MINIMALLY INVASIVE PANCREATICODUODENECTOMY FOR PERIAMPULLARY VATER TUMORS

Tran Que Son[1,2], Tran Manh Hung[2], Tran Hieu Hoc[1,2], Nguyen Ngoc Bich[1,2]
[1]Surgery Department – Hanoi Medical University
[2]Bachmai Hospital

Laparoscopic surgery has been applied in pancreatic diseases and has great potential when performed for tumors located at the body and tail of pancreas with quick recovery and short hospitalization. However, laparoscopic pancreaticooduodenectomy (LPD) has not been widely applied although the first case had been done by Gagner since 1994, due to involving many important and complex blood vessels. Moreover, this technique requires additional surgery time about 5 to 10 hours with three anastomosis including pancreatojejunostomy, choledojejunostomy and gastrojejuostomy. While an increasing number of open procedures are now routinely performed laparoscopically or robotically, minimally invasive pancreaticoduodenectomy (MIPD) remains one of the most challenging operation in abdomen. Worldwide, many researches showed that LPD got advantages over OPD. In Vietnam, there are studies with report of positive initial results. This article aims to introduce the method of PD, current status and development of MIPD.

Keywords: Laparoscopic Pancreaticoduodenectomy, Laparoscopic assisted Pancreaticoduodenectomy, Laparoscopic Pancreaticoduodenectomy with mini-laparotomy

I. INTRODUCTION

Periampullary cancer are common diseases found in the gastrointestinal tract, of which pancreatic head cancer are the most common disease accounting for about 80%, Vater cancer (10%), lower bile duct cancer (5%) and duodenal cancer (5%). Cancers of the ampulla of Vater account for about 0.2% of all gastrointestinal cancer diseases and it was the best prognosis with five years postoperative survival from 30% to 50% with no lymph node metastases [1]. Pancreaticoduodenectomy (PD) is one of the most complex techniques in hepatobiliary and pancreatic surgery for treatment of periampullary tumors or severe pancreatic injury with long operation time and mortality rate changed from 0% to 5%. The incidence of postoperative pancreatic fistula complications was 11.4% - 64.3% in many studies [2 - 4]. Recently, in laparoscopic surgery, using Harmonic Scalpel and Ligasure, minimally invasive surgery has been used extensively in pancreatic surgery. Total laparoscopic surgery may be a feasible and safe procedure for the pancreato-hepatology. Laparoscopic distal pancreatectomy has gained popularity because of its feasibility and relative safety, and is now accepted as the standard procedure for resection of benign lesions in the body and tail of the pancreas. However, unlike laparoscopic distal pancreatectomy, total laparoscopic pancreaticoduodenectomy

Corresponding author: Tran Que Son,
Hanoi Medical University
Email: quesonyhn@gmail.com
Received: 21/05/2019
Accepted: 16/07/2019

(TLPD) is only performed at a limited number of centers and its safety and benefits relative to open pancreaticoduodenectomy (OPD) have been questioned [5 - 6].

Gagner described the first minimally invasive pancreaticoduodenectomy (MIPD) in a patient with chronic pancreatitis in 1994, concluding that MIPD was technically feasible but the advantages of MIPD were not obvious and were compromised due to its high morbidity [36]. In comparative studies, TLPD is reported to offer the advantages of minimally invasive surgery, which include visual magnification, improved exposure, early postoperative recovery, reduce blood loss, reduce blood transfusion and shortened hospital stay but longer time operation than open PD. The inherent technical difficulty of intra-corporeal reconstruction is a major problem, and has hindered the widespread acceptance of LPD [2; 5; 7; 8]. In order to overcome this limitation, pancreaticoduodenal resection may be performed laparoscopic, and reconstruction all anastomosis through a mini-laparotomy [5; 9; 10]. In Vietnam, some researches of LPD and LAPD had been reported with early results of low complications [11 - 13]. The article aims to introduce the method of minimally invasive pancreatic head resection and the factors related to the applications of laparoscopic surgery.

II. OVERVIEW CONTENTS

A pancreaticoduodenectomy or Whipple procedure is a major surgical operation most often performed to remove cancerous tumors of the head of the pancreas. It is also used for the treatment of pancreatic or duodenal trauma, or chronic pancreatitis. Due to the shared blood supply of organs in the proximal gastrointestinal system, surgical removal of the head of the pancreas also necessitates removal of the duodenum, proximal jejunum, gallbladder, and, occasionally, part of the stomach.

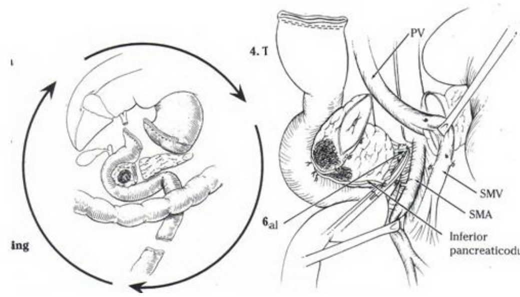

Figure 1. Steps of clockwise surgery

1. Surgical procedures

Minimally invasive pancreaticoduodenectomy (MIPD) included:

(1) Total/pure LPD, where both resection and digestive reconstruction were completed laparoscopically

(2) Hand-assisted LPD (HALPD), where a hand port or a mini incision was added to facilitate the progress.

(3) Laparoscopy-assisted LPD (LALPD), in which dissection was performed laparoscopically and reconstruction was completed through a small mini-laparotomy incision

(4) Total/pure robotic pancreaticoduodenectomy (RPD), where both resection and digestive reconstruction were completed using da vinci surgical system;

(5) Robotic assisted pancreaticoduodenectomy (RAPD), where dissection was performed laparoscopically and reconstruction was completed by da vinci surgical system.

Pancreaticoduodenectomy is most often performed as curative treatment for periampullary cancer, which include cancer of the bile duct, duodenum or head of the pancreas. The shared blood supply of the pancreas, duodenum and common bile duct, necessitates en bloc resection of these multiple structures. Other indications for pancreaticoduodenectomy include chronic pancreatitis, benign tumors of the pancreas, pancreatic metastases from other primary malignancies, and gastrointestinal stromal tumors [11]. The main difference in pancreaticoduodenectomy techniques is the method of reconstruction anastomosis between the pancreas, biliary tract and stomach to the small digestive (pancreatojejunostomy or pancreatogastrostomy) as well as use of auxiliary methods (pancreatic duct stent, biliary drainage, biological glue of pancreatic anastomotic...).

Pancreatojejunostomy (PJ) technique:

Child (1941): Introduced about end-to-end PJ technique

Varco (1945): performed PJ technique and stent pancreatic duck.

Whipple (1946): end-to-side PD

Peng (2001): PJ dunking [12]

Blumgart (2003): had applied the PJ anastomosis in all cases. Pancreaticojejunal anastomosis was constructed using 2–3 transpancreatic U sutures on either side of the main pancreatic duct [13].

Grobmyer S. R (2008): had apllied Roux-en-y PJ anastomosis [14].

In 2014, Modified Blumgart anastomosis PJ were applied by Japanese authors [15].

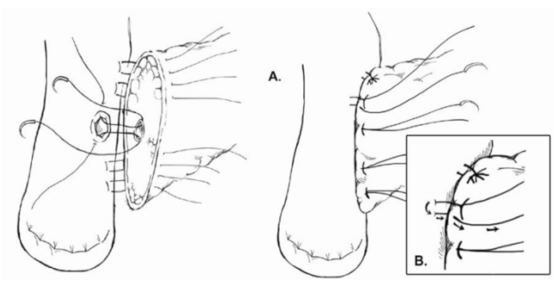

Figure 2. Blumgart anastomosis PJ (2003) [16]

In the 70s, some authors preferred pancreatogastrostomy (PG) anastomosis rather than PJ anastomosis because of the advantages of a thick gastric wall and an abundance of gastric blood vessels to reduce

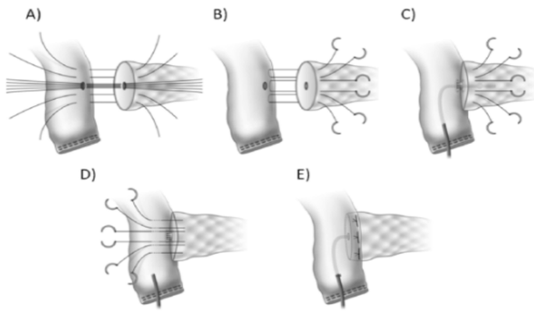

Figure 3. (A) Kakita (2001) techinique and (B,C,D,E) Modified Blumgart anastomosis PJ

post-operative pancreatic fistula. In addition, gastric ascites has inhibitory factors that activate pancreatic exocrine enzymes, so there is less possibility of postoperative pancreatitis. (Tripodi and Sherwin first joined the gastric pancreas in 1934. The surgical team at the Mayo Clinic 1946, later by Mackie and his colleagues applied this technique)

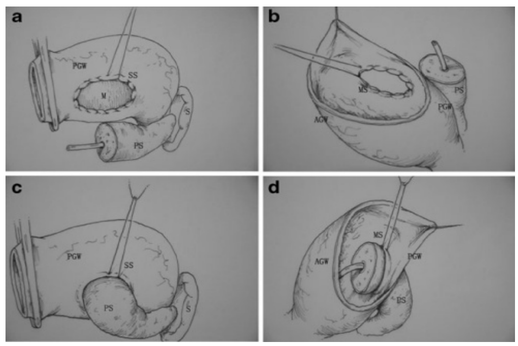

Figure 4. Zhu's PG anastomosis Seromuscular suture [17]

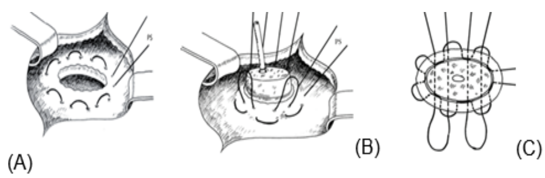

Figure 5. Bartsch's PG anastomosis. (A) continuous hemstitch suture,(B) Two trans-fixing matters sutures [18]

Pylorus preserving Pancraeaticoduodenectomy – PPPD:

(Also known as Traverso – Longmire procedure (1970) has been gaining popularity, especially among European surgeons. The main advantage of this technique is that the pylorus, and thus normal gastric emptying, should in theory be preserved. There is conflicting data as to whether pylorus-preserving pancreaticoduodenectomy is associated with increased likelihood of gastric emptying. In practice, it shows similar long-term survival as a Whipple's (pancreaticoduodenectomy + hemigastrectomy), but patients benefit from improved recovery of weight after a PPPD, so this should be performed when the tumor does not involve the stomach and the lymph nodes along the gastric curvatures are not enlarged [11; 19]

2. Literature search strategy

PubMed were electronically searched using the keywords "laparoscopic", or "laparoscopy", or "hand-assisted", or "minimally invasive", or "robotic", or "da vinci" combined with "pancreaticoduodenectomy", or "duodenopancreatectomy", "Whipple", or "pancreatic resection". Published articles written in English reporting more than 10 cases were included in this study.

Exclusion criteria

Articles published with only abstract, case reports, review articles, techniques reports and articles written in non-English were excluded from final analysis.

3. Statistical analysis

Data extraction

The variables extracted from the included studies were as follows: base information (author, publication year, number of patients, country), surgical technique, intraoperative detail and short-term surgical outcomes (operative time, blood loss, conversion rate, length of postoperative hospital stay, complication and surgical mortality)

A weighted average (WA) is used to calculate a statistical weighted mean of all different means collected from the included studies:

$WA=(w1x1+ w2x2+...+)/(w1+ w2+...+ wn)$

where *w* is the number of cases in a publication and *x* is the *n* of a specific variable. Statistical analyses including chi-square or Fisher's exact for categorical variables between groups and Student's unpaired t test for nuous variables were performed where appropriate using the SPSS statistical ware package (version 16.0, SPSS Inc., Chicago, IL, USA).

III. RESULTS

Table 1. Summary of published articles with more than 10 MIPDs

Author	Year	Country	No. of cases	No. of PDA included
Kim [20]	2016	Korea	12	7 (58.3%)
Wang [21]	2015	China	31	5 (16.1%)
Senthilnathan [22]	2015	India	130	58 (44.6%)
Piedimonte [23]	2015	Canada	26	16 (61.5%)
Mendoza [5]	2015	Korea	18	12 (66.7%)
Liu [24]	2015	China	21	6 (28.6%)
Liang [25]	2015	Canada	15	0
Dokmak [26]	2015	France	46	15 (32.6%)

Chen [27]	2015	China	60	19 (31.7%)
Baker [28]	2015	USA	22	15 (68.2%)
Adam [29]	2015	USA	983	831 (84.5%)
Hakeem [30]	2014	UK	12	0
Croome [7]	2014	UK	108	108 (100%)
Cho [31]	2014	Japan	15	1 (6.7%)
Bao [32]	2014	USA	28	10 (35.7%)
Zureikat [33]	2013	USA	132	54 (40.9%)
Zhan [34]	2013	China	16	NA
Lei [35]	2013	China	11	5 (45.5%)
Lee [36]	2013	Korea	42	1 (2.4%)
Kim [37]	2013	Korea	100	7 (7.0%)
Corcione [38]	2013	Italy	22	11 (50.0%)
Boggi [39]	2013	Italy	34	5 (14.7%)
Asbun [40]	2012	USA	53	22 (41.5%)
Kuroki [41]	2012	Japan	20	0
Lai [42]	2012	China	20	7 (35.0%)
Chalikonda [43]	2012	USA	30	14 (46.7%)
Giulianotti [44]	2010	USA	60	26 (43.3%)
Palanivelu [45]	2009	India	75	23 (30.7%)
Pugliese [46]	2008	Italy	19	11 (57.9%)
Lu [47]	2007	China	13	1 (7.7%)
Dulucq [48]	2006	France	25	11 (44.0%)
Gagner M [49]	1997	USA	10	4 (40.0%)

All listed authors are the first authors

PDA: Pancreatic ductal adenocarcinoma

Thirty-two studies, involving 2209 cases were included in this review [5], [20 - 49]. The first included study of MIPD was documented in 1997 [49], and it was nine years since the second large series of MIPD (n = 25 cases) was published by Dulucq [48]. USA (9 articles) and China (7 articles) are the countries with more published articles regarding MIPD than other countries. Although PDA is the most common indication for pancreaticoduodenectomy, MIPD was not very popular and was not well accepted to treat patients with PDA globally before Croome reported the promising outcomes of MIPD in patients with PDA [7]. The technical complexity, the inherent instrumental limitations, and the requirement of a lengthy learning period delayed the widespread acceptance and use of this challenging surgery. Therefore, it is not difficult to understand that the interval between the first and the second large series reports (n ≥ 10 cases) of MIPD approached

8 years [48; 49]. Afterwards, an increasing number of studies have been published, indicating the safety and acceptable outcomes of this technique [21; 37; 38; 44]. However, these results were limited by strictly selected patients, specialized surgeons, and high-volume institutions. And the comparison between MIPD and OPD is still a concern (Table 1). Unsurprisingly, considering the complex nature and oncologic safety of MIPD, patient selection is necessary. Some authors agreed that MIPD should be indicated in lower-grade malignancy tumors with limited invasion, and patients with PDA should be carefully assessed preoperatively during the early stage of MIPD [39]. With the improvement of surgical instruments and techniques, MIPD expanded to patients diagnosed with PDA in some centers [7; 20; 23; 29].

Table 2. Surgical technique

Author	Surgical types	Closure of GDA	Management of pancreatic stump	Pylorus preservation
Kim	Pure LPD	NA	Invaginated/end-to-end	NA
Wang	HALPD/Pure LPD	Clips	Two-layer duct to-mucose PJ	10 (32.2%)
Senthilnathan	Pure LPD	NA	NA	NA
Piedimonte	RAPD	Stapler	Two-layer duct to-mucose PJ	0
Mendoza	LAPD	Clips	Two-layer duct to-mucose PJ	16 (88.9%)
Liu	LAPD	Clips	End-to-side PJ	21 (100%)
Liang	Pure LPD/ LAPD	Clips	Two-layer duct to-mucose PJ	0
Dokmak	Pure LPD	Clips/ stapler	NA	0
Chen	RAPD	NA	Two-layer duct to-mucose PJ	0
Baker	Pure RPD	Clips/ stapler	Two-layer duct to-mucose PJ	22 (100%)
Adam	NA	NA	NA	NA
Hakeem	Pure LPD	NA	Two-layer duct to-mucose PJ	0
Croome	Pure LPD	Ligasure/ cips	Two-layer duct to-mucose PJ	NA
Cho	Pure LPD	Clips	Dunking PJ	15 (100%)
Bao	RAPD	NA	Two-layer duct to-mucose PJ	5 (17.9%)
Zureikat	RAPD	NA	NA	NA
Zhan	Pure RPD	NA	NA	NA
Lei	Pure LPD/ HALPD	Ligasure		
Lee	LAPD	NA	Pancreaticogastrostomy	42 (100%)
Kim	Pure LPD/ LAPD	Clips	Two-layer duct to-mucose PJ/ Dungking	100 (100%)

Author	Surgical types	Closure of GDA	Management of pancreatic stump	Pylorus preservation
Corcione	Pure LPD	NA	Two-layer duct to-mucose PJ/ duct occlusion	0
Boggi	Pure RPD	Ligasure	Two-layer duct to-mucose PJ/ Invaginated PJ	NA
Asbun	Pure LPD	NA	Two-layer duct to-mucose PJ	39 (92.8%)
Kuroki	LAPD	NA	Two-layer duct to-mucose PJ	16 (80%)
Lai	RAPD	Clips	Two-layer duct to-mucose PJ/ Dunking	0
Chalikonda	RAPD	Clips	Two-layer duct to-mucose PJ	30 (100%)
Giulianotti	RAPD	Ligasure	PG/duct occlusion	10 (16.6%)
Palanivelu	Pure LPD	NA	Two-layer duct to-mucose PJ	75 (100%)
Pugliese	Pure LPD/ LAPD	Clips	One-layer end-to-side PJ	5 (26.3%)
Lu	Pure LPD	NA	Two-layer duct to-mucose PJ/ Binding	0
Dulucq	Pure LPD/ LAPD	Clips	Two-layer duct to-mucose PJ	0

LPD: Laproscopic pancreaticoduodenectomy

RAPD: Robotic-assisted pancreaticoduodenectomy

HALPD: Hand-assited pancreaticoduodenectomy RPD: Robotic pancreaticoduodenectomy.

NA: Not applicable

The surgical techniques were heterogeneous, including pure LPD, LAPD, HAPD, RAPD, and pure RPD. Twenty-five authors used one technique, while seven authors reported two surgical methods. The methods regarding the closure of gastroduodenal artery were mentioned in 17 articles. Clips alone, reported in 10 articles, was the most common method, followed by ligature alone (2 articles), and clips plus stapler (2 articles). Stapler alone, Ligasure alone, and ligature plus clips were used in 1 article each. The management of pancreatic duct is the most complicated step during the digestive tract reconstruction. The majority of authors (27 articles, 84.4%) shared their experience on this topic. Pancreaticojejunostomy, reported in 25 articles, was more popular than the management of pancreatic stump, including pancreaticogastrostomy (2 articles) and pancreatic duct occlusion (2 articles). Furthermore, two-layer duct-to-mucosa pancreaticojejunostomy is the common anastomosis, and some modified pancreaticojejunostomy methods were also reported, including invaginated, dunking, sleeving-jointened to end, and binding pancreaticojejunostomy [20; 31; 35; 42]. Pylorus preservation or not was definitely indicated in 25 articles. Pylorus preservation was performed in all patients in 8 articles (315 patients), gastric antrum resection was employed in all patients in 10 articles, and pylorus was preserved in selective patients in 7 articles (patient percentage: 16.6%~92.8%). Of all the included articles in this review, only three authors described the HALPD (10 patients in total) [35;

50]. An 8 cm mini-incision in the right subcostal area for the nondominant hand was made for retraction, Kocher dissection, palpation of tumor extension, evaluation of tumor resectability, and bleeding control were described in Gagner's study. However, it is difficult to use this incision in the right subcostal area to facilitate the digestive tract reconstruction. Even so, HALPD could still be applied to allow tumor palpation and act as "conversion" from pure LPD when difficulties are encountered. According to this review, pure LPD was the most common MIPD, however, the main disadvantage of pure LPD was the highly technical demands of reconstruction and hemorrhage control in a total laparoscopic surrounding. Surgeons need to overcome a lengthy learning curve to achieve technical competence in pure LPD [51]. The limitations of pure LPD, including reduced freedom of movement, 2D view, reduced precision and poor ergonomics, promoted the development of robotic surgery which is more advantageous in precise tissue manipulation, 3D imaging, elimination of surgeon tremor, and the articulation of the robotic arms with almost 540° of motion. Nevertheless, the advantages of robotic surgery should be balanced with associated cost. Although no literature regarding the cost-comparisons between laparoscopic and robotic pancreaticoduodenectomy is available until now, the increased cost can result from set-up and annual maintenance costs. And this can partially explain why robotic PD is less frequently performed than LPD.

Table 3. Intraoperative and short-term outcomes

Author	Operative time (min)	Blood loss (mL)	Conversion n (%)	LOS (days)	Complication (≥ III) n (%)	PF (%)	SM n (%)
Kim E.Y	411.6 ± 59.2	118 ± 57	0	12.5 ± 4.5	0	0	NA
Wang	515.0	260	3 (9.7%)	12.6	3 (9.7%)	25.8	0
Senthilnathan	310 ± 34	110 ± 22	1 (0.7%)	8 ± 2.6	5 (3.84%)	8.5	2 (1.5%)
Piedimonte	596.6	275	NA	7.8	7 (25.0%)	NA	1 (3.8%)
Mendoza	530	500	NA	13	3 (16.7%)	22.2	NA
Liu	316	240	1 (4.9%)	14	NA	4.9	NA
Liang	342	NA	NA	8	5 (33.0%)	20	1 (7.0%)
Dokmak	342	368	3 (6.5%)	25	13 (28.0%)	24	0
Chen	410 ± 103	400	1 (1.7%)	20 ± 7.4	7 (11.7%)	13.3	1 (1.7%)
Baker	454	425	3 (13.6%)	7	3 (13.6%)	4.6	0
Adam	NA	NA	294 (30%)	NA	NA	NA	NA
Hakeem	NA	NA	NA	14.9 ± 6.6	2 (16.7%)		0
Croome	379.4 ± 93.5	492.4 ± 519.3	7 (0.9%)	6	6 (5.6%)	11	1 (1.0%)

Author	Operative time (min)	Blood loss (mL)	Conversion n (%)	LOS (days)	Complication (≥ III) n (%)	PF (%)	SM n (%)
Cho	356	75	NA	12	NA	13	0
Bao	431	100	4 (14.0%)	7.4	NA	29	2 (7.0%)
Zureikat	527 ± 103	NA	11 (8.0%)	10	28 (21.0%)	35.7	5 (3.8%)
Zhan	299.2 ± 133.5	431.8 ± 309.0	0	29.4 ± 9.1	NA	6.2	NA
Lei	473.7 ± 88.27	1106 ± 52.67	0	18.1 ± 5.9	NA	9.1	0
Lee	404b	374.5 ± 176.9	3 (7.1%)	17.1 ± 9.2	NA	7.1	1 (2.3%)
Kim, S. C	487.3 ± 121.9	NA	5 (4.7 %)	15 ± 9.7	NA	6.0	1 (0.9 %)
Corcione	392	NA	2 (9.1 %)	23	NA	27.3	1 (4.5%)
Boggi	597	220	0	23	5 (14.7%)	38.2	0
Horacio Asbun	541 ± 88	195 ± 136	9 (16.9 %)	8 ± 3.2	13 (24.5%)	16.7	3 (5.6 %)
Kuroki	656.6 ± 191.4	376.6 ± 291.4	0	NA	NA	45	NA
Lai	491.5 ± 94	247	1 (5.0%)	13.7 ± 6.1	NA	35	0
Chalikonda	476	485	3 (10.0%)	9.8	NA	6.6	1 (3.3%)
Giulianotti	421	394	11 (18.3%)	22	NA	31.6	2 (3.3%)
Palanivelu	357	74	0	8.2	NA		1 (1.3%)
Pugliese	461 ± 90	NA	6 (31.5 %)	18±7	NA	15.7	0
Lu	447	800	NA	26.6	NA		2 (15.4%)
Dulucq	287 ± 39	107 ± 48	3 (12.0 %)	16.2 ± 2.7	NA	4.5	1 (4.5 %)
Gagner	510	NA	4 (40.0%)	22.3	NA	10	NA

PF: Pancreatic fistula

SM: Surgical mortality

LOS: Length of hospital stay

NA: Not applicable

The mean operative time, available in 25 studies, ranged from 287.0 to 656.6 min, with a weighted average (WA) of 427.3 min, while median operative time, reported in 5 articles, ranged from 342.0 to 596.6 min. The average volume of intraoperative blood loss, reported in 20 articles, ranged from 74 to 1106 mL, with a WA of 289.4 mL, while median intraoperative blood loss, provided in 4 articles, ranged from 260 to 500 mL. 26 articles provided data on conversion rate, and 375 patients required conversion to OPD in total, with an overall conversion rate of 17.8%. The mean length of postoperative stay was reported in 27 articles, ranging from 6 to 29.4 days, with a WA of 13.1 days. The postoperative severe complications (the Clavien–Dindo Classification≥III), which were recorded in 14 articles, occurred in 3.8% to 33.0% patients, with an overall severe morbidity of 14.3%. Particularly, the incidence of postoperative pancreatic fistula (POPF) was definitely recorded in 30 articles, the ISGPF classification of POPF was employed in 21 articles, and the remaining 9 articles only gave the overall POPF incidence (ranging from 4.0% to 35.0%). According to the 21 articles, where the ISGPF classification was available, the occurrence of grade B or C POPF ranged from 0% to 43.5%, with an overall rate of 8.0%. The postoperative mortality rate was available in 25 articles, which ranged from 0 to 15.4%. In 26 cases patients died, with an overall postoperative mortality rate of 2.3%. The causes of mortality included sepsis, cardiac events, pulmonary complications, bleeding and others. Although a variety of MIPD can be implemented, no one can significantly shorten the overall operative time. The extended operative time of MIPD remains as a topic of debate. Based on this review, the overall conversion rate was 17.8%, and conversions are principally due to tumor adherence, positive margins, uncontrollable bleeding, limited operative space, robotic system malfunction and other unexpected events [39]. We must emphasized that conversions to OPD should not be treated as a failure if they did not increase surgical risk and a conversion rate of zero should not be the pursued goal, especially during the initial learning period. Complications may occur during the laparoscopic step such as superior mesenteric artery rupture, bleeding from the portal vein, duodenal perforation, vascular bleeding around the pancreatic head, mild or right colon artery rupture causing colon necrosis. Causes for conversion rate to open surgery up to 40% are due to the adhesion of tumors to the vena cava (44%), bleeding (13%), peritoneal adhesion (6%), atypical arterial anatomy (13%) [43; 52; 10].

Table 4. Oncologic outcomes

Author	Malignancy n/%	Harvested lymph nodes	R0 resection %	TNM stage N/Y
Kim E.Y	11/91.7%	14.2 ± 2.3/mean ± SD	NA	N
Wang, M	30/96.8%	13 (11 – 19)/median (IQR)	100%	Y
Senthilnathan	130/100%	18.15 ± 4.73/mean ± SD	90.8%	Y
Piedimonte	11/82.1%	22.5 (4 – 44); 22 (13–56)/median (range)	85.7%	N
Mendoza AS	18/100%	12.8 ± 8.1/mean ± SD	83.3%	N
Zhao Liu	18/85.7%	14 (8 - 26)/median (range)	95.0%	N
Liang S	9/60.0%	9 (5 - 22)/median (range)	100%	N
Dokmak S	36/78.3%	20 (8 - 59)/mean (range)	60.0%	N
Shi Chen	38/63.3%	13.6 ± 6/mean ± SD	97.8%	Y
Baker EH	18/81.8%	NA	77.8%	N

Author	Malignancy n/%	Harvested lymph nodes	R0 resection %	TNM stage N/Y
Adam MA	NA	NA	NA	N
Hakeem	12/100%	20.7 ± 6.3/mean±SD	75.0%	Y
Croome, K. P	108/100%	21.4 ± 8.1/mean±SD	77.8%	Y
Akihiro Cho	10/66.7%	NA	NA	N
Bao, P. Q	19/67.9%	15 (8 - 32)/median (range)	63.0%	N
Zureikat, A. H	106/80.3%	19 (4 - 61)/median (range)	87.7%	N
Zhan, Q	NA	NA	100%	N
Lei, Z	9/81.9%	NA	100%	N
Lee, J. S	40/95.3%	16/mean	100%	N
Kim, S. C	12/12.0%	13 (7 - 34)/median (range)	100%	Y
Corcione, F	22/100%	15 (14 - 20)/mean (range)	100%	Y
Boggi, U	22/64.7%	32 (15 - 76)/mean (range)	100%	N
Horacio J Asbun	39/73.6%	23.44 ± 10.1/mean±SD	94.9%	Y
Kuroki	20/100%	NA	NA	N
Lai, E. C	15/75.0%	10 ± 6/mean±SD	73.3%	N
Chalikonda, S	18/60.0%	13.2 (1 – 37)/mean (range)	100%	N
Giulianotti	46/76.7%	21 (5 - 37); 14 (12 - 45)/mean (range)	91.7%	Y
Palanivelu	72/96.0%	14 (8 - 22)/mean (range)	97.2 %	N
Pugliese	18/94.7%	13.0 (4 - 22)/mean (range)	100%	Y
Lu	13/100%	NA	NA	N
Dulucq	20/90.9%	NA	100%	N
Gagner M	8/80.0%	7 (3 - 14)/mean (range)	NA	N

SD: Standart deviation

NA: Not applicable

TNM: Tumor-Note-Metastis

U/Y; No/yes

The etiology was available in 30 articles, and 962 (79.5%) patients diagnosed with malignancies. The mean number of excised lymph nodes, reported in 17 articles, ranged between 7 and 32, with a WA of 17.9, and the median number of harvested nodes, provided in 7 articles, ranged between 9 and 22. Resected margin status was described in 26 studies, with the rate of R0 resection ranging from 60.0% to 100.0%. Only ten authors classified the malignancies according to TNM stage. Oncologic safety of MIPD is controversial [26], given that pancreaticoduodenectomy is mainly indicated in patients with malignancies. On the basis of this review, a WA of 17.9 collected lymph nodes were identified, and this number was within the recommended range (11–17 lymph nodes) for the minimum number of harvested lymph nodes necessary to provide optimal staging and to serve as a quality indicator [53; 54]. And the R0 resection ranged between 60.0% and 100.0%. Some authors compared the oncologic outcomes of MIPD with OPD, concluding that MIPD is equivalent to OPD regarding oncologic outcomes [5; 7; 40; 42]. However, this result can be biased by the patient selection favoring lower grade and smaller tumors. With the maturation of this technique, a future prospectively randomized control trial using strict methodology is required to confirm the oncologic safety of MIPD.

Table 5. Comparion of MIPD versus OPD

Variables	MIPD	OPD	P-value
WA of operative time (min)	436.3	367.9	0.000
	(n = 337 cases)	(n = 723 cases)	
WA of blood loss (mL)	548.1	601.7	0.012
	(n = 277 cases)	(n = 603 cases)	
WA of LOS (days)	15.9	18.4	0.000
	(n = 221 cases)	(n = 490 cases)	

MIPD: minimally invasive pancreaticoduodenectomy

OPD: Open pancreaticoduodenectomy

WA: Weighted average

LOS: Length of hospital

Comparisons of the outcomes between MIPD and open pancreaticoduodenectomy (OPD) were summarized in some institutions [5; 25; 26; 28; 29; 32; 40]. The WA of operative time, calculated from 7 articles, showed significantly longer in MIPD group than that in OPD group (436.3 vs. 367.9 min, P = 0.000). The WA of intraoperative blood loss, reported in 6 studies, was 548.1 and 601.7 mL in MIPD and OPD groups respectively (P = 0.012). Compared with OPD, MIPD shortened postoperative hospital stay (WA from 6 studies: 15.9 vs. 18.4 days, p = 0.000). No significant differences were observed in terms of surgical complications and death between MIPD and OPD groups.

To unify grading standard, the Clavien-Dindo classification of surgical complications is widely used. Because the majority of mild complications (Clavien<III) can be conservatively cured, surgeons preferred to focus on the incidence of severe complications (Clavien ≥ III). The Clavien-Dindo classification was adopted in 14 articles, and the occurrence of severe complications was reported in 3.8% to 33.0% patients, with an overall severe morbidity of 14.3% according to this review. The most frequent specific complication after pancreaticoduodenectomy is postoperative pancreatic fistula (POPF). Regretfully, the overall incidence of POPF could not be calculated from the 31 articles, because the ISGPF classification of POPF was not employed in every study.

Pancreatojejunostomy (PJ) or Pancreatogastrostomy (PG):

The authors' main concern is the weakness of Achill's heel (Achill's Heel) causing post-surgery complications such as peritonitis, pancreatic fistula, bleeding (40 - 60%) and is the main cause of death after PD (30%). Thus, many improvements have been made:

1. How to head pancreatectomy: using harmonic scalpel, ligasure or mono electronic.

2. Limit the excretion of exocrine pancreatic secretions: temporarily blocking the pancreatic duct (pancreatic ligation and fibrin glue – Goldsmith – 1971)

3. Stent drainage the pancreatic duct to the outside or Roux-en-Y procedure

4. Restricting pancreatic secretions with Octreotide (Yeo – 2000, Connor – 2005)

5. Pancreaticojejunostomy or Pancreaticogastrostomy with many modified techniques (more than 80 types).

Systemic lymphadectomy: many studies consistently showed that the overall survival rate after 5 years was significantly higher in patients with radical lymphadectomy than those without lymphadectomy, especially those with metastatic lymphoma (Yeo – 2002, Farnell – 2005)

IV. CONCLUSION

The perioperative and long-term outcomes of MIPD are better than OPD in estimated blood loss and hospitalization time. Though with strict control of indications, standardized training, and learning, ensuring safety and reducing cost are still and will always the keys to a robust development of LPD, the best time for this procedure is in the horizon.

Acknowledgement

The authors would like to express our thanks to The Party Committee, The leadership of Bachmai Hospital, the staffs of the surgical department, and the staffs of the Department of General Surgery to facilitate the patients in the research group to have surgery, care and follow up after surgery. We also thanks to Assoc. Prof. Nguyen Tien Quyet and Prof. Tran Binh Giang for their comments on the completed article.

REFERENCES

1. Albores-Saavedra J., Schwartz A. M., Batich K., et al (2009). Cancers of the ampulla of Vater: demographics, morphology, and survival based on 5,625 cases from the SEER program. *Journal of surgical oncology*, **100 (7)** 598-605.

2. Kendrick M. L., Hilst J., Boggi U., et al (2017). Minimally invasive pancreatoduodenectomy. *HPB : the official journal of the International Hepato Pancreato Biliary Association*, **19 (3)**, 215-224.

3. Trịnh Hồng Sơn, Nguyễn Thanh Long (2004). Chín trường hợp cắt khối tá tụy cấp cứu tại bệnh viện Việt Đức. *Tạp chí Y học TP Hồ Chí Minh*, **8 (3)**, 104 - 112.

4. Hu B. Y., Wan T., Zhang W. Z., et al (2016). Risk factors for postoperative pancreatic fistula: Analysis of 539 successive cases of pancreaticoduodenectomy. *World journal of gastroenterology*, **22 (34)**, 7797-7805.

5. Mendoza A. S., Han H. S., Yoon Y. S., et al (2009). Laparoscopy-assisted pancreaticoduodenectomy as minimally invasive surgery for periampullary tumors: a comparison of short-term clinical outcomes of laparoscopy-assisted pancreaticoduodenectomy and open pancreaticoduodenectomy. *Journal of hepato-biliary-pancreatic sciences*, **22 (12)**, 819-824.

6. Venkat R., Edil B. H., Schulick R. D., et al (2012). Laparoscopic distal pancreatectomy is associated with significantly less overall morbidity compared to the open technique: a systematic review and meta-analysis. *Annals of surgery*, **255 (6)**, 1048-1059.

7. Croome K. P., Farnell M. B., Que

F. G., et al (2014). Total laparoscopic pancreaticoduodenectomy for pancreatic ductal adenocarcinoma: oncologic advantages over open approaches? *Annals of surgery*, **260 (4)**, 633-638

8. Dai R., Turley R. S., Blazer D. G (2016). Contemporary review of minimally invasive pancreaticoduodenectomy. *World journal of gastrointestinal surgery,* **8 (12)**, 784-791.

9. Zimmitti G., Manzoni A., Addeo P., et al (2016). Laparoscopic pancreatoduodenectomy with superior mesenteric artery-first approach and pancreatogastrostomy assisted by mini-laparotomy. *Surgical endoscopy*, **30 (4)**, 1670-1671.

10. Wellner U. F., Kusters S., Sick O., et al (2014). Hybrid laparoscopic versus open pylorus-preserving pancreatoduodenectomy: retrospective matched case comparison in 80 patients. *Langenbeck's archives of surgery*, **399 (7)**, 849-856.

11. Cameron J. L. (2015). Two thousand consecutive pancreaticoduodenectomies. *Journal of the American College of Surgeons*, **220 (4)**, 530-536.

12. Peng S. Y., Wang J. W., Hong D. F., et al (2011). Binding pancreaticoenteric anastomosis: from binding pancreaticojejunostomy to binding pancreaticogastrostomy. *Updates in surgery*, **63 (2)**, 69-74.

13. Kleespies A., Rentsch M., Seeliger H., et al (2009). Blumgart anastomosis for pancreaticojejunostomy minimizes severe complications after pancreatic head resection. *The British journal of surgery*, **96 (7)**, 741-750.

14. Grobmyer S. R., Hollenbeck S. T., Jaques D. P., et al (2008). Roux-en-Y reconstruction after pancreaticoduodenectomy. *Arch Surg*, **143 (12)**, 1184-1188.

15. Fujii T., Sugimoto H., Yamada S., et al (2014). Modified Blumgart anastomosis for pancreaticojejunostomy: technical improvement in matched historical control study. *Journal of gastrointestinal surgery: official journal of the Society for Surgery of the Alimentary Tract*, **18 (6)**, 1108-1115.

16. Schoellhammer H. F., Fong Y., Gagandeep S (2014). Techniques for prevention of pancreatic leak after pancreatectomy. *Hepatobiliary surgery and nutrition*, **3 (5)**, 276-287.

17. Zhu F., Wang M., Wang X., et al (2013). Modified technique of pancreaticogastrostomy for soft pancreas with two continuous hemstitch sutures: a single-center prospective study. *Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract*, **17 (7)**, 1306-1311.

18. Bartsch D. K., Langer P., Kanngiesser V., et al (2012). A simple and safe anastomosis for pancreatogastrostomy using one binding purse-string and two transfixing mattress sutures. *International journal of surgical oncology*, 71863-71867.

19. Traverso L. W., Longmire W.P (1980). Preservation of the pylorus in pancreaticoduodenectomy a follow-up evaluation. *Annals of surgery*, **192 (3)**, 306-310.

20. Kim E. Y., Hong T. H (2016). Total Laparoscopic Pancreaticoduodenectomy Using a New Technique of Pancreaticojejunostomy with Two Transpancreatic Sutures with Buttresses. *Journal of laparoendoscopic & advanced surgical techniques*. **Part A, 26 (2)**, 133-139.

21. Wang M., Zhang H., Wu Z., et al (2015). Laparoscopic pancreaticoduodenectomy: single-surgeon experience. *Surgical endoscopy,* **29 (12)**, 3783-3794.

22. Senthilnathan P., Srivatsan Gurumurthy S., Gul S. I., et al (2015). Long-term results of laparoscopic pancreaticoduodenectomy for pancreatic and periampullary cancer-experience of 130 cases from a tertiary-care center in South India. *Journal of laparoendoscopic & advanced surgical techniques*. **Part A, 25 (4)**, 295-300.

23. Piedimonte S., Wang Y., Bergman S., (2015). Early experience with robotic pancreatic surgery in a Canadian institution. Canadian journal of surgery. *Journal canadien de chirurgie*, **58 (6)**, 394-401.

24. Liu Z., Yu M. C., Zhao R., et al (2015). Laparoscopic pancreaticoduodenectomy via a reverse-"V" approach with four ports: initial experience and perioperative outcomes. *World journal of gastroenterology*, **21 (5)**, 1588-1594.

25. Liang S., Jayaraman S (2015). Getting Started with Minimally Invasive Pancreaticoduodenectomy: Is It Worth It? *Journal of laparoendoscopic & advanced surgical techniques*. **Part A, 25 (9)**, 712-719.

26. Dokmak S., Fteriche F. S., Aussilhou B., (2015). Laparoscopic pancreaticoduodenectomy should not be routine for resection of periampullary tumors. *Journal of the American College of Surgeons*, **220 (5)**, 831-838.

27. Chen S., Chen J. Z., Zhan Q., et al (2015). Robot-assisted laparoscopic versus open pancreaticoduodenectomy: a prospective, matched, mid-term follow-up study. *Surgical endoscopy*, **29 (12)**, 3698-3711.

28. Baker E. H., Ross S. W., Seshadri R., et al (2016). Robotic pancreaticoduodenectomy: comparison of complications and cost to the open approach. *The international journal of medical robotics + computer assisted surgery : MRCAS*, **12 (3)**, 554-560.

29. Adam M. A., Choudhury K., Dinan M. A., et al (2015). Minimally Invasive Versus Open Pancreaticoduodenectomy for Cancer: Practice Patterns and Short-term Outcomes Among 7061 Patients. *Annals of surgery*, **262 (2)**, 372-377.

30. Hakeem A. R., Verbeke C. S., Cairns A., (2014). A matched-pair analysis of laparoscopic versus open pancreaticoduodenectomy: oncological outcomes using Leeds Pathology Protocol. *Hepatobiliary & pancreatic diseases international: HBPD INT*, **13 (4)**, 435-441.

31. Cho A., Yamamoto H., Nagata M., et al (2009). Comparison of laparoscopy-assisted and open pylorus-preserving pancreaticoduodenectomy for periampullary disease. *Am J Surg*, **198 (3)**, 445-449.

32. Bao P. Q., Mazirka P. O., Watkins K. T (2014). Retrospective comparison of robot-assisted minimally invasive versus open pancreaticoduodenectomy for periampullary neoplasms. *Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract*, **18 (4)**, 682-689.

33. Zureikat A. H., Moser A. J., Boone B. A., et al (2013). 250 robotic pancreatic resections: safety and feasibility. *Annals of surgery*, **258 (4)**, 554-559

34. Zhan Q., Deng X. X., Han B., et al (2013). Robotic-assisted pancreatic resection: a report of 47 cases. *The international journal of medical robotics + computer assisted surgery : MRCAS*, **9 (1)**, 44-51.

35. Lei Z., Zhifei W., Jun X., et al (2013). Pancreaticojejunostomy sleeve reconstruction after pancreaticoduodenectomy in laparoscopic and open surgery. *JSLS : Journal of the Society of Laparoendoscopic Surgeons*, **17 (1)**, 68-73.

36. Lee J. S., Han J. H., Na G. H., et al (2013). Laparoscopic pancreaticoduodenectomy assisted by mini-laparotomy. *Surgical laparoscopy, endoscopy & percutaneous techniques*, **23 (3)**, 98-102.

37. Kim S. C., Song K. B., Jung Y. S., et al (2013). Short-term clinical outcomes for 100 consecutive cases of laparoscopic pylorus-preserving pancreatoduodenectomy: improvement with surgical experience. *Surgical endoscopy*, **27 (1)**, 95-103.

38. Corcione F., Pirozzi F., Cuccurullo D., et al (2013). Laparoscopic pancreaticoduodenectomy: experience of 22 cases. *Surgical endoscopy*, **27 (6)**, 2131-2136.

39. Boggi U., Signori S., De Lio N., et al (2013). Feasibility of robotic pancreaticoduodenectomy. *The British journal of surgery*, **100 (7)**, 917-925.

40. Asbun H. J., Stauffer J. A (2012). Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the Accordion Severity Grading System. *Journal of the American College of Surgeons*, **215 (6)**, 810-819.

41. Kuroki T., Adachi T., Okamoto T., et al (2012). A non-randomized comparative study of laparoscopy-assisted pancreaticoduodenectomy and open pancreaticoduodenectomy. *Hepato-gastroenterology*, **59 (114)**, 570-573.

42. Lai E. C., Yang G. P., Tang C. N (2012). Robot-assisted laparoscopic pancreaticoduodenectomy versus open pancreaticoduodenectomy--a comparative study. *Int J Surg*, 10 (9), 475-479.

43. Chalikonda S., Aguilar-Saavedra J. R., Walsh R. M (2012). Laparoscopic robotic-assisted pancreaticoduodenectomy: a case-matched comparison with open resection. *Surgical endoscopy*, **26 (9)**, 2397-2402.

44. Giulianotti P. C., Sbrana F., Bianco F. M., et al (2010). Robot-assisted laparoscopic pancreatic surgery: single-surgeon experience. **Surgical endoscopy**, **24 (7)**, 1646-1657.

45. Palanivelu C., Rajan P. S., Rangarajan M., et al (2009). Evolution in techniques of laparoscopic pancreaticoduodenectomy: a decade long experience from a tertiary center. *Journal of hepato-biliary-pancreatic surgery*, **16 (6)**, 731-740.

46. Pugliese R., Scandroglio I., Sansonna F., et al (2008). Laparoscopic pancreaticoduodenectomy: a retrospective review of 19 cases. *Surgical laparoscopy, endoscopy & percutaneous techniques*, **18 (1)**, 13-18.

47. Lu B., Huang Y., Cai X., et al (2007). A novel method for reconstruction in laparoscopic pancreaticoduodenectomy: an experience of 13 cases. *Frontiers of medicine in China*, **1 (4)**, 369-372.

48. Dulucq J.L., Wintringer P., Mahajna A (2006). Laparoscopic pancreaticoduodenectomy for benign and malignant diseases. *Surgical endoscopy*, **20 (7)**, 1045-1050.

49. Gagner M., Pomp A (1994). Laparoscopic pylorus-preserving pancreatoduodenectomy. *Surgical endoscopy*, **8 (5)**, 408-410.

50. Wang M., Cai H., Meng L., et al (2016). Minimally invasive pancreaticoduodenectomy: A comprehensive review. *Int J Surg*, **35**, 139-146.

51. Speicher P. J., Nussbaum D. P., White R. R., et al (2014). Defining the learning curve for team-based laparoscopic pancreaticoduodenectomy. *Annals of surgical oncology*, **21 (12)**, 4014-4019.

52. Trần Quế Sơn, Trần Hiếu Học, Trần Mạnh Hùng, và cs (2018). Nhận xét kết quả cắt khối tá tụy có nội soi hỗ trợ với mổ mở trong điều trị khối u vùng bóng Vater tại Bệnh viện Bạch Mai. *Tạp chí nghiên cứu Y học*, **115 (6)**, 158 - 168.

53. Huebner M., Kendrick M., Reid-Lombardo K. M., et al (2012). Number of lymph nodes evaluated: prognostic value in pancreatic adenocarcinoma. *Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract*, **16 (5)**, 920-926.

54. Valsangkar N. P., Bush D. M., Michaelson J. S., et al (2013). N0/N1, PNL, or LNR? The effect of lymph node number on accurate survival prediction in pancreatic ductal adenocarcinoma. *Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract,* **17 (2)**, 257-266.