Surgical Endoscopy (2018) 32:3839–3845
https://doi.org/10.1007/s00464-018-6113-4

Laparoscopic distal pancreatectomy: which factors are related to open conversion? Lessons learned from 68 consecutive procedures in a high-volume pancreatic center

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Received: 23 October 2017 / Accepted: 7 February 2018 / Published online: 12 February 2018

Abstract

Background Laparoscopic distal pancreatectomy represents a difficult surgical procedure with an high conversion rate to open procedure. The factors related to its difficulty and conversion to open distal pancreatectomy were rarely reported. The aim of the present study was to identify which factors are related to conversion from laparoscopic to open distal pancreatectomy.

Methods A retrospective study of a prospective database of 68 patients who underwent laparoscopic distal pancreatectomy was conducted at a high-volume center by pancreatic surgeons experienced with laparoscopic surgery. Pre-intra and post-operative data were collected. Patients who completed a laparoscopic distal pancreatectomy were compared with those who needed a conversion to the open approach as regard demographic, clinical, radiological, and surgical data. Univariate and multivariate analyses were carried out.

Results Univariate analysis suggested that the site of the lesion, the extension of pancreatic resection, and the requirement for an extended procedure to adjacent organs were significantly associated with the risk of conversion to the open approach. Multivariate analysis showed that only the extension of the pancreatic resection (subtotal pancreatectomy) was significantly related to the odds of conversion [odds ratio (OR) 19.5; 95% confidence interval (CI) 1.1–32.3; $P=0.038$]. Preoperative suspicion of malignancy differed between the two groups; however, this difference did not reach statistical significance ($P=0.078$).

Conclusions Despite the limitations of the study, only the extension of pancreatic resection seemed to be the main factor related to conversion during laparoscopic distal pancreatectomy.

Keywords Pancreas · Laparoscopic distal pancreatectomy · Open distal pancreatectomy · Conversion · Pancreatic resection

Laparoscopic distal pancreatectomy (LDP) has become an increasingly adopted technique, and recent systematic reviews and meta-analyses have demonstrated its feasibility and safety for both benign and malignant pancreatic lesions, reporting postoperative outcomes at least comparable to those obtained with the open approach [1–7]. Nevertheless, LDP remains a difficult surgical procedure with technical limitations as well as a limited range of motion, 2-dimensional visualization, and difficulty controlling large blood vessels. The higher conversion rate reported (mean 22%; range 0–66%) [8] from laparoscopic to open distal pancreatectomy with respect to other advanced laparoscopic procedures, as well as colectomy (6%) [9] or adrenalectomy (3%) [10], is an evident demonstration of its difficulty. However, the difficulty of a surgical procedure is highly subjective and it remains difficult to integrate all the risk factors and an objective prediction of technical difficulty. Several authors [11–14] believe that difficult laparoscopic procedures are associated with a high rate of conversion to laparotomy. Regarding the other advanced laparoscopic procedures, using a large national database, several factors related to conversion have been reported; for instance, for colectomy, age over 50 years, obese patients, American Society

Authorship: All the authors have participated equally in the study according to the guidelines of the International Committee of Medical Journal Editors (ICMJE).

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of Anesthesiologists (ASA) score III–IV, the presence of ascites, smoking, and the presence of weight loss have been associated with increased odds of conversion [9]. On the contrary, for conversion from laparoscopic to open distal pancreatectomy, several articles have reported the reasons for conversion to open procedure;[8, 15, 16] however, only two papers [17, 18] have identified the risk factors predictive of conversion. Thus, the main purpose of the present study was to identify which factors were related to an open conversion of LDP in a high-volume pancreatic center having experience in laparoscopic advanced surgery in order to evaluate the odds of the laparoscopic distal pancreatectomy being completed safely for each patient.

Materials and methods

Study design

This is a retrospective study of a prospective database regarding 68 consecutive patients who were scheduled for a laparoscopic distal pancreatectomy for resectable body–tail pancreatic tumors from January 2004 to December 2016. Before 2015, the suspicion of pancreatic ductal adenocarcinoma (PDAC) was considered an absolute contraindication for the laparoscopic approach and the indications to perform a LDP were all the non-malignant pancreatic lesions of the body–tail. Subsequently, with the increasing expertise and with the literature evidence that LDP oncological results were similar to open procedure in pancreatic cancer [11], our policy was revised considering small (cT1-2) PDACs eligible for mini-invasive surgery. With the approval of the Ethics Committee of S.Orsola-Malpighi Hospital and patient informed consent, preoperative (gender, age, presence of comorbidities, American Society of Anesthesiologists (ASA) score, Body Mass Index (BMI), previous abdominal surgery, size and site of lesion, suspicious diagnosis, preoperative suspicion of malignancy, learning curve completed, type of resection planned LDP with or without splenectomy), intraoperative (type of resection performed LDP with or without splenectomy, unplanned splenectomy, extension of pancreatic resection-left pancreatectomy or subtotal pancreatectomy, extended procedures and conversion rate), and postoperative data (mortality and morbidity, pancreatic fistula, postpancreatectomy hemorrhage, reoperation rate, length of hospital stay, and final pathological diagnosis) were collected.

Surgical technique

Surgical technique and postoperative course were described in a previous report [19]. Briefly, after general anesthesia, the patient was placed in a supine position with a 20° head-up and foot-down tilt (reverse Trendelenburg position) and 30° right lateral decubitus with the patient's hip at the break in the table. The surgeon stood between the patient's lower limbs, with the first assistant holding the laparoscope on the right side, the second assistant on the left side, and the scrub nurse on the right side by the feet of the patient. Trocar placement should be adapted to both the size of the patient and the location of the tumor (body or tail). Usually, four to five trocars are placed in a semicircular fashion centered around an umbilical camera. Dissection was performed using diathermy hook and ultrasonic dissectors device (recently, Harmonic HD 1000i, Ethicon). Transection of the pancreas was always performed with a stapler (recently, Echelon 60, Ethicon) and a careful hemostasis of the resection line was performed. A drain was always placed close to the resection line of the pancreas. Sometimes, fibrin glue is adjunct in the surgical field. The surgical procedures were performed by two experienced pancreatic and laparoscopic surgeons. For each surgeon, the learning curve was considered completed after 17 procedures as previously reported [14].

Terminology and definition

Open conversion was defined to be a distal pancreatectomy via the laparoscopic approach but which required an open incision to complete the resection regardless of the incision size. Left pancreatectomy was defined to be the transection of the pancreatic parenchyma which was located to the left of the portal vein; on the contrary, subtotal pancreatectomy was defined to be the transection of the pancreatic parenchyma which was located to the right of the portal vein. An extended procedure was defined as a surgical resection involving other organs in addition to the pancreas. Postoperative mortality was defined as the number of deaths occurring during hospitalization or within 90 days after surgery. Postoperative morbidity included all complications following surgery up to the day of discharge according to the Clavien–Dindo classification [20]. A postoperative pancreatic fistula (POPF) was defined according to the definition proposed by the International Study Group of Pancreatic Fistula [21]. Postpancreatectomy hemorrhage (PPH) was defined as intra-abdominal or intestinal bleeding according to the criteria of the International Study Group of Pancreatic Surgery [22]. Reoperation was defined as any surgical procedure performed in the first 30 postoperative days or before discharge from the hospital. Length of hospital stay (LOS) was calculated as the interval from the day of surgery to the date of discharge.

Statistical analysis

All the categorical variables were reported as frequencies and percentages while the continuous variables were

reported as medians and ranges. Univariate analysis was carried out using the Fisher's exact test for discrete variables and the Student's *t* test for continuous variables. All variables presenting a P value < 0.150 in the univariate analysis were included in the multivariate model. The multivariate analysis was carried out using logistic regression analysis. The results were reported as odds ratio (OR) and a 95% confidence interval (95% CI). Two-tailed P values < 0.05 were considered statistically significant. All statistical analyses were carried out by running the Statistical Package for the Social Science (SPSS, Chicago, IL), version 13 on a personal computer.

Results

One hundred and sixty patients underwent distal pancreatectomy from January 2004 to December 2016 of which sixty-eight underwent LDP (42.5%). Of these patients, 13(19.1%) required a conversion from laparoscopic to open distal pancreatectomy, while 55 (80.9%) successfully completed the laparoscopic distal pancreatectomy. The preoperative characteristics, intraoperative results, and postoperative outcomes are summarized in Tables 1 and 2. In particular, it should be noted that the median size of the tumors was small (2.6 cm; range 0.5–13), they were mainly located in the pancreatic tail (58.8%) and malignancy was rarely suspected (36.8%). The type of resection performed was often a left pancreatectomy (91.8%), with splenectomy (79.4%), and without extended procedures (92.6%). Postoperatively, mortality was null, major complications were present in 16.1%, with 25% having a POPF of grade B/C, 4.4% of PPH grade B/C, and a reoperation rate of 4.4%. The length of hospital stay was acceptable (median 9 days; range 6–39). Final pathological diagnosis was rarely PDAC (7 cases = 10.3%).

The univariate and multivariate analyses of pre- and intraoperative factors influencing conversion in our cohort of patients are reported in Table 3. The univariate analysis showed that the site of the lesion ($P = 0.030$), the extension of the pancreatic resection ($P = 0.010$), and the need to perform a resection in addition to the pancreas ($P = 0.045$) were statistically significant factors related to open conversion. In addition, the suspicion of preoperative malignancy ($P = 0.056$) and the type of resection performed ($P = 0.055$) were not significantly related to conversion but showed a trend to significance. Thus, as previously reported, the multivariate analysis was built also including those factors which did not reach statistical significance, but which had a trend to significance ($P < 0.150$). The multivariate analysis showed that only the extension of the pancreatic resection was significantly related to the conversion rate. In fact, subtotal pancreatectomy significantly increased the risk of conversion to the open approach with respect to left pancreatectomy

Table 1 Pre and intraoperative characteristics of the 68 patients who underwent laparoscopic distal pancreatectomy

Characteristics	*N* (%)
Sex	
Male	28 (41.2)
Female	40 (58.8)
Age (years; median; range)	59 (15–84)
Comorbidity	
None	30 (44.1)
One or more	38 (55.9)
ASA score	
I	4 (5.9)
II	33 (48.5)
III	31 (45.6)
BMI (kg/m^2; median; range)	25.5 (18–40)
Previous abdominal surgery	
No	35 (51.5)
Yes	33 (48.5)
Size of lesions (cm; median; range)	2.6 (0.5–13)
Site of lesion	
Body	28 (41.2)
Tail	40 (58.8)
Suspicious preoperative diagnosis	
Solid neoplasm	36 (52.9)
Cystic neoplasm	32 (47.1)
Absolute contraindication for PDAC	
Yes (before 2015)	53 (77.9)
No (after 2015)	15 (22.1)
Learning curve completed	
No	37 (54.4)
Yes	31 (55.6)
Type of resection planned	
LDP spleen-preserving	25 (36.8)
LDP with splenectomy	43 (63.2)
Type of resection performed	
LDP spleen-preserving	14 (20.6)
LDP with splenectomy	54 (79.4)
Unplanned splenectomy	
No	49 (72.1)
Yes	19 (27.9)
Extension of pancreatic resection	
"Left pancreatectomy"	62 (91.2)
"Subtotal pancreatectomy"	6 (8.8)
Extended procedures	
No	63 (92.6)
Yes	5 (7.4)
Conversion	
No	55 (80.9)
Yes	13 (19.1)

ASA American Society of Anesthesiologists, *BMI* Body Mass Index, *PDAC* pancreatic ductal adenocarcinoma, *LDP* laparoscopic distal pancreatectomy

Table 2 Postoperative course of the 68 patients who underwent laparoscopic distal pancreatectomy

Postoperative outcomes	*N* (%)
Mortality	0 (0)
Morbidity	
No	31 (45.6)
Clavien 1	8 (11.8)
Clavien 2	18 (26.5)
Clavien 3	9 (13.2)
Clavien 4	2 (2.9)
POPF	
No	45 (66.2)
Grade A	6 (8.8)
Grade B	16 (23.5)
Grade C	1 (1.5)
PPH	
No	64 (94.1)
Grade A	1 (1.5)
Grade B	3 (4.4)
Grade C	0 (0)
Reoperation	3 (4.4)
LOS (days, median; range)	9 (6–39)
Final pathological diagnosis	
PDAC	7 (10.3)
NET G1-2	26 (38.2)
IPMN	12 (17.7)
MCN	8 (11.8)
SCN	6 (8.8)
Others	9 (13.2)

POPF postoperative pancreatic fistula, *PPH* postpancreatectomy hemorrhage, *LOS* length of stay; *PDAC* pancreatic ductal adenocarcinoma, *NET G1-2* neuro endocrine tumors, *IPMN* intraductal papillary mucinous neoplasm, *MCN* mucinous cystic neoplasm, *SCN* serous cystic neoplasm

(OR 9.65; 95% CI 1.18–78.81; $P=0.038$). However, other factors were not significantly related to the conversion rate but showed an evident trend. In fact, a lesion located in the tail of the pancreas seemed to be a protective factor (OR 0.27; 95% CI 0.58–1.22; $P=0.089$) while, on the contrary, preoperative suspicion of malignancy and extended procedures increased the odds of conversion regarding fourfold and sevenfold, respectively (OR 3.62; 95% CI 0.86–15.18; $P=0.078$ and OR 7.27; 95% CI 0.74–71.70; $P=0.089$).

Discussion

Laparoscopic distal pancreatectomy represents an advanced laparoscopic procedure, commonly performed for surgically resectable benign and malignant lesions in the body–tail of the pancreas. It is a challenging procedure with technical limitations and a high conversion rate to an open procedure. In the current literature, for the most part, only the reasons of conversion to open procedure have been described. Daouadi et al. [15], in 90 LDPs, reported the need to convert to open procedure associated with the presence of a PDAC. Lee et al. [16], in 131 LDPs, reported multiple factors: obesity (31.7%), tumor proximity to major vessels (29.3%), hemorrhage (12.2%), adhesions (9.6%), margin assessment (7.3%), and oversewing of the pancreatic stump (4.9%). Finally, the completion of the learning curve was often reported as the main factor responsible for conversion to an open procedure [13, 14]. However, to our knowledge, only two study has fully investigated which factors are associated with conversion from laparoscopic to open distal pancreatectomy [17, 18]. Gho BKP et al.,[17] comparing LDP completed ($n=30$) with LDP converted ($n=10$), identified three risk factors significantly related to open conversion: LDP with splenectomy, institutional experience, and individual surgeon volume < 5 cases. Hua et al. [18] comparing 180 LDP completed with 31 converted, stated that the risk factors independently associated with conversion included diagnosis of malignant disease, multiorgan resection, and surgeons' case experience (< 15 cases).

The present study is the third which has fully investigated the factors predictive of conversion from laparoscopic to open distal pancreatectomy. Comparing this study with the previous, it should be noted that the sample was more numerous (68 cases versus 40 cases) with respect to the study of Goh et al. [17] but smaller than the study of Hua et al. [18] (211 cases), even if this latter was a dual-institution study. The conversion rate resulted higher than that reported by Hua et al. [18] (19.1 vs. 14.7%) but lower than that by Goh et al. [17] (25%). Finally, in the present study, a high-volume surgeon was considered when he completed the learning curve and performed 17 LDPs, as previously reported. [14], while in the previous studies [17, 18], the surgeon volume cut-off was inferior (5 and 15, respectively). In the present study, only one factor was significantly related to conversion but, conversely, another three showed a trend. Other factors, as well as completion of learning curve, [13, 14] BMI, [9, 16], and LDP with splenectomy, [17] were not associated with the conversion rate. Regarding, surgeon experience, it is generally accepted [17, 18] that the increasing number of procedures reduces the risk of conversion. In our experience, on the contrary, the completion of the learning curve (17 LDP) was not related to conversion to open procedure. This result was due probably to the increasing institutional/team experience. Regarding BMI value, it is to note that in the present study, the mean BMI was 25.5 kg/m^2 that represents a normal value and it cannot explain the impact of obesity (BMI > 35 kg/m^2) in the conversion to open. However, a recent paper from John Hopkins [18] did not report in obese patients (BMI > 35) an higher rate

Table 3 Pre- and intraoperative factors influencing conversion in the 68 patients who underwent laparoscopic distal pancreatectomy

Characteristics	Univariate			Multivariate	
	LDP	CLDP	*P* value	OR (95% CI)	*P* value
Sex					
Male (%)	33 (82.5)	7 (17.5)	0.759	*	*
Female (%)	22 (78.6)	6 (21.4)			
Age (years; median; range)	59 (15–84)	55 (36–77)	0.906	*	*
Comorbidity					
None (%)	26 (86.7)	4 (13.3)	0.360	*	*
One or more (%)	29 (76.3)	9 (23.7)			
ASA score					
I (%)	4 (100)	0 (0)	0.668	*	*
II (%)	26 (78.8)	7 (21.2)			
III (%)	25 (80.6)	6 (19.4)			
BMI (kg/m^2; median; range)	25 (18–40)	28 (20–40)	0.206	*	*
Previous abdominal surgery					
No (%)	24 (72.7)	9 (27.3)	0.220	*	*
Yes (%)	28 (87.5)	4 (12.5)			
Size of lesions (cm; median; range)	2.5 (0.5–13)	3 (0.5–12)	0.963	*	*
Site of lesion					
Body (%)	19 (67.9)	9 (32.1)	0.030	1 (referent)	
Tail (%)	36 (90)	4 (10)		0.27 (0.58–1.22)	0.089
Suspicious preoperative diagnosis					
Solid neoplasm (%)	29 (80.6)	7 (19.4)	0.672	*	*
Cystic neoplasm (%)	26 (81.3)	6 (18.7)			
Suspicious preoperative malignancy					
No (%)	38 (88.4)	5 (11.6)	0.056	1 (referent)	
Yes (%)	17 (68)	8 (32)		3.62 (0.86–15.18)	0.078
Absolute contraindication for PDAC					
Yes (before 2015)	44 (83)	9 (17)	0.462	*	*
No (after 2015)	11 (73.3)	4 (26.7)			
Learning curve completed					
No (%)	32 (86.5)	5 (13.5)	0.230	*	*
Yes (%)	23 (74.2)	8 (25.8)			
Type of resection planned					
LDP spleen-preserving (%)	22 (88)	3 (12)	0.345	*	*
LDP with splenectomy (%)	33 (76.7)	10 (23.3)			
Type of resection performed					
LDP spleen-preserving (%)	14 (100)	0 (0)	0.055	*	*
LDP with splenectomy (%)	41 (75.9)	13 (24.1)			
Unplanned splenectomy					
No (%)	39 (79.6)	10 (20.4)	1.000	*	*
Yes(%)	16 (84.2)	3 (15.8)			
Extension of pancreatic resection					
"Left pancreatectomy"	53 (85.5)	9 (14.5)	0.010	9.65 (1.18–78.81)	0.034
"Subtotal pancreatectomy"	2 (33.3)	4 (66.7)			
Extended procedure					
No	53 (84.1)	10 (15.9)	0.045	7.27 (0.74–71.70)	0.089
Yes	2 (40)	3 (60)			

ASA American Society of Anesthesiologists; *BMI* Body Mass Index; *LDP* laparoscopic distal pancreatectomy; *CLDP* converted laparoscopic distal pancreatectomy

of conversion to open. Nevertheless, many authors [16, 18] stated that patients with more visceral fat mass were more likely to have procedures that were converted because the exposure of the different organs resulted to be more difficult than in normal weight patients.

In the present study, performing a subtotal pancreatectomy was significantly related to conversion, approximately ninefold with respect to left pancreatectomy. In a subtotal pancreatectomy, the pancreatic resection is extended to the right of the portal/superior mesenteric trunk. The proximity of the tumor to major vessels as well as to the portal vein, superior mesenteric vein, common hepatic artery, and celiac trunk could determine technical difficulties for safely controlling these major vascular structures. Some authors [15, 16] have advocated the robotic approach to overcome these limitations because this approach allows magnified 3-dimensional visualization and improves the surgeon's ability to manipulate instruments intracorporeally, using stable articulated instruments. Thus, these data could be explained by the technical limitations of the laparoscopic procedure, and it is probable that technological improvements could decrease it. To reinforce this result, the present study showed an increase in the conversion rate both in patients in whom the tumor was located in the body of the pancreas and in those in whom there was a preoperative suspicion of malignancy. The site of the tumor was clearly related to the extension of the pancreatic resection: tumors located in the tail undergoing left pancreatectomy and those in the body undergoing subtotal pancreatectomy. In addition, preoperative suspicion of malignancy required a subtotal pancreatectomy to be performed as well as proper lymphadenectomy. Thus, it is evident that the extension of the pancreatic resection represents the only independent factor. In addition, the preoperative suspicion of malignancy meant that preoperative imaging showed a pancreatic lesion with morphological findings of malignancy and/or the tumor extended beyond the pancreas. In these cases, the laparoscopic approach could be difficult due to the characteristics of the tumor and the relationship of the pancreatic mass with the surrounding structures. Moreover, it should be noted that the final pathological diagnosis of these cases was not always pancreatic ductal adenocarcinoma ($n=7$), but also branch-duct intraductal papillary mucinous neoplasm ($n=12$) and mucinous cystic neoplasm ($n=6$). Thus, when there is suspicion of malignancy, the risk of conversion can be considered not only in pancreatic cancer but also in cystic tumors when they involve neighboring structures. Finally, the need for an extended procedure increased the conversion rate approximately sevenfold, even if it was not a significant risk factor. This meant that the need for a gastrectomy or colectomy increased the risk of the conversion rate which was probably due to the increasing difficulty of the surgery and to the limitations of the laparoscopic approach which could impair surgeon dexterity.

This study has several limitations: the retrospective design covering a long time period during which the surgical technique evolved; patient selection bias and the small sample in a single center. In fact, our cohort of patients who underwent LDP, consisted of mainly small tumors and only rarely was LDP performed for PDAC. Finally, it has institutional bias.

In conclusion, the present study confirmed that laparoscopic distal pancreatectomy was a challenging procedure with a high conversion rate. Some risk factors seemed to be predictive of the major difficulty of the laparoscopic procedure, increasing the odds of conversion: subtotal pancreatectomy, tumor located in the body of the pancreas, preoperative findings of malignancy, and resection extending to the neighboring organs. All these factors seemed to be related to the technical limitation of the laparoscopic approach which became evident when large blood vessels had to be controlled safely. In addition, these risk factors have to be considered in patients selection for LDP. However, even if it is difficult to integrate all risk factors and an objective prediction of technical difficulty, they can be helpful for pancreatic surgeons in differentiating the easy laparoscopic procedure, which can be performed safely, from the difficult procedures, at high risk of conversion. Nevertheless, it is to underline the potential advantages of a laparoscopic start even in the event of open conversion for easier dissection and enhanced visualization. Additional prospective, multicentric studies are needed to identify the risk factors predictive of conversion to open distal pancreatectomy.

Compliance with ethical standards

Disclosures Riccardo Casadei, Claudio Ricci, Carlo Alberto Pacilio, Carlo Ingaldi, Giovanni Taffurelli, and Francesco Minni declare that they have no conflict of interest.

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