancreaticoduodenectomy is also described including critical step that lead to conversion.

Results: Thirty-four patients underwent this procedure with peri-operative results, morbidity and mortality comparable to open pancreaticoduodenectomy.

Conclusion: Laparoscopic left posterior superior mesenteric artery approach is safe and feasible.

Keywords: Laparoscopic pancreatic surgery, Minimally invasive pancreatic surgery, Pancreatic resection, Pancreatectomy, Pancreaticoduodenectomy, Whipple operation

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Pancreaticoduodenectomy is a gold standard treatment for periampullary carcinoma which is a heterogeneous group of neoplasms arising from the head of the pancreas, the distal part of the common bile duct, the second part of duodenum and also the ampulla of Vater[1]. The first successful single stage pancreaticoduodenectomy was performed by Whipple et al in 1935[2]. However, this operation was considered as a high risk surgery due to its high morbidity and mortality. Although morbidity and mortality of pancreaticoduodenectomy has gradually declined during the last few decade[3-6], the complication rate of the operation, ranging from 24.0 to 59.0%, is still considered high[7,8].

Following an emerging of the first laparoscopic cholecystectomy, minimally invasive techniques have been developed in many surgical fields including pancreatic surgery. Finally, the first laparoscopic pancreaticoduodenectomy (LPD) was successfully done in 1994 by Gagner and Pomp[9]. However, the adoption of LPD is very slow due to its complexity and unproven benefit of this minimally invasive surgery. Only a few reports from high volume centers have been documented[10].

In Thailand, LPD was first reported by Khaimook A. in 2010[11]. In contrast to other minimally invasive surgery, LPD has not gained popularity with only few centers have developed LPD as an option for periampullary carcinoma. In 2013, the author successfully developed technique of LPD from left posterior superior mesenteric artery (SMA) first approach pancreaticoduodenectomy technique proposed by Kurosaki et al in 2011[12]. Since then, LPD was done with this technique by single surgeon (ST) in thirty four cases. To the best of our knowledge, this is the first report of laparoscopic left posterior SMA first approach pancreaticoduodenectomy.

In the present study, the authors present our technique, peri-operative outcomes, post-operative outcomes and the pathologic result. The authors aim to establish the appropriate patient suitable for LPD and address the critical step that may lead to conversion in our experience.

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Materials and Methods

The present study was conducted with approval of Ethic consideration committee, Rajavithi Hospital, Thailand. Between December 2013 and May 2018, thirty-four cases of LPD were performed at our institution by single surgeon (ST) with the same surgical technique. All the patients were thoroughly evaluated pre-operatively with complete investigations, including tumor markers for pancreatic malignancy (CA 19-9, CEA), triple phase helical computerized tomography (CT) with oral and intravenous contrast, upper gastrointestinal endoscopy and biopsy of ampullary lesions, as indicated. Magnetic resonance cholangiopancreatography, endoscopic retrograde cholangiopancreatography (ERCP) with brush biopsy or endoscopic ultrasound (EUS) with fine needle biopsy were performed in doubtful lesion at distal bile duct and head of pancreas. Trans-ampullary biliary stent or percutaneous transhepatic biliary drainage (PTBD) was placed in patients who had cholangitis, marked jaundice and malnutrition. The operative records, post-operative outcome and oncologic result data were retrospective reviewed from medical records.

Surgical techniques

Set up, position and port placement

Under general anesthesia, the patient was placed in supine position with the legs being separated (French position). The primary surgeon stood between the legs of patient and camera man stood on left side of the patient in early operative phase and move to right side of the patient later. Room set up was shown in Figure 1.

The first ten-millimeter port was inserted by an open technique through infra-umbilicus incision and pneumoperitoneum was created at 10 to 15 mmHg. Other two of 10 mm ports were placed at left and right para-umbilical area and 5 mm ports were placed at both subcostal areas as shown in Figure 2. After all ports were placed, patient position was changed to 15 to 30 degree reverse Trendelenburg position. The entire operative procedure was divided into two major phases including dissection and resection phases then followed by reconstruction phase. Thirty-degree, ten millimeters laparoscopic lens was used for the whole operation.

Dissection and resection phase

The dissection and resection phase can be divided into three fields including SMA Field, central field and right sub-hepatic fields.

The operation was commenced at the SMA field which left para-umbilical port was used as camera port. The transverse colon along with its mesentery and omentum were lifted up for infracolic approach. Then retroperitoneal dissection started between duodenojejunal junction and Inferior mesenteric vein to expose aorta and inferior vena cava (IVC). The dissection continued cephaladly until the root of SMA was identified at superior border of left renal vein (Figure 3). After transection of proximal jejunum by

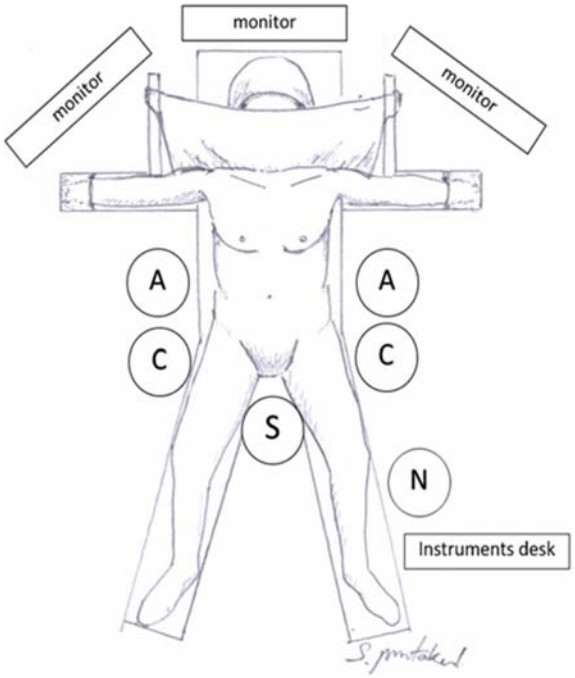

Figure 1. Patient position and room set up. A = assistant surgeon; C = camera man; S = surgeon; N = nurse.

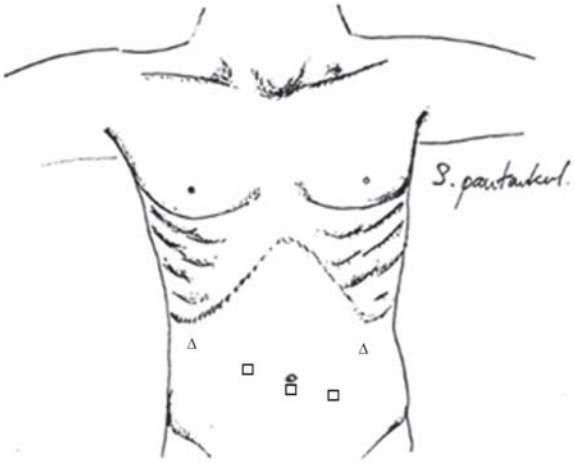

Figure 2. The demonstration of ports position, the square were 10 to 12 mm and the triangle were 5 mm. The specimen was removed via Pfannenstiel incision.

endoscopic stapling device, the dissection along right side of SMA was carried out to free uncinate process from SMA. Then superior mesenteric vein (SMV) was also dissected free from uncinate process (Figure 4).

Then the camera was moved to second field of

dissection at umbilical port, so called 'central field'. After the uncinate process was freed from SMV, the gastrocolic omentum was divided and the transverse colon especially the hepatic flexor was taken down to open lesser sac widely and expose pancreatic head along with duodenum. At this stage, the right gastroepiploic vessels were clipped and divided.

After exposing duodenum and pancreatic head, the camera was then moved to right para-umbilical port, this operative field is called 'right subhepatic field'. The surgery continued with extended Kocherization. This dissection would reach retroperitoneal space which was fully dissected in SMA field; at this point the uncinate process, duodenum and proximal jejunum would be free from SMA and SMV and were easily moved to right side of the vessels. The antrum of stomach was then transected with endoscopic stapling device. After the neck of pancreas, which should be freed from portal vein at this stage, was transected by ultrasonic shearing device, the common hepatic artery (CHA) was clearly identified on the superior border of pancreas and the lymph nodes around CHA (group 8) were dissected. Then pancreatic head was freed from CHA to identify gastroduodenal artery (GDA) which then was clipped and divided at junction with CHA. The dissection was continued along hepatic artery proper to free it from common hepatic duct (CHD) and all fibro-fatty tissue including lymph node group 12 within the hepatoduodenal ligament to prepare for transection of CHD. After gallbladder was dissected freely from liver, CHD was transected above cystic duct junction to complete resection phase and the specimen was freed as demonstrated in Figure 5.

The specimen was then put in plastic bag and removed through Pfannenstiel incision.

Reconstruction phase

After the specimen was removed and Pfannenstiel incision was closed, reconstruction phase continued in right subhepatic field. The proximal end of jejunum was brought up through the retrocolic route to create pancreatojejunal anastomosis by modified Blumgart technique with plastic stent across the anastomosis and then hepaticojejunal anastomosis was done in end-to-side fashion (Figure 6).

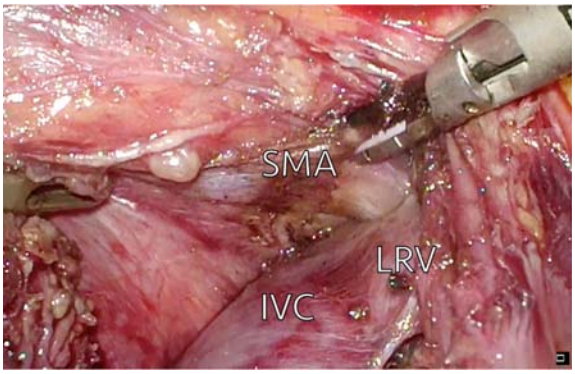

Figure 3. Retroperitoneal dissection at SMA field show IVC, left renal vein (LRV) and SMA.

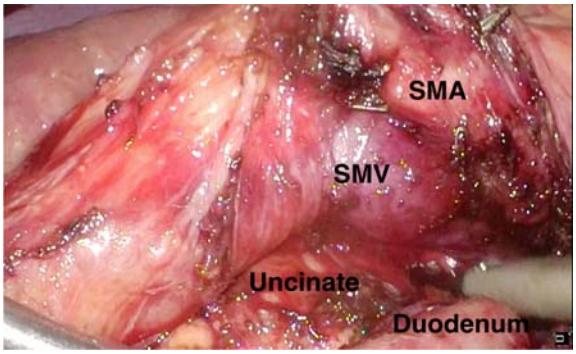

Figure 4. After complete dissection of SMA and SMV from uncinate process.

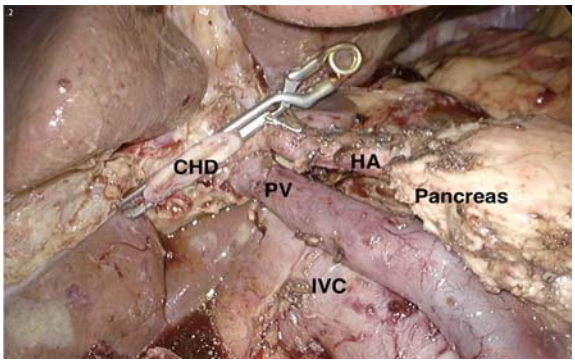

Figure 5. Operative field after complete resection. CHD = common hepatic duct; PV = portal vein; HA = hepatic artery; IVC = inferior vena cava.

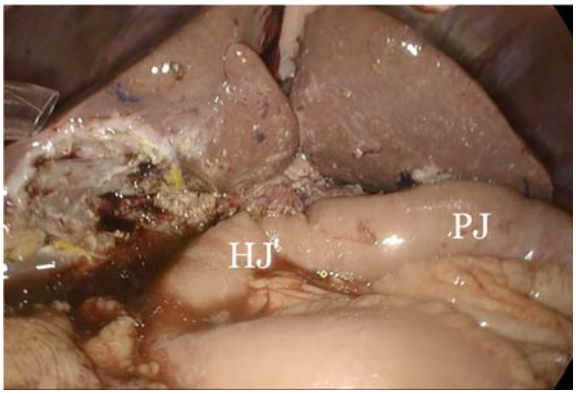

Figure 6. After pancreaticojejunostomy (PJ) and hepaticojejunostomy (HJ).

Finally, by moving camera to central field, side-to-side gastrojejunal anastomosis was created by endoscopic stapling device to complete reconstruction phase.

After checking every anastomoses and hemorrhage, a silicone tube drain was placed in retroperitoneal space behind pancreatic anastomosis. Then all ports were removed and incisions were closed.

Statistical analysis

Categorical data were described as number (percentage), median (minimum, maximum), and mean ± standard deviation (SD). The IBM SPSS statistics version 22 was used.

Results

Demographic data and pre-operative intervention

Thirty-four cases of LPD were included in the study. Of these, 23 patients were male and 11 were female. Their mean age was 59.50±13.55 years old. The body weight was range from 40 to 86 Kg. with the mean body weight of 59.14±12.16 kg and average body mass index (BMI) of 22.17±3.26 kg/m^2. Ampullary cancer was the provisional diagnosis in majority patients. Fifteen patients had ERCP done pre-operatively, while EUS was done in three patients in order to confirm diagnosis. Pre-operative biliary drainage was performed in nineteen patients which including fourteen trans-papillary plastic stent, two trans-papillary self-expandable metallic stent and PTBD in three patients. The detail of basic characteristic was given in Table 1.

Peri-operative outcome

The LPD operation was complete in 24 patients, but converted to laparoscopic assisted pancreaticoduodenectomy in four patients and converted to open surgery in the other six patients. The incision for laparoscopic assisted LPD was upper midline incision in all four cases. The most common indication for conversion to open surgery was uncontrolled bleeding. The detail of indication for conversion is demonstrated in Table 2. In the complete LPD group, the average operative blood loss was 875±423.23 ml. While the average operative time was 640.5±119.25 minutes. Three days (3±1.21) after surgery most of the patients can tolerated soft diet and the length of hospital stay (LOS) was 10.9±5.8 days in the complete laparoscopic group while the laparoscopic assisted and conversion group was 11.20±6.85 days.

Early post-operative complications

Within first 30 days after surgery, there were two mortality cases of acute myocardial infarction and severe sepsis after the leakage of hepatico-jejunal anastomosis. Morbidity occurred in eight patients, one patient in our series develop pulmonary embolism which was successfully treated medically while the others seven patients developed nine complications (Table 3). None of the patient in our series developed wound complication including wound infection, evisceration or incisional hernia.

Table 1. Demographic data of the patients (n = 34)

Characteristics	n (%)
Sex	
Male	23 (67.6)
Female	11 (32.4)
Body weight (kg), mean ± SD	59.14±12.16
BMI, mean ± SD	22.17±3.26
ERCP	15
EUS	3
Pre-operative biliary drainage	19
Trans-papillary plastic stent	14
Trans-papillary SEMs	2
PTBD	3

BMI = body mass index; ERCP = endoscopic retrograde cholangiopancreatography; EUS = endoscopic ultrasonography; SEMS = self-expandable metallic stent; PTBD = percutaneous transhepatic biliary drainage

Table 2. Indications for conversion to laparoscopic assisted or open surgery

Indications	Number of cases
Convertion to laparoscopic assisted surgery	4
Not secure anastomosis	1
Suspected of portal vein invasion	1
Tear jejunum	1
CO_2 retention	1
Convertion to open surgery	6
Portal vein injury	3
Branch of pancreaticoduodenal artery injury	1
IVC and right ureter injury	1
Branch of SMV injury	1

IVC = inferior vena cava; SMV = superior mesenteric vein

Table 3. Morbidity and mortality of the patients

Mortality-Morbidity	Numbers of cases	Clavien-Dindo classification[13]
Mortality		
Acute myocardial infarction	1	V
HJ leakage	1	V
Morbidity		
Pneumonia	2	II
PJ leakage	2	II
Adhesive small bowel obstruction	1	IIIa
Pressure ulcer	1	IIIa
Gastroparesis	1	IIIb
HJ leakage	1	IIIb
Pulmonary embolism	1	Iva

HJ = hepaticojejunal anastomosis; PJ = pancreaticojejunal nastomosis

Oncologic results

Among 34 cases, seventeen of them have ampullary carcinoma. The pancreatic head cancer and distal bile duct cancer are the second most common pathology. Pathological findings are demonstrated in Table 4. Concerning resection margin, 94% of the patients had R0 resection margin while two patients had R1 resection margin. One patient with poorly differentiated ampullary carcinoma had R1 resection at gastric margin, and another case with distal cholangiocarcinoma had R1 resection margin at proximal bile duct. The details of resection margin are shown in Table 5.

Discussion

Since Gagner and Pomp described the first laparoscopic pancreaticoduodenectomy in 1994[9], the procedure has not gained popularity. In the review by Merkow et al, only eight articles from high volume centers have reported more than twenty cases of LPD[10].

In Thailand, only a case report was documented. In this article, we reported 34 cases of LPD, which is the largest case series in Thailand. Even though most laparoscopic procedures have showed benefit over open surgery, the benefit of LPD remains controversial. In 2012, Asbun et al have reported a large case series of LPD showing less intraoperative blood loss, shorter ICU stay and shorter LOS, but longer operative time, with comparable overall complication rates[14]. Moreover, Croome et al have compared vascular resection between 31 LPD abd 58 open pancreaticoduodenectomy (OPD). They have found no difference in terms of operative time and overall complications. But LPD group had more lymph nodes harvested, lesser blood loss and shorter LOS[15]. Regarding the cost of treatment, Mesleh et al have demonstrated that the surgical cost of LPD patients to be higher than OPD, but lower admission cost[16]. These resulted in comparable overall cost[16]. In our series, even though LOS was not shortened but the recovery after discharge, quality of life and time to return to work might be different between the patients underwent laparoscopic and those underwent open surgery. The reason for unproven shorter LOS in our series could be due to very long LOS for major complications, for example, one cases of HJ leakage had LOS of 259 days. Another concern regarding laparoscopic surgery is port site metastasis. Young et al reported a case of port site metastasis[17]. In the present study, one patient, who had large poorly differentiated adenocarcinoma of ampulla of Vater with tumor cell closed to pancreatic surface margin on pathological examination, developed port site metastasis with carcinomatosis peritonei and died seven months after surgery. Concerning wound complication which is one of common morbidity after OPD, the authors did not encounter any kind of wound complications such as infection, evisceration or incisional hernia in our series.

Table 4. Oncologic results of the patients

Oncologic result	Numbers of cases
Adenocarcinoma of ampulla of Vater	
Well differentiated	9
Moderately differentiated	6
Poorly differentiated	2
Tubular adenoma with high grade dysplasia of ampulla of Vater	2
Adenocarcinoma of pancreatic head	3
Adenocarcinoma of distal bile duct	3
PNET	2
IPMN	2
Chronic pancreatitis with mass at pancreatic head	2
Adenocarcinoma of second part duodenum	1
Pancreatic pseudocyst with intraepithelial neoplasia	1
Solid Pseudopapillary neoplasm of pancreas	1

PNET = pancreatic neuroendocrine tumor; IPMN = intraductal papillary mucinous neoplasm

Table 5. Resection margin

Resection margin	Number of case	%
R0	32	94.12
R1	2	5.88
Ampullary carcinoma	1	2.94
Distal cholangiocarcinoma	1	2.94

R0 = free margin; R1 = microscopic positive margin

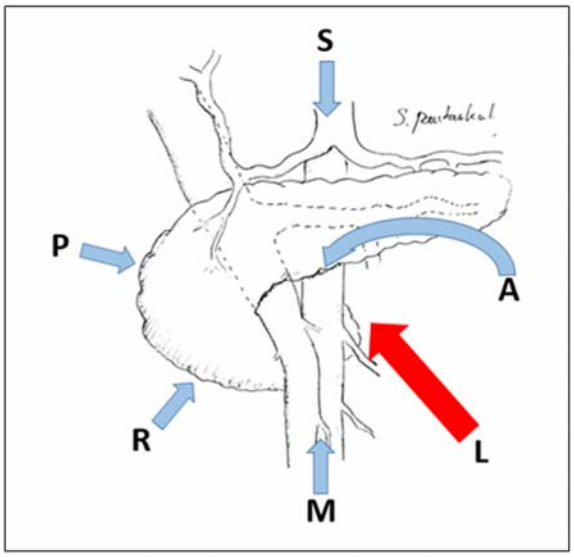

Figure 7. Diagram showing the six approaches to the superior mesenteric artery. S = superior approach; A = anterior approach; P = posterior approach; L = left posterior approach; R = right/medial uncinate approach; M = mesenteric approach.

Recent advance in OPD is the introduction of SMA first approach which have been categorized by Sanjay et al into six different approaches to SMA (Figure 7)[18]. All these approaches to SMA have a benefit of early assessment of resectibility of periampullary tumor that involves SMA before committing an irreversible step in the operation. The left posterior SMA first approach, described by Kurosaki et al, is one of SMA first approach that has the specific benefit on tumor along uncinate process by facilitating skeletonization of SMA in retroperitoneum without Kocherization of duodenum[12]. In the present study, the left posterior SMA first approach was successfully adapted for LPD and our technique could be replicated in 34 patients. Furthermore, at the present time this technique is used as the standard for LPD in our center. The critical step in this approach was the dissection around the retroperitoneal major vessels including SMA, SMV, IVC and also the aorta. As shown in our data, major vessels injury and uncontrol bleeding were the leading causes of conversion to open surgery.

Conclusion

LPD represents one of the most technically challenging procedure. SMA first approach gives the benefit of early assessing resectibility in operation. By combining these two approaches, this technique should have a good option for patients with periampullary carcinoma. Laparoscopic left posterior SMA first pancreaticoduodenectomy is feasible and safe in selected cases with comparable peri-operative and oncologic outcomes. However, this technique should be performed by an experience surgeon and team. The critical step is the dissection around major vessels and bleeding is the main indication for conversion to open surgery. To minimize the conversion, skills for laparoscopic vascular control and repair are required.

What is already known on this topic?

Pancreaticoduodenectomy is standard treatment for periampullary carcinoma. Minimally invasive surgery is a new trend of all surgical fields. Laparoscopic pancreaticoduodenectomy is a highly complex procedure with only few centers perform this procedure. However, reports from high volume centers showed the feasibility and peri-operative benefits of this procedure. Recent advance in pancreaticoduodenectomy is the introduction of superior mesenteric artery (SMA) first approach; there are limited reports of laparoscopic SMA first approach pancreaticoduodenectomy.

What this study adds?

Laparoscopic left posterior SMA first pancreaticoduodenectomy is feasible with comparable peri-operative results. This technique of laparoscopic pancreaticoduodenectomy should benefit some patient with periampullary carcinoma.

Potential conflicts of interest

The authors declare no conflicts of interest.

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