CHAPTER 24

Indications and contraindications for laparoscopic pancreas surgery

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EDITOR COMMENT

It is important to us that we provide a balanced view on the advantages of laparoscopic surgery in this book. This is especially true for laparoscopic pancreas surgery, an approach that is in its developmental stages. For this chapter we have elicited the opinion of experts to provide a critical discussion of the advantages and short-comings of laparoscopic pancreas surgery. The lack of randomized and prospective data regarding the advantages of a minimally invasive approach over an open one, as well as some of the technical challenges of laparoscopic pancreaticoduodenectomy, are highlighted. Nonetheless, the promising available retrospective data on laparoscopic distal pancreatectomy and pancreatic enucleation are discussed. This chapter concludes with an excellent section on the minimally invasive management of pancreatitis, focusing on indications for intervention, timing, and approaches. This balanced and sometimes critical view on minimally invasive pancreas surgery by expert pancreatic surgeons reminds the community of the overall goals of surgery, which is excellence in outcomes.

Keywords: laparoscopic distal pancreatectomy, laparoscopic enucleation, laparoscopic pancreatectomy, laparoscopic pancreaticoduodenectomy, minimally invasive management of pancreatitis

24.1 Introduction

In a number of abdominal operations, minimally invasive approaches have yielded favorable outcomes regarding postoperative pain, blood loss, recovery time, and functional convalescence compared with open surgery. Moreover, the use of laparoscopic surgery, particularly in patients with colon cancer, has shown that the benefits of laparoscopy can be achieved without compromises on oncological outcomes [1].

The benefits of laparoscopic approaches are mainly due to reduced access trauma and minimal mechanical abdominal wall and organ retraction. The laparoscopic approach has therefore become the standard approach for a majority of abdominal surgeries performed today and an important pillar of fast-track programs for colorectal surgery. The downsides of a laparoscopic approach include difficulties in achieving adequate exposure, resulting in a narrow working space, limited orientation in a three-dimensional space, fewer degrees of freedom with instrumentation as well as decreased haptic feedback. In 2014, at our institution, a minimally invasive approach was selected for surgeries of the colon, rectum, appendix, gallbladder, esophagus, and spleen in 50%, 50%, 86%, 76%, 17%, and 43% of cases, respectively. These case distributions might be reflective of the use of laparoscopy at referral centers with obligations to complex patient care as well as student and resident training.

Gagner and Cuschieri first successfully used minimally invasive approaches for major pancreatic resections in 1994 [2,3]. However, the rapid development of this technique to become the widely accepted standard approach in pancreatic surgery has been limited by several factors, including the pancreas' retroperitoneal location and fragility of the gland, the complexity of the surrounding anatomical structures, the proximity to major blood vessels and the

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proneness of these procedures to postoperative complications. Laparoscopic surgery in patients with pancreatic diseases was therefore mainly limited to diagnostic or palliative purposes. With the development of novel energy devices such as ultrasound dissectors and staplers, more widespread use of laparoscopic techniques for pancreatic resections occurred. The resulting case series and studies indicate promising results of the minimal invasive approach in selected cases.

The development of laparoscopic pancreas resection mirrors the advancements in laparoscopic colon surgery: in colon surgery, the indications evolved from benign, such as diverticulosis, towards malignant tumors over time. In pancreas surgery, lesions included small endocrine tumors or in some cases cystadenomas located in the distal pancreas, where no reconstruction following resection is needed. With increasing experience with the technique, some surgeons have expanded the indications to small malignant lesions in the pancreas. However, obtaining a negative resection margin and performing adequate lymph node dissection are nonetheless pivotal for oncological outcome and only sparse data exist indicating equivalence of open and laparoscopic techniques for pancreas surgery. Therefore, most surgeons still do not use laparoscopy for pancreatic surgery or limit the laparoscopic approach to benign and low-grade malignant lesions confined to the pancreas. In our experience, because of the aggressive biology of pancreatic cancer, few patients present with malignant lesions that are eligible for a laparoscopic approach, which makes these indications at our institution relatively rare. This in turn reduces the case volume available to ascend the steep learning curve that exists for these difficult laparoscopic procedures.

Despite the observed overall reduction in the operative morbidity of pancreatic surgery over the last decades, these operations are still associated with a high rate of severe complications and perioperative mortality compared with nonpancreatic procedures. Although the extent of the access trauma (i.e. laparotomy vs laparoscopy) accounts for some of the overall morbidity, in large pancreatic resections the procedural trauma may far exceed the access trauma [4] (Figure 24.3). Proper

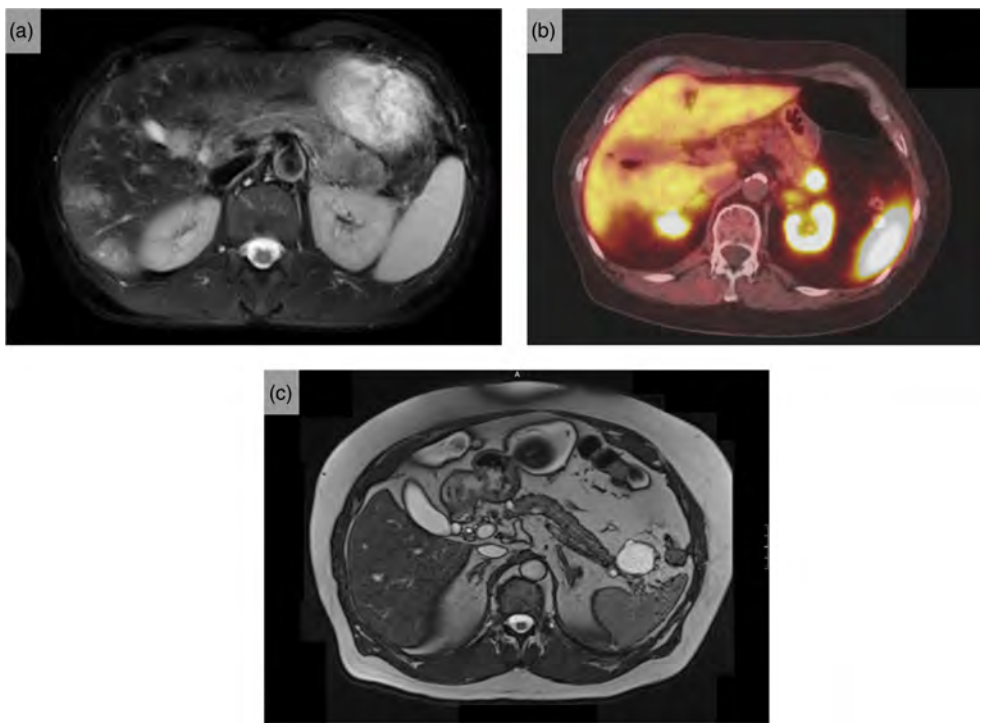

Figure 24.1 Examples of indications for the laparoscopic approach in distal pancreatectomy. Representative MR/DOTA-TATE PET CT images of patients operated on laparoscopically at our institution. Indications were: (a,b) neuroendocrine tumor, (c) mucinous cystic neoplasia.

healing of the anastomoses created during the reconstruction phase of pancreatic resections represents the main determinant of postoperative morbidity and mortality. In cases of ductal adenocarcinoma of the pancreas, overall and disease-free survival rates are positively influenced by adjuvant chemotherapy protocols. Complications in the postoperative course can delay the timely initiation of adjuvant treatment and thus may negatively influence survival rates. In our opinion, anastomoses during pancreatic surgery should be created under optimal conditions, as they are the key determinant for postoperative complications. A completely laparoscopic approach by surgeons with limited laparoscopic experience may potentially impact negatively on the reconstruction as a result of the drawbacks in exposure and lack of haptic feedback as well as the limitations of instruments available today.

When no pancreatic anastomosis has to be created, the benefits of the laparoscopic approach may outweigh these technical challenges even for surgeons with intermediate laparoscopic experience. These procedures include distal pancreatectomy with or without splenectomy, enucleation, and pancreatic necrosectomy.

24.2 Indications, contraindications, and outcomes

24.2.1 Laparoscopic distal pancreatectomy (LDP)

Distal pancreatectomy (DP) is the most commonly performed laparoscopic pancreatic operation. Data from a population-based study in the United States, which analyzed almost 9000 distal pancreatectomies, indicate that the proportion of laparoscopic procedures tripled in the preceding 10 years, to 7.3% of cases in 2009. On a national level, the projected number of LDP was 1908 per year [5]. In Figure 24.2 and Figure 24.3, common indications for the laparoscopic approach as well as important steps of the procedure are shown.

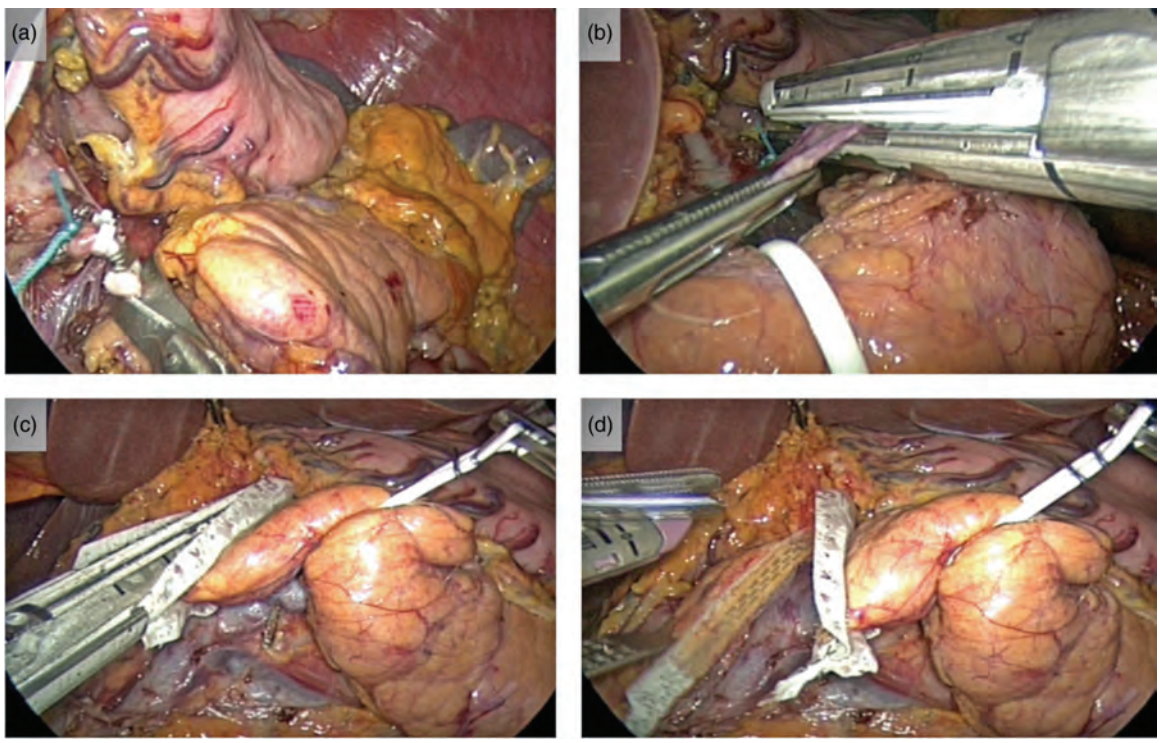

Figure 24.2 Screenshots from stages of laparoscopic distal pancreatectomy. (a) Exposure of the pancreas after accessing the lesser sac. (b) Division of the splenic vein using stapling device. (c,d) Division of the pancreatic parenchyma using Gore Seamguard covered staple line reinforcement.

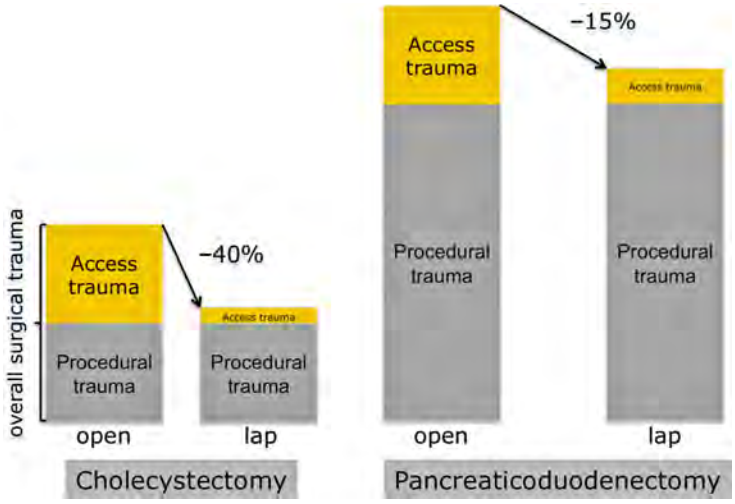

Figure 24.3 Estimated proportion of access trauma in relation overall surgical trauma. When equal procedural traumata, i.e. the actual resection and for PD also the reconstruction phases, are assumed, the proportion of access trauma in relation to overall surgical trauma is much higher for smaller procedures such as cholecystectomy. Hence, it is essential to minimize dissection trauma and postoperative complications in a laparoscopic Whipple procedure to preserve a potential benefit of the minimally invasive approach. If both cannot be ensured, an open approach is safer.

Indications for LDP range from neuroendocrine tumor other than gastrinoma, mucinous cystic neoplasia, large serous cystadenoma, intraductal papillary mucinous neoplasms (IPMNs), chronic pancreatitis, solid pseudopapillary tumors, pancreatic pseudocysts to pancreatic adenocarcinoma, metastasis, or other malignant lesions [6,7]. With the increasing sensitivity of modern abdominal imaging, a higher number of small, asymptomatic benign or premalignant lesions are discovered. For benign to low-grade malignant lesion, performing LDP with preservation of the spleen is an important option. The advantages include prevention of the very rare but potentially life-threatening overwhelming postsplenectomy sepsis with encapsulated bacteria and the reduction in left-sided portal hypertension. Nevertheless, the availability of laparoscopy should not be seen as an indication to resect benign lesions that typically do not require resection, such as a small asymptomatic serous cystadenoma.

Splenic salvage can be achieved by sparing both the splenic vein and the artery, as described by Mallet-Guy and Vachon in 1943 [8]. Alternatively, the Warshaw technique can be performed, in which the splenic vessels are both divided. This results in the spleen being perfused via the short gastric vessels [9]. The question of whether to perform en bloc splenectomy or to salvage the spleen, and if so, by which technique, is a matter of debate. For open distal pancreatic resection, retrospective studies have shown data both supporting and refuting splenic preservation. Some investigators found a lower rate of pancreatic complications such as fistulas or subphrenic abscesses in the splenic resection group [10]. Others have shown higher rates of postoperative infectious and severe complications in patients who underwent splenic resection [11].

In cases of malignant neoplasms, most surgeons would advocate performing en bloc splenectomy along with distal pancreatectomy in order to achieve a negative retroperitoneal margin and complete lymph node dissection [12]. Some authors, however, describe positive effects of splenic preservation even in cases of pancreatic adenocarcinoma as long as no direct tumor infiltration of the spleen is present [13]. It has been hypothesized that the putative immune surveillance mechanism of the preserved spleen may even improve long-term survival following resection of pancreatic cancer [14]. By using the Warshaw technique for salvage of the spleen, the important extended retroperitoneal lymphadenectomy can be performed after dissection of the splenic vessels.

It remains unclear if splenic function following spleen-preserving distal pancreatectomy can still be considered normal, especially following separation of the splenic vessels. In a large study by Beane *et al.*, the authors concluded that no short-term advantage can be achieved by preserving the spleen using the Warshaw technique rather than splenic resection [15]. Even in LDPs performed with the intention of sparing the splenic vessels, a small retrospective study revealed postoperative occlusion of the splenic artery and vein in 14% and 59% of cases, respectively. This phenomenon occurs at higher frequency with the laparoscopic approach. Thus the authors concluded that laparoscopic instruments used for pancreatic dissection from the splenic vessels and

the laparoscopically available methods of hemostasis are a main cause for this high rate of postoperative splenic vein occlusion [16,17]. Thus, further development of laparoscopic instruments and optimization of surgical technique are needed.

So far, no randomized, controlled prospective studies comparing open and laparoscopic distal pancreatectomy have been published. However, more than 20 retrospective comparative studies exist in the literature on this topic to date (Table 24.1). Conclusions from most of these reports, however, are limited by the selection bias involved in these uncontrolled retrospective studies: several of these studies, for example, limit the laparoscopic approach to benign diseases, spleen-preserving procedures or to patients without prior operations. Furthermore, in many studies conversion rates to open procedures are not reported or even excluded from the studies. Numerous studies comparing open distal pancreatectomy (ODP) and LDP differ significantly in baseline characteristics such as lesion size or rate of malignant lesions, with larger and more malignant tumors preferentially operated on via an open approach.

Nigri *et al*. performed a meta-analysis on the first 10 studies on this topic [18]. The results of this analysis indicate a reduction of blood loss, overall complications, shorter time to oral intake and shorter hospital stay in patients who underwent LDP, with no significant differences in operative time. In a more recent meta-analysis from Venkat *et al*. that comprised 18 retrospective studies with over 1800 patients, findings were similar but the analyses were more detailed [19]. In addition to the meta-analysis by Nigri *et al*., the authors assessed the quality of the included studies and conducted sensitivity and subgroup analyses. The overall findings of the analysis indicate superiority of the laparoscopic approach with respect to lower blood loss, lower overall complication and wound infection rates, and shorter length of hospital stay, while no difference in operating time was noted.

A subgroup meta-analysis was performed on the 10 available studies with matched clinicopathological findings in order to overcome, at least in part, the strong selection bias of these studies. In our opinion, selection bias is the main barrier for drawing final conclusions from these retrospective comparative studies. Nevertheless, LDP in most of these studies has shown less blood loss, faster recovery, and fewer surgical site infections while no difference in overall postoperative complications and even significantly longer operation times for LDP were observed.

To further support evidence for the benefits of LDP, a multicenter study from the Central Pancreas Consortium using matched-pair analysis of age, ASA score, tumor size, resected pancreas length, and diagnosis indicates significantly reduced overall complication rates, reduced blood loss, and shorter hospital stay in the laparoscopic group, while achieving the same negative margin rates [20]. In another retrospective multicenter study from the same group of patients who underwent LDP for ductal adenocarcinoma focusing on oncological outcome, the authors were not able to observe a difference in number of lymph nodes harvested, rate of positive resection margins, or overall survival rates between ODP and LDP. A limitation is, however, that the latter group consisted of 23 patients only [21]. In our opinion, these findings should be confirmed in prospective, multicenter, randomized trials before LDP can be considered an oncologically equivalent alternative to ODP for treatment of pancreatic cancer.

Postoperative pancreatic fistula following DP is one of the most concerning complications. It seems that the risk for pancreatic fistulas is independent of the selected operative approach, as the vast majority of studies report no difference between ODP and LDP in rate or severity of fistulas. Risk factors that are regarded as more relevant for the development of pancreatic fistulas following distal pancreatectomy than the choice of operative approach are surgical technique and a soft gland. Accordingly, the randomized, controlled DISPACT trial, which compared hand-sewn (rarely used in LDP) with stapled closure of the pancreatic remnant, was unable to identify specific risk factors for the development of pancreatic fistula [22].

We believe that obese patients, who are at an increased risk for postoperative atelectasis and pneumonia, may particularly benefit from the smaller access trauma and reduced postoperative pain of LDP. Besides body habitus, other patient factors such as cardiopulmonary comorbidities or a history of previous abdominal operations might make the surgeon decide on the conventional open approach.

Although it has been hypothesized from retrospective data that LDP and ODP may be equally effective in achieving negative margins and optimal oncological outcome in a selected patient group, it is our practice to limit the laparoscopic approach to benign, premalignant, and low-grade malignant lesions, while laparoscopic surgery for malignant disease should be entered in registries or included in randomized controlled trials (RCTs). In particular, laparoscopic resection of locally advanced

Table 24.1 Comparative series of laparoscopic distal pancreatectomies with >50 patients.

Reference	LDP/ODP	OR time (min)	Blood loss (mL)	Mortality	Morbidity	Pancreatic fistula	Tumor size (cm)	% malignancy	Conversion rate	Lymph node harvest
Cho [31]	254 lap	NS	>300 cc: 24%	0.5%	12%	23%	>3.5 cm: 40%	9%	9.4%	n/a
	439 open		>300 cc: 54%*	1%	15%	27%	58%	29%		
DiNorcia [47]	71 lap	250	150	0%	28.2%	11.3%	2.5/3.6	12.7%	25.3%	6/8
	92 open	270*	900*	1%	43.8%	14.1%		38.5%		
Jayaraman [48]	107 lap	194	150	0%	27%	15%	3	17%	30%	6/7
	236 open	163*	350*	0.8%	40%*	13%	3*	47%		
Vijan [49]	100 lap	214	171	3%	34%	17%	3.3	23%	4%	NS
	100 open	208	519*	1%	29%	17%	4*	23%		
Kim [50]	93 lap	195	NS	0%	24.7%	8.6%	3	0%	n/a	n/a
	35 open	190		0%	29%	14.3%	3	0%		

LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy; NS, no significant difference; OR, operating room.
*$P < 0.05$; n/a: data not available.

malignancies or tumors located close to the pancreatic neck and major blood vessels bears significant technical challenges.

24.2.2 Laparoscopic pancreas enucleation (LPE)

Pancreatic enucleation is a technique that allows for parenchyma-sparing resection of tumors. Thus, the chances of preserving a sufficient degree of the exo- and endocrine function of the pancreas are higher than under extended pancreatic resection such as PD or DP. Enucleation of the pancreas does not fulfill the criteria of an adequate oncological resection, although lymphadenectomy can be performed. However, safety margins are not sufficient for malignant disease. Therefore, the potential presence of malignancy of the lesion to be resected should be very carefully considered prior to performing an enucleation.

In our opinion, diagnoses that allow for this limited pancreatic resection include insulinoma and other neuroendocrine tumors not exceeding 2 cm in size, and potentially side-branch IPMNs outside the Sendai criteria [23]. We believe that for mucinous cystic neoplasms and nonfunctioning neuroendocrine tumors (NF–NET) exceeding 2 cm in diameter, the risk of inadequate treatment with enucleation may be too high. We believe that these patients should rather be treated by extended pancreatic resection including lymphadenectomy. NF–NETs smaller than 2 cm show malignancy when discovered incidentally in 6% of cases only. However, this proportion rises exponentially with increasing tumor size [24]. In the rare case of isolated pancreatic metastases, some authors advocate enucleation as the treatment of choice. However, the recurrence rate of metastases to the pancreas is higher following enucleation than following pancreatectomy [25].

In conclusion, to be eligible for laparoscopic enucleation, any lesion should be benign, not be in excess of 3 cm in size (in NF–NET <2 cm), and be distant from the main pancreatic duct (2–3 mm) [6,23]. Enucleation of any lesion closer to the duct than 2–3 mm leads to an increased risk of local duct necrosis and postoperative pancreatic fistula [26]. We think that lesions closer than 2–3 mm to the pancreatic duct should be resected rather than enucleated.

Amikura *et al*. published the first report of a laparoscopically performed enucleation of an islet cell tumor of the pancreas in 1995 [27]. As with any laparoscopic pancreatic procedure, no RCTs and, in the case of LPE, not even large comparative studies assessing the benefits of laparoscopic over open access exist in the literature. However, it is generally accepted that the indications for open pancreatic enucleation can be applied to LPE, when the lesion is located superficially in the pancreatic body or tail, distant from the splenic vessels and main pancreatic duct, thus allowing a safe preparation. A thorough preoperative diagnostic imaging work-up and the use of intraoperative ultrasound are crucial for the successful localization of the lesion. Failure to identify the tumor intraoperatively represents a common cause for conversion to laparotomy [28].

As for distal pancreatectomy, postoperative pancreatic fistulas are the most important complication following enucleation. The existing case series indicate that the safety of LPE may be similar to that of open enucleation [26]. Rates reported from comparatively large case series (with the largest comprising 24 patients) for postoperative pancreatic fistulas, morbidity, and mortality following LPE range from 13% to 38%, 17% to 48.2%, and 0% to 4%, respectively [29,30].

In our experience, there is a significant difference between the open and laparoscopic approach in haptic feedback from tissues with surgical instruments available for dissection of the pancreatic parenchyma during enucleation. We think that there is room for improvement of surgical instrumentation available today for the laparoscopic approach. This might improve safety and allow for an even more widespread diffusion of the laparoscopic method of enucleation into surgical practice.

24.2.3 Laparoscopic pancreaticoduodenectomy (LPD)

Pancreaticoduodenectomy (PD) induces the greatest operative trauma from pancreatic resections and involves a considerable rate of severe postoperative complications. The procedure consists of extensive retroperitoneal dissection as well as the creation of three anastomoses, including that of the pancreatic remnant to reconstruct the upper gastrointestinal tract. Complete healing of these anastomoses is a key factor in avoiding significant complications that would, if they occur in cases of pancreatic cancer, significantly delay the initiation of adjuvant chemotherapy. Because of the complexity of LPD, many experienced pancreas surgeons hesitate to adopt the technique and LPD has thus been very slow to evolve since its first description in 1994.

Two main methods of conducting LPD have been described: (i) a total laparoscopic approach (TLPD), where

all anastomoses are performed laparoscopically; and (ii) a laparoscopic-assisted hybrid approach (LAPD), in which the dissection is performed laparoscopically but the reconstruction is mainly conducted via a small laparotomy, which is also used to extract the specimen [31,32].

In early reported case series, most authors limited the use of LPD to resection of benign to low-grade tumors that were small in size and located close to the duodenal ampulla and distal common bile duct without any vascular or extrabiliary involvement. Thus, indications for LPD mainly included mucinous cystic neoplasms and IPMNs of the pancreatic head as well as other small ampullary and periampullary tumors [23]. Yet, there are also case series that included patients who underwent LPD for pancreatic ductal adenocarcinoma [32].

There are some retrospective studies in the literature that compare outcomes of open PD with one of the laparoscopic approaches (Table 24.2). A meta-analysis of six comparative studies analyzed 169 pooled patients who were treated only with TLPD, including robotic operations, compared with 372 patients who underwent open PD as control [33]. The pooled analysis indicated a decreased hospital stay and a higher number of lymph nodes retrieved in the LPD group. Other significant factors of the analysis were a higher rate of R0 resections and lower operative blood loss in the LPD group. The findings of this meta-analysis may be attributable to an underlying selection bias of the mostly unmatched retrospective studies. An indication of selection bias is the significantly higher rate of larger tumors in the open PD group. On the other hand, despite the smaller tumor size in these patients, operative time was significantly longer in the LPD group. Most of the studies were not analyzed in an intention-to-treat manner, i.e. cases of unexpected vascular involvement or any other cause for conversion to open PD (such as hemorrhage) excluded these patients from the LPD arm and instead were counted as open PD in several studies. It is also noteworthy that many of the retrospective comparative studies comprise open control groups with high complication rates, operative time, and blood loss as well as low number of harvested lymph nodes (see Table 24.2). One should bear in mind that even large case series of open surgery from unselected patient cohorts report a mean operation time of less than 350 minutes and a median number of harvested lymph nodes of 24 [34,35].

Despite the limitations of existing data, LPD may be technically feasible in selected cases. Although small case series may indicate adequate oncological safety, registries or controlled trials with long-term follow-up are necessary to prove equivalence in oncological outcome between open and laparoscopic PD. Therefore, it is important to emphasize that laparoscopic and open PD must be conducted by the same oncological principles with the same technique and operational steps.

24.2.4 Laparoscopic pancreatic necrosectomy

Acute pancreatitis is one of the most common gastrointestinal diseases causing hospitalization in the industrialized world. About 15% of patients with acute pancreatitis develop pancreatic necrosis and about a third of those patients suffer from secondary infection of the necrosis. The development of necrosis increases the risk for death in these patients to 15%, and in cases of secondary infection, this risk increases to 30% [36].

There is consensus among international experts that even severe necrotizing pancreatitis is best managed conservatively in the early phase of disease [37]. Sterile acute necrotic collections almost never require interventional treatment in the first weeks of disease. Later in the course, intervention is indicated only when significant symptoms exist. Any intervention should be delayed for about 4–6 weeks until the infected necrosis is walled off and demarcated with at least partial liquefaction. There is clear evidence from a RCT that early open surgical necrosectomy within the first 2–3 days after onset of acute pancreatitis, which was the treatment of choice a decade ago, results in higher morbidity and mortality than delayed intervention after at least 12 days [38]. Early open surgical intervention has been identified as an independent predictor of poor outcome in patients with necrotizing pancreatitis [39].

However, patients with infected necrosis, which usually does not occur until the second or third week following onset of symptoms, are required to undergo interventional treatment. The diagnosis of infected necrosis, and thus indication for intervention, may be proved by fine needle aspiration (FNA) of necrotic tissue/fluid and positive culture results. However, the use of FNA is reduced owing to today's possibilities of percutaneous and endoscopic drainage placement. Infection should be strongly suspected in patients who develop systemic inflammatory response syndrome (SIRS) or organ failure later in the course of necrotizing pancreatitis (>7 days). In particular, this includes those patients who were

Table 24.2 Comparative studies of laparoscopic pancreaticoduodenectomies (LPD).

Reference	LPD/OPD	OR time (min)	Blood loss (mL)	Mortality	Morbidity	Pancreatic fistula	Tumor size (cm)	% PDAC	Conversion rate	Lymph node harvest
Asbun [51]	53 TLPD	541	195	5.7%	NS	16.7%	2.74	41.5%	15%	23.44
	215 OPD	401*	1032*	8.8%		17.3%	3.14	46.5%		16.84*
Kuroki [52]	20 LAPD	656.6	376.6	n/a	NS	45%	n/a	0%	0%	n/a
	31 OPD	554.6*	1509.5*	n/a	NS	39%	n/a	12.9%		n/a
Zureikat [53]	14 TLPD	456	300	7%	62%	36%	2.2	57%	14%	18.5
	14 OPD	372*	400	0%	42.8%*	42.8%	3.6*	57%		19.1
Cho [31]	15 LAPD	338	445	0%	27%	13%	n/a	6.7%	0%	18.5
	15 OPD	287	552		27%	13%	n/a	13.3%		20

LAPD, laparoscopically assisted pancreaticoduodenectomy; OPD, open pancreaticoduodenectomy; PDAC, pancreatic ductal adenocarcinoma; TLPD, total laparoscopic pancreaticoduodenectomy.
*$P < 0.05$.
In our opinion, the open control groups of some of these studies show unacceptable results.

previously clinically stable or even improving [37]. The use of antibiotics to prevent occurrence of infected necrosis has been extensively studied, but double-blinded, placebo-controlled studies failed to show a positive effect of this treatment [40].

Optimal timing of interventions and using an approach of gradual increase in invasiveness of these interventions are pivotal and have a strong impact on several outcome parameters in the treatment of patients with necrotizing pancreatitis. There is strong evidence suggesting that, compared with less invasive approaches, the physiological stress of open necrosectomy is more detrimental to the already severely ill patient.

Several minimally invasive approaches to pancreatic necrosis have been described. These can be classified according to the access route (peritoneal, retroperitoneal, transoral) and the method used for visualization (laparoscopic, rigid nephroscopic, flexible endoscopic) [41]. The transperitoneal laparoscopic approach includes laparoscopic visualization of the pancreas followed by hand-assisted or laparoscopic debridement of infected necrosis. The advantage of this approach is the good accessibility of all abdominal compartments but most surgeons fear the intra-abdominal dissemination of an extra-abdominal septic focus and thus avoid a transperitoneal laparoscopic approach. The more commonly performed techniques, however, use the retroperitoneal access route that is usually established under radiological image guidance. Through dilation of the tract or minimal incision, a rigid nephroscope, laparoscope, or flexible endoscope can be inserted into the cavity for direct visualization, debridement, and irrigation. These techniques have been termed "sinus tract endoscopy" and "video-assisted retroperitoneal debridement (VARD)." In the former, a nephroscope is inserted through the dilated drain tract and debridement is carried out using forceps followed by jet irrigation of the cavity [42]. The procedure is repeated if the patient fails to recover. The authors report a median of 3–5 procedures per patient until sufficient control of the septic focus is achieved. In a large but unmatched, and thus potentially biased, comparative retrospective study of the open approach, significant differences favoring sinus tract endoscopy concerning mortality rate, complication rate, organ failure rate, and required postoperative intensive care unit (ICU) support were reported [43].

The VARD technique involves a subcostal incision along a preoperatively placed drain followed by limited direct debridement. Then video-assisted debridement with use of gas insufflation of the retroperitoneum and a 0° camera is performed. Continuous lavage is started postoperatively via two large drains. In contrast to sinus tract endoscopy for pancreatic necrosectomy, VARD allows vigorous debridement, thus resulting in a median number of only one procedure per patient [44].

The prospective, randomized PANTER trial compared the effects of open necrosectomy as described by Beger [45] against a step-up approach of interventional drainage placement (either percutaneous or endoscopic) followed by minimally invasive VARD if there was no clinical improvement after drain placement [46]. The study population consisted of patients with confirmed or suspected infected necrosis, and the study interventions were performed at a median time of about 30 days after onset of symptoms, which was similar in both groups. Although the study did not directly compare the two operation methods of open necrosectomy with VARD, but rather compared it with a less invasive treatment scheme, and thus one cannot conclude from this trial that one operation method is superior to the other, the results of the study show a clear benefit from the less invasive treatment approach. Thirty-five percent of patients were sufficiently treated by interventional drain placement and did not need surgery at all. Patients in the minimally invasive group had significantly fewer major complications such as multiple organ failure, fewer incisional hernias, fewer cases of new-onset diabetes and exocrine insufficiency, and fewer ICU admissions. Mortality rate and length of ICU as well as hospital stay did not differ significantly.

KEY POINTS

- Minimally invasive pancreatic surgery is in a developmental stage and prospective data comparing it with open surgery are lacking. The benefits of laparoscopic pancreas surgery from reduced access and retraction trauma will be offset if significant complications occur.
- Oncological principles are key in performing laparoscopic pancreas surgery for cancer. Benign and borderline malignant lesions are good indications for a minimally invasive approach.
- Distal pancreatectomy has demonstrated good outcomes compared with open surgery for selected patients.

- Laparoscopic enucleation, mainly performed for neuroendocrine tumors of the pancreas, is an organ-sparing approach with limited morbidity. The main pancreatic duct needs to be protected.
- Minimally invasive management of pancreatitis needing intervention is an important innovation, but the principles of open pancreatitis management regarding indication, timing, and extent of debridement apply.

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