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Laparoscopic pancreatectomy: Indications and outcomes

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Abstract

The application of minimally invasive approaches to pancreatic resection for benign and malignant diseases has been growing in the last two decades. Studies have demonstrated that laparoscopic distal pancreatectomy (LDP) is feasible and safe, and many of them show that compared to open distal pancreatectomy, LDP has decreased blood loss and length of hospital stay, and equivalent post-operative complication rates and short-term oncologic outcomes. LDP is becoming the procedure of choice for benign or small low-grade malignant lesions in the distal pancreas. Minimally invasive pancreaticoduodenectomy (MIPD) has not yet been widely adopted. There is no clear evidence in favor of MIPD over open pancreaticoduodenectomy in operative time, blood loss, length of stay or rate of complications. Robotic surgery has recently been applied to pancreatectomy, and many of the advantages of laparoscopy over open surgery have been observed in robotic surgery. Laparoscopic enucleation is considered safe for patients with small, benign or low-grade malignant lesions of the pancreas that is amenable to parenchyma-preserving procedure. As surgeons' experience with advanced laparoscopic and robotic skills has been growing around the world, new innovations and breakthrough in minimally invasive pancreatic procedures will evolve.

Core tip: This review discusses recent advances in laparoscopic distal pancreatectomy (LDP), minimally invasive pancreaticoduodenectomy (MIPD), and enucleation. Recent studies show that LDP have improved perioperative recovery and equivalent oncologic outcomes. Studies on MIPD demonstrate that it is safe in terms of intra-operative outcomes, post-operative recovery and early oncologic outcomes; however, it requires advanced laparoscopic skills. Laparoscopic enucleation has become the operation of choice for small benign tumours that are away from the main pancreatic duct, especially insulinomas. We also summarize key results in pre-operative, perioperative and post-operative outcomes from contemporary series comparing open and laparoscopic pancreatic resections in the tables.

INTRODUCTION

Pancreatic resection is technically challenging due to anatomic factors such as retroperitoneal location, and close proximity to the duodenum and major vasculature. As a result, the application of laparoscopy to pancreatectomy has been slower compared to other abdominal procedures. As surgeons become more adept at advanced laparoscopy, there is increasing evidence demonstrating not only the safety and feasibility of laparoscopic pancreatic

Table 1 Summary of laparoscopic distal pancreatectomy series comparing the pre-operative variables and intra-operative outcomes laparoscopic distal pancreatectomy and open distal pancreatectomy

Ref.	LDP/ODP	BMI	Comorbidity	Splenic preservation	OR time (min)	Blood loss (cc)	Conversion
Abu Hilal *et al*[2]	35/16	N/A	N/A	40%/19%	200/225	200/394[a]	0.0%
Fox *et al*[3]	42/76	27.3/26.5	NS	35.7%/22.4%	304/281	375/375	11.9%
Mehta *et al*[4]	30/30	N/A	N/A	70%/30%[a]	188/226	294/729[a]	N/A
Limongelli *et al*[5]	16/29	26.4/27.1	NS	31%/14%	204/160[a]	160/365[a]	6.0%
Soh *et al*[6]	10/21	25/21	NS	N/A	383/330	275/600[a]	N/A
Butturini *et al*[7]	43/73	N/A	N/A	44.2%/11%[a]	180/180	N/A	0.0%
Cho *et al*[8]	254/439	NS	NS	34%/10%[a]	NS	24%/54% (> 300cc)	9.4%
Aly *et al*[9]	40/35	21/21	N/A	32%/8%[a]	342/250[a]	363/606[a]	10.0%
DiNorcia *et al*[10]	71/192	N/A	NS	15.5%/15.6%	250/270[a]	150/900[a]	25.3%
Jayaraman *et al*[11]	107/236	27/27	N/A	21%/14%	194/163[a]	150/350[a]	30.0%
Kooby *et al*[12]	23/189	28.5/26.2	NS	N/A	238/230	422/790[a]	17.0%
Vijan *et al*[13]	100/100	27.4/27.9	NS	25%/N/A	214/208	171/519[a]	4.0%
Baker *et al*[14]	27/85	N/A	NS	N/A	236/253	219.4/612.6[a]	3.6%
Finan *et al*[15]	44/104	28.3/26.9	NS	2%/2.7%	156/200[a]	157/719[a]	4.1%
Nakamura *et al*[16]	21/16	23.4/21.3	NS	35%/31%	308/282	249/714[a]	4.8%
Bruzoni *et al*[17]	7/4	29.5/29	N/A	100%/100%	182/152	214/362	0.0%
Eom *et al*[18]	31/62	22.2/23	N/A	42%/NR	217.7/194.8	N/A	N/A
Kim *et al*[19]	93/35	23.4/23.9	NS	40.9%/5.7%[a]	195/190	NS	N/A
Matsumoto *et al*[20]	14/19	N/A	NS	N/A	290.7/213.8[a]	247.1/400.3	7.0%
Misawa *et al*[21]	8/9	N/A	N/A	12.5%/0%	255/205	14/307[a]	0.0%
Tang *et al*[22]	9/5	N/A	NS	55.6%/0%	180/210	100/450[a]	0.0%
Teh *et al*[23]	12/16	26.4/27.5	NS	41.7%/6.3%	212/278[a]	193/609[a]	16.0%
Velanovich *et al*[24]	15/15	N/A	N/A	0%/0%	N/A	N/A	20.0%
Fernández-Cruz *et al*[25]	5/41	N/A	N/A	100%/39.9%	N/A	450/N/A	N/A

Summary of laparoscopic distal pancreatectomy (LDP) series comparing the pre-operative variables and intra-operative outcomes LDP and open distal pancreatectomy (ODP). The results are shown as "LDP/ODP"; [a]*P* < 0.05. NS: Statistically non-significant between the two groups; N/A: Data not available.

resection, but also potential advantages in postoperative recovery and equivalent oncological outcome. Here, we review recent advances in laparoscopic distal pancreatectomy, pancreaticoduodenectomy, and enucleation, with emphasis on patient selection, surgical technique, perioperative outcomes, oncologic outcomes, and the emerging role of robotics.

LAPAROSCOPIC DISTAL PANCREATECTOMY

Laparoscopic distal pancreatectomy (LDP) is the most commonly performed pancreatic resection using minimally invasive techniques. The main advantages of LDP over open distal pancreatectomy (ODP) are the potential for improved surgical exposure and visualization, and enhanced post-operative recovery and morbidity[1]. A summary of series that compare the pre-operative, intra-operative and post-operative factors and outcomes in LDP and OPD at their institutions is shown in Tables 1 and 2[2-25].

PATIENT SELECTION

Appropriate patient selection is essential for any surgical procedure attempted with a laparoscopic approach. Patient factors, such as body habitus, cardiopulmonary comorbidity, and a history of previous laparotomy are typical factors that may make laparoscopic surgery more challenging. High BMI is not a contraindication for LDP,

nor is the size of the tumour being resected[8,11,12,26]. The laparoscopic approach may be even more beneficial in patients with higher BMI because of better access into the deep abdomen, less post-operative incisional pain and faster postoperative recovery.

Tumor factors may also affect a patient's suitability for a laparoscopic resection. Malignant potential should not necessarily be a limiting factor for laparoscopic resection. However, large, locally advanced malignancies may not be technically feasible laparoscopically due to concerns with tumor handling, seeding, and risk of positive margins. Likewise, cancerous lesions located near the neck of the pancreas or close to the celiac trunk and its branches should be approached with caution[11]. In the absence of randomized controlled trials, most series suggest that patients with isolated benign, pre-malignant or small low-grade malignant lesions in the distal pancreas should be considered for undergoing LDP[1]. In experienced centres, LDPs can be safely performed in patients with high BMI, large tumour size and malignant diseases.

SURGICAL TECHNIQUE AND INTRA-OPERATIVE CONSIDERATIONS

In the early 1990s the first reports of laparoscopic pancreatic resection were published[27]. Since then, this technique has gained widespread adoption. Distal pancreatectomy in many respects is an ideal minimally invasive approach since it involves resection without reconstruction.

To help ascend the learning curve for a novel ap-

proach, some authors advocate the use of hand-access ports in the midline and right lower quadrant[28]. The main advantages of hand-access ports are allowing direct palpation of the tumour, and control of hemorrhage by manual pressure[1]. The need for these ancillary access devices has been mitigated by advances in surgical technique, vascular sealing devices and endomechanical staplers which allow for safe performance of pancreatic resections fully laparoscopically.

LDP may be performed with or without splenic preservation. The main advantage to splenic preservation is to avoid the risk of overwhelming post-splenectomy infection, which has an annual incidence of 0.23%-0.42% per year and a lifetime risk of 5%[29]. LDP with preservation of the spleen is preferred for benign diagnoses as the need for lymph node retrieval is not as crucial[1,30]. Likewise, the splenic vasculature should be taken in malignant cases to facilitate total extirpation and negative margins. Distal pancreatectomy with splenic preservation has similar rates of post-operative morbidity and pancreatic fistulas as distal pancreatectomy with splenectomy[10]. Although long-term prospective studies are lacking, we advocate preservation of the spleen in LDP performed for benign diseases whenever possible in order to minimize the effect on the immune system against encapsulated organisms.

Spleen-preserving distal pancreatectomy may also be performed using the Warshaw technique, which divides the splenic artery and vein while preserving the blood supply to the spleen from the short gastric vessels[31].

Intraoperative variables include operating time, blood loss, and conversion, and selected studies comparing LDP and ODP at the same institutions are shown in Table 1. Some series report a shorter operating time for LDPs compared to ODP[10,15,23], but some of the studies' calculation of the average LDP operating time does not include the converted cases, which are much longer[10,15]. Other series reported equivalent or longer operating time with LDP compared to ODP[9,11,12]. One may note that the operating time is variable even though the surgical techniques are similar. This may be explained by the difference in the surgeons' learning curve[26].

A LDP that is not converted to open is associated with significantly less intra-operative blood loss compared to ODP in many series[2,4-6,10-12,14,16,21,23]. The usual rate of conversion to ODP is about 10%-20% (Table 1), but can be over 25% in series with less selected patients[11,32]. Reasons for conversion include high BMI, adhesions, difficulty localizing the lesion, large and proximal tumours, hemorrhage, and concern for margin adequacy. Conversion to open surgery may also be associated with a greater risk of postoperative complications[11].

POST-OPERATIVE OUTCOMES

Patients with cardiac and pulmonary comorbidities risk prolonged postoperative recovery and comorbidity after undergoing a midline laparotomy or subcostal incision due to postoperative pain, atelectasis, pneumonia, and ileus. Some argue that these patients are ideal candidates for laparoscopic resection due a potential greater benefit of an enhanced postoperative recovery. Although there is a lack of randomized trials comparing LDP and ODP, there have been many retrospective series in the past decade studying the post-operative outcomes of LDP (Table 2). The main advantages of LDP include shorter hospital stay (difference of 2 d or more)[2-6,9,11-16,19-21,23,24], decreased requirement for pain medications, and swifter return to regular diet (difference of 1.7 d)[19]. The overall morbidity is approximately 26%-40%[2,10,11,13], which is similar to ODP from contemporary series (29%-57%). Most published series suggest mortality is rare with the laparoscopic technique and that it can be done reliably and safely in most cases[10-12,15].

The rate of pancreatic fistula is similar between LDP and ODP, with most studies reporting it to be in the acceptable ranges for both approaches[10,11,13,15]. There is a wide range of reported rates of pancreatic fistulas, as shown in Table 2. The large difference in rates of pancreatic fistulas may be explained by the different reporting strategies. For example, some studies report an overall rate, whereas others report only the pancreatic fistulas that require interventions. In addition, this difference may also be due to differences in intra-operative technique and equipment.

In summary, LDPs demonstrate significantly faster post-operative recovery and shortened length of stay, and similar safety compared to ODP.

ONCOLOGIC OUTCOMES

Oncologic outcomes can be categorized into intra-operative and long-term. Comparisons between LDP and ODP in pathologic considerations, such as tumour size, specimen length, proportion of malignant histology, margin positivity and lymph node harvest have been described in various case series comparing their LDP with ODP experience (Table 2). In Kneuertz *et al*[26] there is no difference in tumour size, proportion of malignant histology, and margin positivity between early and recent experiences.

Patients undergoing LDP tend to have smaller size lesions (2.5-3.3 cm in LDP *vs* 3-7.7 cm in ODP)[10,11,13,15]. The range for specimen length in LDP is 7.7-9.4 cm[10,12,13], which is slightly smaller than in ODP (9.4-10 cm). In most series, patients with malignancy tend to undergo open resections. Therefore, the margin positivity from the LDP group in these series should be interpreted with caution, because of pre-existing selection bias. However, in Kooby *et al*[12]'s analysis of patients undergoing LDP and ODP for malignant diseases only, they reported similar rates of margin positivity (26% in LDP and 27% in ODP), lymph node retrieval (13.8 *vs* 12.5), and specimen length (9.4 cm *vs* 9.9 cm).

There is little data on long term oncologic outcomes after LDP. Marangos *et al*[33] found that the 3-year survival

Table 2 Summary of laparoscopic distal pancreatectomy series comparing the post-operative outcomes in laparoscopic distal pancreatectomy and open distal pancreatectomy

Ref.	Hospital stay	Mortality	Morbidity	Re-operation	Pancreatic fistula	Tumour size (cm)	% Malignancy	Margin positivity	Lymph node harvest
Abu Hilal *et al*[2]	7/11[a]	0%/6%	40%/69%	N/A	29%/44%	3.4/3.3	11%/25%	2.9%/6.2%	N/A
Fox *et al*[3]	5/7[a]	0	21.4%/19.7%	4.76%/2.63%	28.57%/13.16%[a]	2.9/3.5	4.8%/2.6%	N/A	N/A
Mehta *et al*[4]	8.7/12.6[a]	0%/3.3%	50%/43.3%	3.3%/6.7%	16.7%/13.3%[1]	3.8/4.3	23.3%/23.3%	N/A	8.4/13.8
Limongelli *et al*[5]	6.4/8.8[a]	0%/3%	25%/41%	0%/7%	18%/20%	3.2/4.3[a]	37%/45%	6%/7%	N/A
Soh *et al*[6]	5/8[a]	0	70%/57.1%	N/A	70%/42.9%	2.45/5[a]	10%/66.7%[a]	N/A	2/4[a]
Butturini *et al*[7]	8/9	0	48.2/45.2%	9.3%/9.6%	29.7%/13.7%	3.9/4.0	4.7%/2.7%	N/A	N/A
Cho *et al*[8]	16/54% (> 7d)	0.5%/1%	12%/15%	1%/3%	23%/27%	40%/58% (> 3.5 cm)	9%/29%	N/A	N/A
Aly *et al*[9]	22/27[a]	0	20%/31%	N/A	12%/17%	3/4	N/A	N/A	N/A
DiNorcia *et al*[10]	5/6[a]	0%/1%	28.2%/43.8%[a]	5.6%/3.6%	11.3%/14.1%	2.5/3.6[a]	12.7%/38.5%[a]	2.8%/13%[a]	6/8
Jayaraman *et al*[11]	5/7[a]	0%/0.8%	27%/40%[a]	2%/2%	15%/13%	3/3[a]	17%/47%[a]	3%/4%	6/7
Kooby *et al*[12]	7.4/10.7[a]	N/A	N/A	N/A	N/A	3.5/4.5	100%/100%	26%/27%	13.8/12.5
Vijan *et al*[13]	6.1/8.6[a]	3%/1%	34%/29%	N/A	17%/17%	3.3/4[a]	23%/23%	0	NS
Baker *et al*[14]	4.0/8.6[a]	0%/2%	37%/35%	N/A	22%/14%	3.78/4.03	30.1%/29.0%	N/A	5.2/9.4[a]
Finan *et al*[15]	5.9/8.6[a]	0%/4.8%	NS	N/A	50%/46%	3.26/7.73[a]	25%/42%[a]	0	N/A
Nakamura *et al*[16]	10/25.8[a]	N/A	0%/18.8%	N/A	0%/12.5%[1]	4.8/4.1[a]	14.3%/6.25%	N/A	N/A
Bruzoni *et al*[17]	6.2/9	N/A	14.2%/0%	N/A	N/A	2.3/3.8	0%/0%	0	N/A
Eom *et al*[18]	11.5/13.5[a]	0	35.5%/24.2%	N/A	9.7%/6.5%	3.95/6.15[a]	9.7%/6.5%	N/A	N/A
Kim *et al*[19]	10/16[a]	0	24.7%/29%	N/A	8.6%/14.3%	3/3	0	N/A	N/A
Matsumoto *et al*[20]	12.9/23.8[a]	0	7.1%/21.1%	N/A	0%/10.5%	3.0/3.4	0	N/A	N/A
Misawa *et al*[21]	10/16[a]	0	N/A	N/A	0%/22%	7.5/2	0%/0%	N/A	N/A
Tang *et al*[22]	7/11	0	33.3%/0%	N/A	22.2%/0%	N/A	0%/0%	0%/0%	N/A
Teh *et al*[23]	6.2/10.6[a]	0	16.7%/56.2%[a]	0	8.3%/6.2%	3.4/3.4	0%/0%	N/A	N/A
Velanovich *et al*[24]	5/8[a]	N/A	20%/27%	N/A	13%/13%	N/A	20%/32%	N/A	N/A
Fernández-Cruz *et al*[25]	6/12	N/A	20%/48%	20%/0%	N/A/12.2%	N/A	N/A	N/A	N/A

[1]Denotes pancreatic fistula rates for grades B and C. Summary of laparoscopic distal pancreatectomy (LDP) series comparing the post-operative outcomes in LDP and open distal pancreatectomy (ODP). The results are shown as "LDP/ODP"; [a]*P* < 0.05. NS: Statistically non-significant between the two groups; N/A: Data not available. In the pancreatic fistula column, the default is recording percentage of patients with pancreatic fistula of all grades and severity.

rate in a cohort of 30-patient with 93% margin negativity for exocrine carcinoma is 36%, and the median survival time was 23 mo (range 0.5-108 mo).

In conclusion, LDP is safe, effective, and has become the operation of choice for lesions involving the distal pancreas. It should be considered a standard approach for most indications for distal pancreatectomy except in large cancers or large, centrally located lesions near the pancreatic neck or major vessels. Its application has been broadened to include patients with higher BMIs and comorbidity scores. LDP's main advantages are shorter length of stay, faster post-operative recovery, and decreased requirement for pain medications with no difference in post-operative morbidity, mortality and short-term oncologic outcome. Further studies are needed to evaluate the long-term oncologic outcomes of LDP.

MINIMALLY INVASIVE PANCREATICODUODENECTOMY

Since the first laparoscopic pancreaticoduodenectomy in 1994[34], the experience with minimally invasive pancreaticoduodenectomy (MIPD) has increased. Despite the known benefits of laparoscopy, the anatomic challenges, the inherent technical complexity of this operation and the difficulty of performing three major anastomoses have limited the widespread use of minimally invasive

pancreaticoduodenectomy. A summary of series that compare the pre-operative, intra-operative and post-operative factors and outcomes in MIPD and OPD at their institutions is shown in Tables 3 and 4[35-38].

PATIENT SELECTION

In adopting laparoscopic approaches, or in the infancy of novel techniques, the traditional indications for open surgery include patients with morbid obesity[39,40], and severe cardiac or pulmonary comorbidity[39]. However, these patients may benefit the most from the minimally invasive approaches if they can be done safely. The earliest series of MIPD involved patients with small[39-41], benign or low grade[38,41,42] tumours of the pancreatic head, duodenal ampulla, and distal common bile duct, in the absence vascular or extrabiliary involvement[39,40,42,43]. Patients with ampullary lesions, mucinous cystic neoplasms and Intra-papillary Mucinous Neoplasms (IPMNs) are ideal surgical candidates for MIPD due to the tendency for them to be non-adherent to the major arterial and venous structures near the pancreatic neck and uncinate process.

SURGICAL TECHNIQUE AND INTRA-OPERATIVE CONSIDERATIONS

MIPD has been slow to adopt because of the anatomi-

Table 3 Summary of minimally invasive pancreaticoduodenectomy series comparing the pre-operative variables and intra-operative outcomes minimally invasive pancreaticoduodenectomy and open pancreaticoduodenectomy

Ref.	TLPD	LAPD	HAPD	OPD	BMI	Comorbidity	Indication	Pylorus preservation	OR time (min)	Blood loss (cc)	Conversion
Asbun *et al*[35]	53	N/A	N/A	215	27.6/26.6	NS	N/A	73.6%/45.6%[a]	541/401[a]	195/1032[a]	15%
Kuroki *et al*[36]	N/A	20	N/A	31	21.9/22.9	NS	N/A	80%/83.9%	656.6/554.6	376.6/1509.5[a]	0
Zureikat *et al*[37]	14	N/A	N/A	14	28.5/30	NS	N/A	0/0	456/372[a]	300/400	14%
Cho *et al*[38]	N/A	15	N/A	15	23/25	NS	N/A	100%/100%	338/287	445/552	0

Summary of minimally invasive pancreaticoduodenectomy (MIPD) series comparing the pre-operative variables and intra-operative outcomes MIPD and open pancreaticoduodenectomy (OPD). The results are shown as "MIPD/OPD"; [a]*P* < 0.05. TLPD: Total laparoscopic pancreaticoduodenectomy; LAPD: Laparoscopically assisted pancreaticoduodenectomy; HAPD: Hand-assisted pancreaticoduodenectomy; NS: Statistically non-significant between the two groups; N/A: Data not available.

Table 4 Summary of minimally invasive pancreaticoduodenectomy series comparing the post-operative outcomes in minimally invasive pancreaticoduodenectomy and open pancreaticoduodenectomy

Study	Hospital stay	Mortality	Overall morbidity	Re-operation	Pancreatic fistula	Tumour size (cm)	PDAC	Margin positivity	Lymph node harvest
Asbun *et al*[35]	8/12.4[a]	5.7%/8.8%	NS	3.8%/7%	16.7%/17.3%	2.74/3.14	41.5%/46.5%	5.1%/17%	23.44/16.84[a]
Kuroki *et al*[36]	N/A	N/A	NS	N/A	45%/39%	N/A	0/12.9%	N/A	N/A
Zureikat *et al*[37]	8/8.5	7%/0%	62%/42.8%	7%/7%	36%/42.8%	2.2/3.6[a]	57%/57%	0/8.3%	18.5/19.1
Cho *et al*[38]	16.4/15.6	0	27%/27%	N/A	13%/13%	N/A	6.7%/13.3%	0	18.5/20

Summary of minimally invasive pancreaticoduodenectomy (MIPD) series comparing the post-operative outcomes in MIPD and open pancreaticoduodenectomy (OPD). The results are shown as "MIPD/OPD"; [a]*P* < 0.05. N/A: Data not available.

cal and reconstructive challenges previously mentioned. There are two general approaches to MIPD: a total laparoscopic approach (TLPD) where the anastomoses (pancreaticojejunostomy, hepaticojejunostomy, gastrojejunostomy) along with the resection are done intracorporeally; and the laparoscopic-assisted, or hybrid approach where the reconstruction is done through a small incision which is also used for specimen extraction[38,40,42,44-46].

TLPD and the hybrid approach have similar mean operative time (268 min *vs* 286 min), blood loss (75 cc *vs* 83 cc), complication rate (33% *vs* 25%), and length of stay (13.4 d *vs* 14 d)[45]. Several retrospective series demonstrate that MIPD can be safely performed in experienced hands. The average operating time and blood loss for three large MIPD series are 368-541 min, and 65-240 cc, respectively[35,41,43]. In comparison, a contemporary OPD series by Cho *et al*[38] shows that the average operating time is shorter (287 min), and blood loss is greater (552 cc) in open cases. Asbun *et al*[35] and Kuroki *et al*[36] compared their LPD and OPD cases and also found that LPD resulted in significantly less blood loss. The rate of converting MIPD to open ranges from 0%-31.6%[36,38,40,41,44]. Common reasons for conversion are hemorrhage, portal vein bleeding, difficult dissection, adhesions, and tumour involvement of major vascular structures[1,47].

POST-OPERATIVE RECOVERY

It is unclear whether patients who undergo TLPD or hybrid have better post-operative outcomes than OPD. It is also difficult to compare the post-operative outcome measures across series because each hospital may have

different practices and enhanced recovery programs in post-operative pain management, diet advancement, and criteria for discharge. In addition, the institutional and personal experience with the technical challenges of MIPD varies among the series, and the studies may take place in different stages of the institution and surgeon's learning curves. Since many MIPD series are small in sample size and they often exclude patients with major vascular involvement, extensive adhesions, large tumours and morbid obesity, the post-operative outcomes may favor MIPD over OPD, because of the intrinsic differences in patient selection. As a result, it is very difficult to objectively compare and summarize the rate of major morbidity and mortality among the studies. Tables 3 and 4 lists studies that compared outcomes of LPDs and OPDs at their institutions.

Most MIPD series report low mortality rate[38-46]; Gumbs *et al*[48] reviewed 285 cases and found the overall mortality was 2%. A more recent series reports a 100-d mortality rate of 5.7%, which is not significantly different than the mortality rate of 8.8% in the OPD group in the same series[35]. Their reported mortality rate is higher than many other past studies because the authors extended the time range to 100 d. The majority of MIPD series have a 30-d mortality rate that is lower than that reported by the American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) database of pancreaticoduodenectomy (mortality rate of 1.9%-2.8% in 6988 patients)[49]. The MIPD's rate of major morbidity in the series mentioned above ranges from 25%-48%, compared to 31% in OPD[50]. The rate of pancreatic fistulas is an important post-operative outcome and is reported in

majority of series. the rate of International Study Group of Pancreatic Fistula (ISGPF) grade B pancreatic fistula ranges from 2.4%-18%[35,38,40,41,43]. Cho *et al*[38] and Asbun and Stauffer[35] compared their MIPD to contemporary OPD, and found that the OPD group have similar rate of pancreatic fistula (3%-13%). Other complications reported include biliary leak (2.4%-7%)[38,40,41], delayed gastric emptying (7%-9.1%)[38,44], small bowel obstruction 6.2%[45], intra-abdominal hemorrhage (5.3%)[40], intra-abdominal abscess (2.4%-19.9%)[35,40], wound infection (11.3%)[35], pulmonary complications and DVT (2.4%-14.3%)[39,41].

The average length of stay for MIPD varies between 8 and 18[35,38-41,44,45]. Asbun *et al*[35] found that the length of stay is significantly shorter in MIPD group compared to OPD group (8 d *vs* 12.4 d), whereas Cho *et al*[38] did not (16.4 d *vs* 15.6 d)[38]. Diet advancement usually occurs around 7 d[38,40,46], which is similar to OPD in Cho *et al*[38] series. In summary, there is no clear evidence that MIPD results in significant improvement in post-operative mortality, morbidity and recovery (Tables 3 and 4). Tremendous patient selection and institutional bias undoubtedly influences the published literature.

ONCOLOGIC OUTCOMES

The short-term oncologic outcomes of MIPD appear similar to OPD. Once again, published series have highly selected patients without major vascular involvement and relatively small tumour sizes of 2.1-3 cm[40,41,43-45]. Negative margins are achieved in 100% cases in these series which is far different from the typical R0 margin rate of 70%-80% in large trials of OPD[50]. We believe this is a reflection of patient selection in that patients with smaller, lower grade lesions are likely selected for MIPD. The rate of lymph node retrieval in published reports of MIPD seems adequate[35,38].

There are few long-term oncologic outcome studies in MIPD. Palanivelu *et al*[41] found that the median survival for 42 patients undergoing MIPD is 46 mo; their five-year survival rates for pancreatic head adenocarcinoma is 19.1%, and for ampullary adenocarcinoma is 30.7%. The authors did comment on the biased patient selection based on non-obese patients with small, early lesions. Therefore, it is difficult to make conclusions on oncologic outcomes in the absence of randomized studies or studies with large sample size and long-term follow-up.

In conclusion, MIPD has not yet been wide adopted for lesions involving the ampulla and pancreatic head. MIPD is safe in experienced hands, but there is no clear evidence in favor of MIPD in post-operative major morbidity, mortality, recovery, and oncologic outcomes compared to OPD. TLPD and LAPD do not seem to differ in operative time, blood loss, length of stay, or rate of complications. A plausible explanation is that both TLPD and hybrid require a mini-laparotomy of similar length, so the degree of surgical trauma and the resulting post-

operative morbidity should be similar as well. Given that OPD done in high-volume centres has excellent perioperative outcomes, it may be hard to justify the increased operative time and resource utilization in MIPD. However, the traditional advantages of minimally invasive procedures may also hold true, such as decreased blood loss and less post-operative pain. Future studies may consider standardizing institutional or personal experience with MIPD, include larger sample size, and include better separation of outcomes by TLPD *vs* hybrid, Greater follow-up is required and a better understanding of the learning curve for this approach is needed.

ROBOTIC PANCREATECTOMY

Robotic surgery has recently been applied to pancreatectomy. Its main advantages are three-dimensional binocular vision and higher degree of freedom of the instruments than laparoscopy[1]. The main disadvantages are increased operative time and cost. There is different extent of robotic involvement, such as totally robotic technique of resection and reconstruction, laparoscopic resection and robotic reconstruction, and various hybrid techniques. Many of the advantages of conventional laparoscopy over open surgery have been observed in the robotic experience[51]. No clear benefit or advantage over laparoscopy has been established with the application of robotics[51-54]. It may be reasonable to postulate that the added dexterity of the robotic system may facilitate intracorporeal reconstruction[51-53,55-59].

The surgical technique of robotic pancreatectomy has not been standardized, and there is varying extent of the robotic involvement. Recent studies suggest that robotic pancreatectomy has longer operative time and cost, lower conversion rate, and similar post-operative recovery and length of stay as MIPD. In addition, some studies report higher re-operation rate after RPD[53].

LAPAROSCOPIC ENUCLEATION

Laparoscopic enucleation has gained great popularity compared to open enucleation in recent years in treating benign or low-grade malignant pancreatic tumours. It is a "parenchyma-sparing procedure", and its main advantages are preservation of normal pancreatic endocrine and exocrine function, avoidance of dissection or reconstruction of pancreatic or biliary duct, less blood loss and less demand for advanced laparoscopic skills[60,61]. Indication for laparoscopic enucleation is for benign or low-grade malignant tumours that can be safely removed without damaging the pancreatic or biliary duct. Examples include insulinomas, nonfunctional neuroendocrine tumours, cystic tumours, cystadenomas, IPMNs, and solitary metastasis from renal cell carcinoma[60,62].

The main drawback to this technique is the risk of pancreatic fistula formation. A recent review summarizes that the rate of pancreatic fistula ranges from 13%-38%[62]. Dedieu *et al*[60] noted that their incidence

of pancreatic fistula after laparoscopic enucleation in 21 patients was 13%, which is lower than that reported for open enucleation (38%-42%). Their rate of IS-GPF[63] grade B or C fistula was only 4.5%, compared to 21%-23% in open series[60,64,65]. The length of stay is about 6-9 d[60,61,66], which is shorter than 10-14 d in series with enucleation done with open technique in > 90% of the patients[64,65].

Currently, laparoscopic enucleation is considered safe for patients with small benign or low-grade malignant lesions of the pancreas that is amenable to parenchyma-preserving procedure. Pre-operative imaging and intra-operative ultrasound assessment are crucial in ensuring that the tumour can be enucleated with negative margins and leaving the main pancreatic duct intact. In cases of non-functional neuroendocrine tumours, it is also advised to perform lymphadenectomy as these lesions can behave aggressively[61].

CONCLUSION

Recent studies show that LDP is safe, and may result in improved perioperative recovery, and equivalent oncologic outcomes. LDP is increasingly applied to patients with high BMI, history of previous abdominal surgery, presence of comorbidities and large tumours. LDP has become the operation of choice for most lesions involving the distal pancreas. Studies on MIPD demonstrate that it is safe in terms of intra-operative outcomes, post-operative recovery and early oncologic outcomes; however, there is likely a degree of publication bias and little is known regarding the learning curve for this approach. Further studies with larger sample size and long-term follow up are needed. It has not been widely incorporated into surgeons' practice due to the need for advanced laparoscopic skills. Laparoscopic enucleation has become the operation of choice for small benign tumours that are away from the main pancreatic duct, especially insulinomas. Its application has been expanded to non-functional neuroendocrine and low-grade malignant tumours. As surgeons' experience with advanced laparoscopic and robotic skills has been growing around the world, new innovations and breakthrough in minimally invasive pancreatic procedures will evolve.

REFERENCES

1 **Fisher SB**, Kooby DA. Laparoscopic pancreatectomy for malignancy. *J Surg Oncol* 2013; **107**: 39-50 [PMID: 22991263 DOI: 10.1002/jso.23253]

2 **Abu Hilal M**, Hamdan M, Di Fabio F, Pearce NW, Johnson CD. Laparoscopic versus open distal pancreatectomy: a clinical and cost-effectiveness study. *Surg Endosc* 2012; **26**: 1670-1674 [PMID: 22179475 DOI: 10.1007/s00464-011-2090-6]

3 **Fox AM**, Pitzul K, Bhojani F, Kaplan M, Moulton CA, Wei AC, McGilvray I, Cleary S, Okrainec A. Comparison of outcomes and costs between laparoscopic distal pancreatectomy and open resection at a single center. *Surg Endosc* 2012; **26**: 1220-1230 [PMID: 22179451 DOI: 10.1007/s00464-011-2061-y]

4 **Mehta SS**, Doumane G, Mura T, Nocca D, Fabre JM. Laparoscopic versus open distal pancreatectomy: a single-institu-

tion case-control study. *Surg Endosc* 2012; **26**: 402-407 [PMID: 21909859 DOI: 10.1007/s00464-011-1887-7]

5 **Limongelli P**, Belli A, Russo G, Cioffi L, D'Agostino A, Fantini C, Belli G. Laparoscopic and open surgical treatment of left-sided pancreatic lesions: clinical outcomes and cost-effectiveness analysis. *Surg Endosc* 2012; **26**: 1830-1836 [PMID: 22258300 DOI: 10.1007/s00464-011-2141-z]

6 **Soh YF**, Kow AW, Wong KY, Wang B, Chan CY, Liau KH, Ho CK. Perioperative outcomes of laparoscopic and open distal pancreatectomy: our institution's 5-year experience. *Asian J Surg* 2012; **35**: 29-36 [PMID: 22726561]

7 **Butturini G**, Partelli S, Crippa S, Malleo G, Rossini R, Casetti L, Melotti GL, Piccoli M, Pederzoli P, Bassi C. Perioperative and long-term results after left pancreatectomy: a single-institution, non-randomized, comparative study between open and laparoscopic approach. *Surg Endosc* 2011; **25**: 2871-2878 [PMID: 21424200 DOI: 10.1007/s00464-011-1634-0]

8 **Cho CS**, Kooby DA, Schmidt CM, Nakeeb A, Bentrem DJ, Merchant NB, Parikh AA, Martin RC, Scoggins CR, Ahmad SA, Kim HJ, Hamilton N, Hawkins WG, Weber SM. Laparoscopic versus open left pancreatectomy: can preoperative factors indicate the safer technique? *Ann Surg* 2011; **253**: 975-980 [PMID: 21394014 DOI: 10.1097/SLA.0b013e3182128869]

9 **Aly MY**, Tsutsumi K, Nakamura M, Sato N, Takahata S, Ueda J, Shimizu S, Redwan AA, Tanaka M. Comparative study of laparoscopic and open distal pancreatectomy. *J Laparoendosc Adv Surg Tech A* 2010; **20**: 435-440 [PMID: 20518689 DOI: 10.1089/lap.2009.0412]

10 **DiNorcia J**, Schrope BA, Lee MK, Reavey PL, Rosen SJ, Lee JA, Chabot JA, Allendorf JD. Laparoscopic distal pancreatectomy offers shorter hospital stays with fewer complications. *J Gastrointest Surg* 2010; **14**: 1804-1812 [PMID: 20589446 DOI: 10.1007/s11605-010-1264-1]

11 **Jayaraman S**, Gonen M, Brennan MF, D'Angelica MI, DeMatteo RP, Fong Y, Jarnagin WR, Allen PJ. Laparoscopic distal pancreatectomy: evolution of a technique at a single institution. *J Am Coll Surg* 2010; **211**: 503-509 [PMID: 20868976 DOI: 10.1016/j.jamcollsurg.2010.06.010]

12 **Kooby DA**, Hawkins WG, Schmidt CM, Weber SM, Bentrem DJ, Gillespie TW, Sellers JB, Merchant NB, Scoggins CR, Martin RC, Kim HJ, Ahmad S, Cho CS, Parikh AA, Chu CK, Hamilton NA, Doyle CJ, Pinchot S, Hayman A, McClaine R, Nakeeb A, Staley CA, McMasters KM, Lillemoe KD. A multicenter analysis of distal pancreatectomy for adenocarcinoma: is laparoscopic resection appropriate? *J Am Coll Surg* 2010; **210**: 779-785, 786-787 [PMID: 20421049 DOI: 10.1016/j.jamcollsurg.2009.12.033]

13 **Vijan SS**, Ahmed KA, Harmsen WS, Que FG, Reid-Lombardo KM, Nagorney DM, Donohue JH, Farnell MB, Kendrick ML. Laparoscopic vs open distal pancreatectomy: a single-institution comparative study. *Arch Surg* 2010; **145**: 616-621 [PMID: 20644122 DOI: 10.1001/archsurg.2010.120]

14 **Baker MS**, Bentrem DJ, Ujiki MB, Stocker S, Talamonti MS. A prospective single institution comparison of peri-operative outcomes for laparoscopic and open distal pancreatectomy. *Surgery* 2009; **146**: 635-643; discussion 643-645 [PMID: 19789022]

15 **Finan KR**, Cannon EE, Kim EJ, Wesley MM, Arnoletti PJ, Heslin MJ, Christein JD. Laparoscopic and open distal pancreatectomy: a comparison of outcomes. *Am Surg* 2009; **75**: 671-679; discussion 679-680 [PMID: 19725289]

16 **Nakamura Y**, Uchida E, Aimoto T, Matsumoto S, Yoshida H, Tajiri T. Clinical outcome of laparoscopic distal pancreatectomy. *J Hepatobiliary Pancreat Surg* 2009; **16**: 35-41 [PMID: 19083146 DOI: 10.1007/s00534-008-0007-0]

17 **Bruzoni M**, Sasson AR. Open and laparoscopic spleen-preserving, splenic vessel-preserving distal pancreatectomy: indications and outcomes. *J Gastrointest Surg* 2008; **12**: 1202-1206 [PMID: 18437500 DOI: 10.1007/s11605-008-0512-0]

18 **Eom BW**, Jang JY, Lee SE, Han HS, Yoon YS, Kim SW. Clini-

cal outcomes compared between laparoscopic and distal pancreatectomy. *Surg Endosc* 2008; **22**: 1334-1338 [PMID: 18027035]

19   **Kim SC**, Park KT, Hwang JW, Shin HC, Lee SS, Seo DW, Lee SK, Kim MH, Han DJ. Comparative analysis of clinical outcomes for laparoscopic distal pancreatic resection and open distal pancreatic resection at a single institution. *Surg Endosc* 2008; **22**: 2261-2268 [PMID: 18528619 DOI: 10.1007/s00464-008-9973-1]

20   **Matsumoto T**, Shibata K, Ohta M, Iwaki K, Uchida H, Yada K, Mori M, Kitano S. Laparoscopic distal pancreatectomy and open distal pancreatectomy: a nonrandomized comparative study. *Surg Laparosc Endosc Percutan Tech* 2008; **18**: 340-343 [PMID: 18716530 DOI: 10.1097/SLE.0b013e3181705d23]

21   **Misawa T**, Shiba H, Usuba T, Nojiri T, Kitajima K, Uwagawa T, Toyama Y, Ishida Y, Ishii Y, Yanagisawa A, Kobayashi S, Yanaga K. Systemic inflammatory response syndrome after hand-assisted laparoscopic distal pancreatectomy. *Surg Endosc* 2007; **21**: 1446-1449 [PMID: 17593462]

22   **Tang CN**, Tsui KK, Ha JP, Wong DC, Li MK. Laparoscopic distal pancreatectomy: a comparative study. *Hepatogastroenterology* 2007; **54**: 265-271 [PMID: 17419274]

23   **Teh SH**, Tseng D, Sheppard BC. Laparoscopic and open distal pancreatic resection for benign pancreatic disease. *J Gastrointest Surg* 2007; **11**: 1120-1125 [PMID: 17623260 DOI: 10.1007/s11605-007-0222-z]

24   **Velanovich V**. Case-control comparison of laparoscopic versus open distal pancreatectomy. *J Gastrointest Surg* 2006; **10**: 95-98 [PMID: 16368497 DOI: 10.1016/j.gassur.2005.08.009]

25   **Fernández-Cruz L**, Sáenz A, Astudillo E, Pantoja JP, Uzcátegui E, Navarro S. Laparoscopic pancreatic surgery in patients with chronic pancreatitis. *Surg Endosc* 2002; **16**: 996-1003 [PMID: 12163971 DOI: 10.1007/s00464-001-9065-y]

26   **Kneuertz PJ**, Patel SH, Chu CK, Fisher SB, Maithel SK, Sarmiento JM, Weber SM, Staley CA, Kooby DA. Laparoscopic distal pancreatectomy: trends and lessons learned through an 11-year experience. *J Am Coll Surg* 2012; **215**: 167-176 [PMID: 22632910 DOI: 10.1016/j.jamcollsurg.2012.03.023]

27   **Gagner M**, Pomp A, Herrera MF. Early experience with laparoscopic resections of islet cell tumors. *Surgery* 1996; **120**: 1051-1054 [PMID: 8957494]

28   **D'Angelica M**, Are C, Jarnagin W, DeGregoris G, Coit D, Jaques D, Brennan M, Fong Y. Initial experience with hand-assisted laparoscopic distal pancreatectomy. *Surg Endosc* 2006; **20**: 142-148 [PMID: 16333550 DOI: 10.1007/s00464-005-0209-3]

29   **Davidson RN**, Wall RA. Prevention and management of infections in patients without a spleen. *Clin Microbiol Infect* 2001; **7**: 657-660 [PMID: 11843905]

30   **Mekeel KL**, Moss AA, Reddy KS, Mulligan DC, Harold KL. Laparoscopic distal pancreatectomy: does splenic preservation affect outcomes? *Surg Laparosc Endosc Percutan Tech* 2011; **21**: 362-365 [PMID: 22002275]

31   **Warshaw AL**. Conservation of the spleen with distal pancreatectomy. *Arch Surg* 1988; **123**: 550-553 [PMID: 3358679 DOI: 10.1001/archsurg.1988.01400290032004]

32   **Boutros C**, Ryan K, Katz S, Espat NJ, Somasundar P. Total laparoscopic distal pancreatectomy: beyond selected patients. *Am Surg* 2011; **77**: 1526-1530 [PMID: 22196669]

33   **Marangos IP**, Buanes T, Røsok BI, Kazaryan AM, Rosseland AR, Grzyb K, Villanger O, Mathisen Ø, Gladhaug IP, Edwin B. Laparoscopic resection of exocrine carcinoma in central and distal pancreas results in a high rate of radical resections and long postoperative survival. *Surgery* 2012; **151**: 717-723 [PMID: 22284762 DOI: 10.1016/j.surg.2011.12.016]

34   **Gagner M**, Pomp A. Laparoscopic pylorus-preserving pancreatoduodenectomy. *Surg Endosc* 1994; **8**: 408-410 [PMID: 7915434 DOI: 10.1007/BF00642443]

35   **Asbun HJ**, Stauffer JA. Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the Accordion Severity Grading System. *J Am Coll Surg*

2012; **215**: 810-819 [PMID: 22999327 DOI: 10.1016/j.jamcollsurg.2012.08.006]

36   **Kuroki T**, Adachi T, Okamoto T, Kanematsu T. A non-randomized comparative study of laparoscopy-assisted pancreaticoduodenectomy and open pancreaticoduodenectomy. *Hepatogastroenterology* 2012; **59**: 570-573 [PMID: 21940382]

37   **Zureikat AH**, Breaux JA, Steel JL, Hughes SJ. Can laparoscopic pancreaticoduodenectomy be safely implemented? *J Gastrointest Surg* 2011; **15**: 1151-1157 [PMID: 21538192 DOI: 10.1007/s11605-011-1530-x]

38   **Cho A**, Yamamoto H, Nagata M, Takiguchi N, Shimada H, Kainuma O, Souda H, Gunji H, Miyazaki A, Ikeda A, Tohma T, Matsumoto I. Comparison of laparoscopy-assisted and open pylorus-preserving pancreaticoduodenectomy for periampullary disease. *Am J Surg* 2009; **198**: 445-449 [PMID: 19342003 DOI: 10.1016/j.amjsurg.2008.12.025]

39   **Ammori BJ**, Ayiomamitis GD. Laparoscopic pancreaticoduodenectomy and distal pancreatectomy: a UK experience and a systematic review of the literature. *Surg Endosc* 2011; **25**: 2084-2099 [PMID: 21298539]

40   **Pugliese R**, Scandroglio I, Sansonna F, Maggioni D, Costanzi A, Citterio D, Ferrari GC, Di Lernia S, Magistro C. Laparoscopic pancreaticoduodenectomy: a retrospective review of 19 cases. *Surg Laparosc Endosc Percutan Tech* 2008; **18**: 13-18 [PMID: 18287976]

41   **Palanivelu C**, Jani K, Senthilnathan P, Parthasarathi R, Rajapandian S, Madhankumar MV. Laparoscopic pancreaticoduodenectomy: technique and outcomes. *J Am Coll Surg* 2007; **205**: 222-230 [PMID: 17660068 DOI: 10.1016/j.jamcollsurg.2007.04.004]

42   **Suzuki O**, Kondo S, Hirano S, Tanaka E, Kato K, Tsuchikawa T, Yano T, Okamura K, Shichinohe T. Laparoscopic pancreaticoduodenectomy combined with minilaparotomy. *Surg Today* 2012; **42**: 509-513 [PMID: 22127534]

43   **Kendrick ML**, Cusati D. Total laparoscopic pancreaticoduodenectomy: feasibility and outcome in an early experience. *Arch Surg* 2010; **145**: 19-23 [PMID: 20083750]

44   **Dulucq JL**, Wintringer P, Mahajna A. Laparoscopic pancreaticoduodenectomy for benign and malignant diseases. *Surg Endosc* 2006; **20**: 1045-1050 [PMID: 16736311]

45   **Dulucq JL**, Wintringer P, Stabilini C, Feryn T, Perissat J, Mahajna A. Are major laparoscopic pancreatic resections worthwhile? A prospective study of 32 patients in a single institution. *Surg Endosc* 2005; **19**: 1028-1034 [PMID: 16027987]

46   **Staudacher C**, Orsenigo E, Baccari P, Di Palo S, Crippa S. Laparoscopic assisted duodenopancreatectomy. *Surg Endosc* 2005; **19**: 352-356 [PMID: 15627172 DOI: 10.1007/s00464-004-9055-y]

47   **Kendrick ML**. Laparoscopic and robotic resection for pancreatic cancer. *Cancer J* 2012; **18**: 571-576 [PMID: 23187844 DOI: 10.1097/PPO.0b013e31827b8f86]

48   **Gumbs AA**, Grès P, Madureira FA, Gayet B. Laparoscopic vs. open resection of noninvasive intraductal pancreatic mucinous neoplasms. *J Gastrointest Surg* 2008; **12**: 707-712 [PMID: 17909923]

49   **Leichtle SW**, Kaoutzanis C, Mouawad NJ, Welch KB, Lampman R, Hoshal VL, Kreske E. Classic Whipple versus pylorus-preserving pancreaticoduodenectomy in the ACS NSQIP. *J Surg Res* 2013; **183**: 170-176 [PMID: 23410660 DOI: 10.1016/j.jss.2013.01.016]

50   **Sohn TA**, Yeo CJ, Cameron JL, Koniaris L, Kaushal S, Abrams RA, Sauter PK, Coleman J, Hruban RH, Lillemoe KD. Resected adenocarcinoma of the pancreas-616 patients: results, outcomes, and prognostic indicators. *J Gastrointest Surg* 2000; **4**: 567-579 [PMID: 11307091 DOI: 10.1016/S1091-255X(00)80105-5]

51   **Zureikat AH**, Moser AJ, Boone BA, Bartlett DL, Zenati M, Zeh HJ. 250 robotic pancreatic resections: safety and feasibility. *Ann Surg* 2013; **258**: 554-559; discussion 559-562 [PMID: 24002300]

52   **Chalikonda S**, Aguilar-Saavedra JR, Walsh RM. Laparoscopic robotic-assisted pancreaticoduodenectomy: a case-matched comparison with open resection. *Surg Endosc* 2012; **26**: 2397-2402 [PMID: 22437947 DOI: 10.1007/s00464-012-2207-6]

53   **Cirocchi R**, Partelli S, Trastulli S, Coratti A, Parisi A, Falconi M. A systematic review on robotic pancreaticoduodenectomy. *Surg Oncol* 2013; **22**: 238-246 [PMID: 24060451]

54   **Jayaraman S**, Davies W, Schlachta CM. Getting started with robotics in general surgery with cholecystectomy: the Canadian experience. *Can J Surg* 2009; **52**: 374-378 [PMID: 19865571]

55   **Daouadi M**, Zureikat AH, Zenati MS, Choudry H, Tsung A, Bartlett DL, Hughes SJ, Lee KK, Moser AJ, Zeh HJ. Robot-assisted minimally invasive distal pancreatectomy is superior to the laparoscopic technique. *Ann Surg* 2013; **257**: 128-132 [PMID: 22868357]

56   **Kang CM**, Kim DH, Lee WJ, Chi HS. Conventional laparoscopic and robot-assisted spleen-preserving pancreatectomy: does da Vinci have clinical advantages? *Surg Endosc* 2011; **25**: 2004-2009 [PMID: 21136089 DOI: 10.1007/s00464-010-1504-1]

57   **Buchs NC**, Addeo P, Bianco FM, Gangemi A, Ayloo SM, Giulianotti PC. Outcomes of robot-assisted pancreaticoduodenectomy in patients older than 70 years: a comparative study. *World J Surg* 2010; **34**: 2109-2114 [PMID: 20526598 DOI: 10.1007/s00268-010-0650-x]

58   **Giulianotti PC**, Sbrana F, Bianco FM, Elli EF, Shah G, Addeo P, Caravaglios G, Coratti A. Robot-assisted laparoscopic pancreatic surgery: single-surgeon experience. *Surg Endosc* 2010; **24**: 1646-1657 [PMID: 20063016 DOI: 10.1007/s00464-009-0825-4]

59   **Zureikat AH**, Nguyen KT, Bartlett DL, Zeh HJ, Moser AJ. Robotic-assisted major pancreatic resection and reconstruction. *Arch Surg* 2011; **146**: 256-261 [PMID: 21079111]

60   **Dedieu A**, Rault A, Collet D, Masson B, Sa Cunha A. Laparoscopic enucleation of pancreatic neoplasm. *Surg Endosc* 2011; **25**: 572-576 [PMID: 20623235]

61   **Fernández-Cruz L**, Molina V, Vallejos R, Jiménez Chavarria E, López-Boado MA, Ferrer J. Outcome after laparoscopic enucleation for non-functional neuroendocrine pancreatic tumours. *HPB* (Oxford) 2012; **14**: 171-176 [PMID: 22321035 DOI: 10.1111/j.1477-2574.2011.00422.x]

62   **Kuroki T**, Eguchi S. Laparoscopic parenchyma-sparing pancreatectomy. *J Hepatobiliary Pancreat Sci* 2014; **21**: 323-327 [PMID: 24027045]

63   **Bassi C**, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J, Neoptolemos J, Sarr M, Traverso W, Buchler M. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery* 2005; **138**: 8-13 [PMID: 16003309 DOI: 10.1016/j.surg.2005.05.001]

64   **Crippa S**, Bassi C, Salvia R, Falconi M, Butturini G, Pederzoli P. Enucleation of pancreatic neoplasms. *Br J Surg* 2007; **94**: 1254-1259 [PMID: 17583892 DOI: 10.1002/bjs.5833]

65   **Crippa S**, Zerbi A, Boninsegna L, Capitanio V, Partelli S, Balzano G, Pederzoli P, Di Carlo V, Falconi M. Surgical management of insulinomas: short- and long-term outcomes after enucleations and pancreatic resections. *Arch Surg* 2012; **147**: 261-266 [PMID: 22430908 DOI: 10.1001/archsurg.2011.1843]

66   **Pitt SC**, Pitt HA, Baker MS, Christians K, Touzios JG, Kiely JM, Weber SM, Wilson SD, Howard TJ, Talamonti MS, Rikkers LF. Small pancreatic and periampullary neuroendocrine tumors: resect or enucleate? *J Gastrointest Surg* 2009; **13**: 1692-1698 [PMID: 19548038 DOI: 10.1007/s11605-009-0946-z]

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