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## Laparoscopic distal pancreatectomy for adenocarcinoma of the pancreas

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### Abstract

Since the first report on laparoscopic distal pancreatectomy (LDP) appeared in the 1990s, the procedure has been performed increasingly frequently to treat both benign and malignant lesions of the pancreas. Many earlier publications have shown LDP to be a good alternative to open distal pancreatectomy for benign lesions, although this has never been studied in a prospective, randomized manner. The evidence for the use of LDP to treat adenocarcinoma of the pancreas is not as well established. The purpose of this review is to evaluate the current evidence for LDP in cases of pancreatic adenocarcinoma. We conducted a review of English language publications reporting LDP results between 1990 and 2013. All studies reporting results in patients with histologically proven pancreatic adenocarcinoma were included. Thirty-nine publications were found and included in the results for a total of 309 cases of pancreatic adenocarcinoma (potential double publications were not eliminated). Most LDP procedures are performed in selected cases and generally involve smaller tumors than open distal pancreatectomy (ODP) procedures. Some of the papers report unselected cases and

include procedures on larger tumors. The number of lymph nodes harvested using LDP is comparable to the number obtained with ODP, as is the frequency of R0 resections. Current data suggest that similar short term oncological results can be obtained using LDP as those obtained using ODP.

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**Key words:** Adenocarcinoma of the pancreas; Laparoscopy; Distal pancreatectomy; Surgical margins; Pancreatic resection

**Core tip:** There are about 300 published cases of laparoscopic distal pancreatectomy for adenocarcinoma reported in the English literature. None of these cases has been included in randomized prospective work and it is doubtful that such a study will ever be conducted. This objective of this review was to evaluate the appropriateness of laparoscopic distal pancreatectomy as treatment for pancreatic adenocarcinoma. The results suggest that this minimally invasive technique may be safely applied to treat the disease in addition to the other more established indications for the operation.

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### BACKGROUND

In the late 80s and early 90s, laparoscopy became an increasingly common surgery. Laparoscopic cholecystectomy, followed by adrenalectomy, splenectomy, and appendectomy, became standard procedures<sup>[1-6]</sup>. Today,

laparoscopic resections for colon cancer are considered safe and oncologically equivalent to open surgery<sup>[7]</sup>. In fact, the introduction of laparoscopy may be described as the largest uncontrolled, unrandomized surgical trial ever undertaken.

In cases of pancreatic malignancies, the initial use of laparoscopy was for staging and palliative procedures<sup>[8-11]</sup>.

In 1994, a study introduced the possibility of laparoscopic distal pancreatectomy (LDP) and assessed the procedure in a porcine model; the authors concluded that the procedure should be possible in humans<sup>[12]</sup>. In that same year, Gagner performed a laparoscopic Whipple to treat a patient with chronic pancreatitis<sup>[13]</sup>.

Only two years later, Gagner *et al*<sup>[14]</sup> reported retrospectively laparoscopic distal pancreatectomy in eight patients with presumed benign tumors (and one unclear) as well as four enucleations. However, this was also the first report on LDP in a patient with adenocarcinoma, as one of the tumors was a cystadenocarcinoma. Cuschieri *et al*<sup>[15]</sup> reported results of the procedure performed in five patients to treat chronic pancreatitis, and, in the same year, case reports further supporting this new approach were published<sup>[15,16]</sup>. The procedure was still in its infancy and was reserved for indications other than pancreatic adenocarcinoma<sup>[17,18]</sup>.

In 1997, the first report on laparoscopic distal pancreatectomy from the United States was published<sup>[19]</sup>. In the same year, the first case report on the preservation of the spleen was published<sup>[20]</sup>.

The second report that included adenocarcinoma of the pancreas reported 2 LDP procedures, one of which was to treat adenocarcinoma<sup>[21]</sup>.

Spleen preservation was further established in the literature in 1999<sup>[22,23]</sup>. The higher rate of spleen preservation seen using LPD compared to open distal pancreatectomy (ODP) has generally been considered positive, while resection of the splenic vessels adds to the oncological radicality of the operation and may increase the number of lymph nodes retrieved<sup>[24]</sup>.

In a series of 15 patients who underwent LDP between 1993 and 2000, two were found to have adenocarcinoma of the pancreas. However, the margin status and lymph node number for these patients is unknown<sup>[25]</sup>.

Fernández-Cruz *et al*<sup>[26]</sup> reported on the results of LDP procedures used to treat chronic pancreatitis in 2002 and compared those results to those of open surgery. This small study of 5 patients suggested that LDP was a feasible alternative for patients with this disease.

In a series of 6 attempted (5 successful) LDPs from 2002, two of the patients underwent operations for adenocarcinoma<sup>[27]</sup>. One underwent an operation with a curative intention and was reported alive and free of tumor at the 2-year follow up. The other patient underwent the operation as part of palliative treatment, and a liver metastasis was removed during the same operation. For these two patients, the number of lymph nodes resected was reported as 19 and 6, respectively, and the margin statuses were R0 and Rx, respectively. Although this re-

port did not compare LDP to ODP, it was the first to report oncological findings.

When the use of LDP was reviewed in 2003, a total of 47 cases were found, as reported in 18 articles. In only 3 of those cases did patients have adenocarcinomas, and the indication for LDP was still found to be non-malignant lesions<sup>[14,21,28]</sup>. At the same time, the indications were evolving from generally including neuroendocrine pancreatic tumors and pancreatitis to also including cystic neoplasias of the pancreas<sup>[29,30]</sup>.

Early results of procedures performed between 1997 and 2003 included a retrospective analysis of 12 LDP procedures that included 4 adenocarcinomas. However, the lymph node count and margin status were not mentioned<sup>[31]</sup>. In another report from 2004, 17 LDPs performed between 1997 and 2002 were presented. Four patients in that study had adenocarcinoma (3 cases were successfully resected with LDP) and two had positive surgical margins. The margin status for the entire cohort of patients with pancreatic lesions was 88% R0; the lymph node count was not provided, and the median survival was 12-13 mo<sup>[32]</sup>.

In 2005, a large retrospective European multicenter study summarized the experience of laparoscopic distal pancreatectomy between 1995 and 2002, reporting that out of 127 patients, only 6 had pancreatic adenocarcinomas<sup>[33]</sup>. In the same year, a report on 21 prospectively registered patients undergoing LDP, including 3 adenocarcinomas, suggested the feasibility of LDP with a low morbidity rate; follow up was between 2 mo and 3.8 years and all patients were reported to be disease free<sup>[34]</sup>. All patients had an R0 resection and a median number of 18 lymph nodes were retrieved.

In a retrospective analysis of prospectively sampled data of 16 hand-assisted LDP procedures performed between 2002 and 2004, two LDPs were performed for adenocarcinomas that were either suspected or had been confirmed by fine needle aspiration. Final pathology showed one case of chronic pancreatitis and one of adenosquamous carcinoma. The R0 frequency was found to be 76% (calculation based on 13 patients with neoplasia in the pancreas) and the mean number of lymph nodes resected was 5.5<sup>[35]</sup>. In another article published in 2006, 15 cases of attempted LDP resulted in 3 conversions to ODP. These 3 surgeries were the only cases of pancreatic adenocarcinoma in the LDP group; the lymph node count and margin status were not described<sup>[36]</sup>. In a report on 13 LDPs performed to treat benign or low-grade malignant lesions, 3 adenocarcinomas were found during final pathology testing, but the lymph node count and surgical margins were not disclosed<sup>[37]</sup>.

In 2007, a single-center analysis of 82 LDPs performed between 1998 and 2007, including 13 ductal adenocarcinomas, was presented with 90% R0 resections in that subgroup. Five other adenocarcinomas were included as well and all patients had R0 resections; the median survival for ductal adenocarcinoma was 14 mo<sup>[38]</sup>. In this report, suspected and overt malignant lesions were

operated on according to the principle of Radical Anti-grade Modular PancreatoSplenectomy (RAMPS). Three of the operations were converted to open surgery and all included extended en block resection of other organs. In median, 14.5 lymph nodes were resected and the median tumor size was 5.3 cm.

In a single institution the retrospective analyses 58 of LDPs performed during the period of 1999 to 2005 were described. The group included 5 ductal adenocarcinomas as well as two mucinous cystadenocarcinomas; however, the surgical margin status or lymph node harvesting was unfortunately not mentioned<sup>[39]</sup>. The surgical approach was a retrograde dissection of the pancreas, and all of the patients with malignant diagnosis, except one who died 3 mo after surgery, were reported to be alive and disease free after a median of 26 mo follow up.

Another single institution report describes 22 LDPs, with 2 of the patients having malignant foci in the MCNs; both had R0 resection, but their lymph node status was not described<sup>[40]</sup>.

The first multicenter experience from the United States was reported in 2008 (data from 2002 to 2006). In 8 centers (of which 3 were defined as high volume, > 30 LDP), 159 LDPs were attempted with 20 (13%) converted to open surgery. Of those, 16 were shown to have adenocarcinoma<sup>[41]</sup>. In a retrospective, case-matched study, LDP ( $n = 31$ ) was shown to be equivalent to ODP ( $n = 62$ ) with respect to complications, the operation time and bleeding, but the hospital stay was shorter in the LDP group. There were, however, no ductal adenocarcinomas in the group<sup>[42]</sup>.

An early 10-year report (1996 to 2006) of 46 attempted LDPs in 5 institutions reports 9 ductal adenocarcinomas (as well as 1 mucinous cystadenocarcinoma). Twelve patients were converted to open surgery (including 4 ductal adenocarcinomas). All malignant cases completed with LDP had negative surgical margins<sup>[43]</sup>.

In a retrospective analysis of 128 patients operated on for benign lesions of the pancreatic body or tail, in which patients were allowed to choose either LDP or ODP, 93 patients chose LDP and 35 ODP<sup>[44]</sup>. The results were similar, but the hospital stay was significantly shorter in the LDP group and splenic preservation was also more common in the LDP group.

In another article from 2008, 25 LDP and seven hand-assisted LDP cases were reported. The mean tumor size was 2.7 cm and 3 adenocarcinomas were included<sup>[45]</sup>.

Twenty-five successful LDPs (31 attempted) that were prospectively evaluated were described; one patient may have had adenocarcinoma although this cannot be confirmed because other laparoscopic pancreatic procedures were described in the article as well. However, all of the patients with malignant diagnosis operated upon had negative surgical margins. Lymph node numbers were not given<sup>[46]</sup>.

During the first 12-14 years after the introduction of LDP, approximately 50 cases of adenocarcinoma of the pancreas had emerged among the benign and low-

**Table 1 Series on laparoscopic distal pancreatectomy that include adenocarcinoma of the pancreas and oncological outcome  $n$  (%)**

Ref.	Number		Lymph nodes	R0	Tumor size (mm)
	Total	AC			
Song <i>et al</i> <sup>[47]</sup>	359	34 (9)	10.3 <sup>1</sup>	92%	30 (26) <sup>1</sup>
Fernández-Cruz <i>et al</i> <sup>[38]</sup>	82	18 (22)	14.5 <sup>2</sup>	90% <sup>2</sup>	53
Marangos <i>et al</i> <sup>[48]</sup>	30	28 (93)	5	93%	50
Taylor <i>et al</i> <sup>[43]</sup>	46	10 (22)	-	100% <sup>3</sup>	-
Melotti <i>et al</i> <sup>[39]</sup>	58	7 (12)	13	100%	35 <sup>4</sup>
Asbun <i>et al</i> <sup>[49]</sup>	29	5 (17)	14 (19) <sup>1</sup>	97%	-
Edwin <i>et al</i> <sup>[52]</sup>	17	4 (24)	-	88 (50) <sup>1</sup>	28
Dulucq <i>et al</i> <sup>[34]</sup>	21	3 (14)	18	100%	42
Bärlechner <i>et al</i> <sup>[27]</sup>	5	2 (40)	19/6	R0/Rx	-
Sa Cunha <i>et al</i> <sup>[46]</sup>	31	1 (3)	-	100% <sup>5</sup>	37
D'Angelica <i>et al</i> <sup>[35]</sup>	16	1 (6)	5.5	77%	40

<sup>1</sup>Indicates numbers from adenocarcinoma diagnosis only; <sup>2</sup>Indicates numbers from ductal adenocarcinoma only ( $n = 13$ ); the other 5 had R0 resection; <sup>3</sup>In 7 malignant cases completed with laparoscopic distal pancreatectomy, all having R0 resection; <sup>4</sup>Indicates numbers from ductal adenocarcinoma only, for 2 mucinous cystadenocarcinoma the corresponding number is 38 mm; <sup>5</sup>One ductal adenocarcinoma with R0 margins. AC: Adenocarcinoma of the pancreas.

malignant diagnoses that were considered established indications for LDP. Unfortunately, no randomized study has been performed on the applicability of LDP for adenocarcinoma of the pancreas. Tables 1 and 2 summarize published series on LDP that include patients with adenocarcinoma of the pancreas.

This review was conducted to try to answer the question of whether LDP is a viable treatment option for adenocarcinoma of the body and tail of the pancreas.

## GENERAL CONSIDERATIONS

Although LDP has not been compared to open distal pancreatectomy in a randomized prospective manner, there is a substantial literature supporting its use for benign lesions as LDP seems to result in less bleeding, a shorter hospital stay and reduced morbidity than ODP<sup>[47]</sup>. During the introduction of the laparoscopic technique, cost considerations have been raised because of the additional cost of the single use of surgical material. However, when the treatment cost is summarized, LDP seems to be at least as cost effective as ODP, mainly due to the shorter hospital stay<sup>[48-50]</sup>.

Despite this, currently only approximately 20% of distal pancreatectomy (DP) cases in the United States are performed laparoscopically, which makes the results presented in the literature somewhat harder to extrapolate<sup>[51]</sup>.

One of the benefits of LDP shown in a number of publications is the higher rate of spleen preservation seen compared to ODP. There are two methods for resecting the distal pancreas without resecting the spleen. One described by Warshaw, where the splenic vessels are removed and the spleen is left with circulation from the short gastric vessels and another where the splenic vessels are dissected from the back-side of the pancreas

**Table 2 Series on laparoscopic distal pancreatectomy that include adenocarcinoma of the pancreas but not oncological outcome *n* (%)**

Ref.	Number		Comment
	Total	AC	
Weber <i>et al</i> <sup>[50]</sup>	219	16 (7)	
Mabrut <i>et al</i> <sup>[33]</sup>	127	6 (5)	
Giulianotti <i>et al</i> <sup>[51]</sup>	46	8 (17)	Robot-assisted LDP
Butturini <i>et al</i> <sup>[52]</sup>	43	1 (2)	
Laxa <i>et al</i> <sup>[45]</sup>	32	3 (9)	7 hand-assisted
Corcione <i>et al</i> <sup>[37]</sup>	13	3 (16)	
Patterson <i>et al</i> <sup>[25]</sup>	15	2 (13)	
Lebedyev <i>et al</i> <sup>[31]</sup>	12	4 (33)	
Gagner <i>et al</i> <sup>[14]</sup>	8	1 (13)	
Santoro <i>et al</i> <sup>[21]</sup>	2	1 (50)	

AC: Adenocarcinoma of the pancreas; LDP: Laparoscopic distal pancreatectomy.

thus leaving the spleen with its circulation intact<sup>[52]</sup>. This, however, is not a valid argument for LDP in the setting of adenocarcinoma of the pancreas, as the oncological completeness of the operation is jeopardized when the spleen is spared<sup>[24,53,54]</sup>.

## ONCOLOGICAL CONSIDERATIONS

As there are no large reports on the long-term oncological results from using LDP and, as the cases published are likely to be highly selective, the oncological results cannot be accurately assessed. Surgical margins and the number of resected lymph nodes may serve as an approximation of the oncological outcomes. On the other hand, it should be kept in mind that LDP has mainly been performed for lesions that are presumed to be benign and, therefore, it is quite possible that the resections have been less extensive for this reason.

To be able to make a meaningful comparison, it is crucial to establish the true quality of ODP. Clean surgical margins are of paramount importance when dealing with adenocarcinoma of the pancreas and the rate of R0 resections with ODP is approximately 90% although numbers as low as 77% have been reported in large studies<sup>[53-57]</sup>. The number of lymph nodes harvested also varies, but the number is typically between 9-15<sup>[53-55,57]</sup>.

The first comparative analysis that includes some oncological markers is from a prospectively registered database where 27 completed LDPs (28 attempted) were compared to 85 ODPs and found to be similar with regards to the operation time and complications. However, the hospital stay was shorter and blood loss lower after LDP. There was one case of ductal adenocarcinoma in the LDP group<sup>[58]</sup>.

In 2009, a report on 148 distal pancreatectomies performed during the period of 2002 to 2007 showed that 50 were attempted LDPs (6 converted to open surgery) and 98 were ODPs. The LDP group included 6 adenocarcinomas. The complication rate was similar, but the hospital stay and blood loss was lower in the LDP

group<sup>[59]</sup>.

In a multi-institutional report on 219 LDP from 2009, 16 adenocarcinomas were found, and the study did not find any correlation between malignancy and an increased risk of major complications. However, the oncological completeness of the resections was not demonstrated<sup>[60]</sup>.

In a retrospective analysis of 100 LDPs compared to matched 100 ODPs, the LDP group was found to have less blood loss and a shorter hospital stay. There were 17 cases of pancreatic adenocarcinoma in the LDP group<sup>[61]</sup>. Seventy-one completed (95 attempted) LDPs, including 3 ductal adenocarcinoma cases, were compared to 168 ODPs and found to result in less intraoperative bleeding and a shorter hospital stay. The number of lymph nodes harvested was similar, and positive surgical margins were significantly more common in the ODP group<sup>[62]</sup>.

In 2010, a multicenter analysis comparing LDP to ODP in the settings of ductal adenocarcinoma at 9 US centers during the period of 2000 to 2008 was presented<sup>[55]</sup>. The study included a total of 212 patients operated on for ductal adenocarcinoma of the pancreatic body or tail. Of these, 23 (11%) were operated with LDP (4 converted to open procedure) and the remaining 189 with ODP. The number of lymph nodes examined and number of patients with positive surgical margins did not differ in the comparison (whole material and 3:1 matched). The hospital stay was shorter in the LDP group however. The median survival was 16 mo in both groups.

In a material of 343 distal pancreatectomies, performed during a 7-year period (2003-2009), 107 were attempted LDP (33 converted) and 97% of the patients in the LDP group had negative margins; also, the number of harvested lymph nodes was 6 compared to 5 in the ODP group. The number of cancer cases in the LDP group was 17, but it is not stated how many of those cases were adenocarcinomas of the pancreas<sup>[63]</sup>.

In a description of the 10 year experience of DP for ductal adenocarcinoma of the pancreas performed between 1999 and 2008, a total of 50 patients were operated on, but 18 were excluded from the analysis as extended resections were performed<sup>[64]</sup>. Five were operated with LDP (starting in 2007, robot assisted). In the ODP group (*n* = 27), 87% had R0 resections and the median number of lymph nodes retrieved was 11.3 compared to 100% (median 8.2) in the LDP group. However, tumor size was 2.4 cm in the LDP group and 3.9 cm in the ODP; the median survival was 28 mo and did not differ between the groups. The authors conclude that LDP can be applied to selected patients with ductal adenocarcinoma of the distal pancreas.

Twenty-two LDP were compared to matched 22 ODP. In the LDP group there were 2 cases of malignant cystic tumors (that may represent mucinous cystic adenocarcinoma). The median tumor size in the LDP group was 2 cm compared to 5 cm in the ODP group. The number of lymph nodes and surgical margin status were omitted from the publication<sup>[65]</sup>.

An interesting addition to the laparoscopic technique

is robot-assisted laparoscopy. This was first reported for LDP in 46 patients of whom 8 suffered from adenocarcinoma of the pancreas in 2010. Unfortunately, the number of lymph nodes retrieved and the margin status for this group is not mentioned in the publication; the median survival of patients who could be followed was 15 mo<sup>[66]</sup>. In another series on 22 ODP, 18 LDP and 17 robot-assisted LDP 2 adenocarcinomas were found in the LDP group and 11 in the ODP group. The mean lesion size in the ODP group was 5 cm compared to 3 cm in the LDP group. Fourteen lymph nodes were harvested in the ODP group, and in the LDP group, the corresponding number was 11. Two patients in the ODP group had positive margins against none in the LDP group<sup>[67]</sup>.

Currently, the largest single center study of LDP is that of the Asian Medical Center, which presented data from 359 patients who underwent LDP between 2005 and 2010. Of those, 24 had ductal adenocarcinoma of the pancreas (in addition, 10 other adenocarcinomas were found), and this was the first report to clearly state that patients were operated on in accordance with the RAMPS procedure. The median number of lymph nodes harvested (from patients in the adenocarcinoma subgroup) was 10.3, and 92% were R0 resections. After a median follow-up of 10 mo, a median survival time was not determined, but the 1 and 2 year survival rates were reported to be 85%<sup>[68]</sup>.

In 2011, a series of 29 patients who underwent LDP in a “clockwise” manner, starting with mobilization of the left colon flexure and continuing along the lower border of the pancreas, was published. In the 22 specimens where lymph node count was given, the median number of lymph nodes was 14; for the 5 patients with adenocarcinoma, the corresponding number was 19. The frequency of R0 resections for operations completed with laparoscopy was 100%, but one patient’s procedure was converted to hand-assisted laparoscopy, which showed a positive surgical margin. The authors conclude that this technique shares similarities with RAMPS, as it allows for wide exposure of the pancreas and makes it feasible to include the left adrenal gland in the resection if needed (as was done in 3 of the cases presented)<sup>[69]</sup>.

In a retrospective (prospectively registered) evaluation of 118 distal pancreatectomies in Toronto, 42 were attempted laparoscopically with 5 converted to open surgery. Hospital stay was shorter in the LDP group than the ODP group, but pancreatic fistula was more common in the LDP group; however, there were more grade B and higher fistulas in the ODP group. Two patients in the LDP group were found to have malignant masses (origin not described)<sup>[49]</sup>.

In a 1:1 case-matched study of 60 patients (who were matched for final pathology and tumor size), hospital stay and intraoperative bleeding were more favorable in patients who underwent LDP when compared to ODP. Both groups had 7 patients with adenocarcinoma and the number of lymph nodes did not differ significantly, although there was a trend towards fewer lymph nodes

being harvested in the LDP group<sup>[70]</sup>.

In a retrospective analysis of 51 distal pancreatectomies performed over a period of 6 years, 35 were LDP and 16 were ODP. There were 4 adenocarcinomas in the LDP group compared to 3 in the ODP group, and one patient in each group had positive surgical margins. The number of retrieved lymph nodes was not discussed<sup>[48]</sup>.

The second largest single center report of LDP for malignancy is of 21 patients with typical ductal adenocarcinomas of the pancreas as well as 7 other adenocarcinomas. The R0 frequency was 93%, but it should be noted that the tumors were larger (median size 5 cm) than in most other series and a significant proportion of operations included resections of organs other than the pancreas. The median number of lymph nodes investigated was 5, and 3 year survival was 30%<sup>[71]</sup>.

A report on 122 LDPs performed over 10 years and focused on the changes between the first 66 and later 66 operations reported 18 malignancies (11 ductal adenocarcinomas) and 5 positive surgical margins (in results cover all 122 patients). Unfortunately, the number of lymph nodes resected was not stated<sup>[72]</sup>.

In an Italian publication on 43 cases of LDP, which included 1 pancreatic adenocarcinoma, the median tumor size was 25 mm, and neither lymph node number nor margin status were mentioned<sup>[73]</sup>.

In a publication focusing on LDP in cases of suspected malignancy, results from 12 LDP procedures were presented. Final pathology revealed 8 malignant cases, all with negative surgical margins, and the median number of harvested lymph nodes was 8. Four of the operations were hand-assisted and one was converted to open surgery<sup>[74]</sup>.

Recently, the experience of a single center making the transition from using mainly open surgery to a laparoscopic approach to the distal pancreas was described. Between 2005 and 2011, 172 patients underwent operations, with 82 LDPs and 90 ODPs. During the first half of the period, all but one of the operations was ODP, but during the latter half, 83% were LDP. In the LDP group, 18 patients had pancreatic adenocarcinoma compared to 21 in the ODP group. No difference was found in lymph node retrieval or in R0 frequency, but hospital stay and intraoperative bleeding differed in favor of the LDP group<sup>[75]</sup>.

In another recent publication focusing on the role of LDP to treat adenocarcinoma, no differences were found between LDP and ODP with respect to negative surgical margins (86% *vs* 88%) or lymph node clearance (11 *vs* 12) in 28 LDP and 32 ODP procedures. The median survival for the cohort was found to be 19 mo, and there was no difference between the two operation methods<sup>[57]</sup>.

Similar results were presented in a study of 8 LDP patients compared to 14 who underwent ODP, which reported that 88% of LDP and 86% of ODP cases had negative margins. In this study, the number of lymph nodes was 16 (LDP) compared to 14 (ODP); 3-year survival was 82% in the LDP group compared to 74% (NS)

**Table 3 Studies comparing laparoscopic distal pancreatectomy and open distal pancreatectomy that include adenocarcinoma of the pancreas and oncological outcomes *n* (%)**

Ref.	Number		Number AC		Lymph nodes		Tumor size (mm)		R0	
	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP
Jayaraman <i>et al</i> <sup>[68]</sup>	107	236	17 (16)	47 (20)	6	7 NS	30	30	97%	96%
Vijan <i>et al</i> <sup>[66]</sup>	100	100	17 (17)	19 (19)	NS	NS	33	40	100%	100%
Stauffer <i>et al</i> <sup>[73]</sup>	82	90	18 (22)	21 (23)	16.5	11 NS	20	28	97%	94%
DiNorcia <i>et al</i> <sup>[67]</sup>	71	168	3 (4)	51 (30)	6	8 NS	25	36	97%	87%
Abu Hilal <i>et al</i> <sup>[54]</sup>	35	16	4 (11)	3 (19)	-	-	34	33	75%	67%
Mehta <i>et al</i> <sup>[72]</sup>	30	30	7 (23)	7 (23)	8.4	13.8 NS	38	43	-	-
Baker <i>et al</i> <sup>[64]</sup>	27	85	1 (4)	18 (21)	5.2	9.4 <sup>a</sup>	38	40	-	-
Magge <i>et al</i> <sup>[63]</sup>	28	34	28 (100)	34 (100)	11	12 NS	37	45	86%	88%
Kooby <i>et al</i> <sup>[61]</sup>	23	189	23 (100)	189 (100)	13.8	12.5 NS	35	45	74%	73%
Waters <i>et al</i> <sup>[71]</sup>	18	22	2 (11)	11 (50)	11	14 NS	40	60	100%	82%
Limongelli <i>et al</i> <sup>[56]</sup>	16	29	1 (6)	7 (24)	-	-	32	43	94%	93%
Rehman <i>et al</i> <sup>[76]</sup>	8	14	8 (100)	14 (100)	16	14	22	32	88%	86%
Kang <i>et al</i> <sup>[69]</sup>	5	27	5 (100)	27 (100)	8.2	11.3 NS	24	42	100%	85%

<sup>a</sup>*P* < 0.05 vs laparoscopic distal pancreatectomy (LDP) group. ODP: Open distal pancreatectomy; NS: Not significant; AC: Adenocarcinoma of the pancreas.

**Table 4 Studies comparing laparoscopic distal pancreatectomy and open distal pancreatectomy that include adenocarcinoma of the pancreas but not oncological outcomes *n* (%)**

Ref.	Number		Number AC		Tumor size	
	LDP	ODP	LDP	ODP	LDP	ODP
Finan <i>et al</i> <sup>[65]</sup>	44	98	6 (13.6)	23 (22.1)	33	77
Fox <i>et al</i> <sup>[55]</sup>	42	76	2 (5)	2 (3)	29	35
Casadei <i>et al</i> <sup>[70]</sup>	22	22	2 (9) <sup>1</sup>	2 (9) <sup>1</sup>	20	50
Velanovich <i>et al</i> <sup>[36]</sup>	15	41	3 (20)	13 (32)	-	-

<sup>1</sup>Malignant cystic tumors that may represent cystadenocarcinoma. ODP: Open distal pancreatectomy; LDP: Laparoscopic distal pancreatectomy.

in the ODP group<sup>[76]</sup>.

In Tables 3 and 4, studies comparing LDP and ODP and including patients with pancreatic adenocarcinoma of the pancreas are summarized.

## DISCUSSION

When feasible, the laparoscopic approach to surgery has spared patients unnecessary suffering. Although initially met with skepticism, the procedure has proven to be useful for treating a great number of benign and malignant tumors<sup>[7]</sup>. Unfortunately, there is a lack of prospective randomized trials that completely evaluate the outcomes of LDP compared to ODP. There is, however, compelling evidence from retrospective series that LDP reduces bleeding and shortens hospital stay<sup>[77-79]</sup>.

In this review, we have gathered the available studies reporting use of LDP in patients with adenocarcinoma. In this patient group, bleeding, major complications and hospital stay are of importance when compared to ODP. The technique must also provide the same results regarding R0 resections and number of retrieved lymph nodes. In the long term, cancer related survival and recurrence ultimately are important. Unfortunately, the presently available studies are small and non-randomized; in addition, survival data are not always presented. Table 5

shows the available survival data from all studies reporting results from at least 5 patients who underwent LDP for pancreatic adenocarcinoma.

In series that compare LDP and ODP, and in which oncological data is presented, the number of lymph nodes harvested does not vary between the groups<sup>[55,57,61-64,67,70,75,76]</sup>. Only one of the early studies has deviating results<sup>[58]</sup>. In reports that provide data on the frequency of negative surgical margins, there is no significant difference between LDP and ODP<sup>[48,50,55,57,61-64,67,73,76]</sup>.

Series that only report LDP have to be compared with the relevant literature presenting results of ODP. The number of lymph nodes harvested in the LDP reports varies between 5 and 19, and most report over 10 lymph nodes harvested. This compares favorably to the results of ODP studies<sup>[38,39,53-55,57,68,69]</sup>. One LDP series described a strategy of only removing enlarged or suspicious lymph nodes, rather than performing a formal lymphadenectomy. The success of the strategy can be debated, and may explain the low number of lymph nodes harvested in that study<sup>[71]</sup>. The other report with notably few lymph nodes harvested included data from an early period (2002-2004), and the same group later compared LDP to ODP and reported no significant difference in lymph node harvesting<sup>[35,63]</sup>. The percentage of negative surgical margins ranges from 88 to 100 in the LDP series, which compares favorably to ODP<sup>[32,38,39,43,53-57,68,69,71]</sup>. One of the studies reports a low R0 frequency of 77%, but the same group later reported excellent results in comparison to ODP<sup>[35,63]</sup>.

The current evidence, although somewhat limited, suggests that LDP may be oncologically equal to the gold standard treatment. Notably, the data related to number of lymph nodes resected comes from studies of very few patients and in which the indications for surgery have mainly been benign or low-malignant lesions, rather than the highly malignant adenocarcinoma. This may hold particularly true for the study in which a significant difference was found between LDP and ODP groups,

**Table 5** Studies presenting survival data after laparoscopic distal pancreatectomy for pancreatic adenocarcinoma and include at least 5 cases

Ref.	Year	n	Survival
Song <i>et al</i> <sup>[47]</sup>	2011	34	2 year 85%
Marangos <i>et al</i> <sup>[48]</sup>	2012	28	3 year 30%
Magge <i>et al</i> <sup>[63]</sup>	2013	28	Median 19 mo
Kooby <i>et al</i> <sup>[61]</sup>	2010	23	Median 16 mo
Fernández-Cruz <i>et al</i> <sup>[38]</sup>	2007	22	Median 14 mo
Rehman <i>et al</i> <sup>[76]</sup>	2013	8	3 year 82%
Giulianotti <i>et al</i> <sup>[51]</sup>	2010	8	Median 15 mo (2 lost in follow up)
Melotti <i>et al</i> <sup>[39]</sup>	2007	7	85% alive after median follow up 26 mo
Kang <i>et al</i> <sup>[69]</sup>	2010	5	Median 28 mo

as the adenocarcinomas were found mainly in the ODP group<sup>[58]</sup>. In light of this, there may be room for improvement in the oncological outcomes of LDP, provided that resections are performed for suspected pancreatic adenocarcinoma. Additionally, one of the advantages of LDP compared to ODP is a higher rate of splenic conservation, which makes LDP desirable when benign lesions are present. As the splenic hilum contains a number of lymph nodes, LDP reduces the number of lymph nodes resected in those cases. Some of the publications reviewed describe conversions to open surgery, and one of the reasons for converting has been increased suspicion of malignancy. Fortunately, most surgeons no longer believe that converting a laparoscopic operation to an open one is a complication. Instead, it is a sign of sound surgical judgment. The reasons given for conversion to open surgery suggest that malignant features often contribute to the decision<sup>[36,38,43,57]</sup>. With that in mind, and with the support of the published data, it should be acceptable or even preferable to operate on adenocarcinoma of the body or tail of the pancreas using LDP.

In the studies currently available, there may be a selection bias, for which LPD is selected in patients with smaller tumors. Moreover, the data on long term cancer related survival and recurrence is very limited. On the other hand, some of the publications report that all, or almost all, distal pancreatectomies are performed using LDP, which would eliminate any potential selection bias<sup>[69,71]</sup>. It would be preferable to conduct a prospective randomized trial on either unselected left sided pancreatic lesions or suspected adenocarcinomas. Until such a study is conducted, the results from series and comparisons using a patient selection ranging from almost exclusively benign or low malignant diseases in the LDP group to unselected patient cohorts must form the basis for these conclusions.

## CONCLUSION

LDP likely offers better outcomes than ODP with respect to morbidity and hospital stay. The current data suggests that oncological outcomes of the two procedures are similar and that LDP should therefore be con-

sidered a viable option for treating malignancies of the pancreatic body and tail. This conclusion should, however, be confirmed in a prospective, randomized study.

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