

# Laparoscopic vs Open Distal Pancreatectomy

## A Single-Institution Comparative Study

Sandeep S. Vijan, MBBS; Kamran A. Ahmed, BS; William S. Harmsen, MS; Florencia G. Que, MD; Kaye M. Reid-Lombardo, MD; David M. Nagorney, MD; John H. Donohue, MD; Michael B. Farnell, MD; Michael L. Kendrick, MD

**Hypothesis:** Laparoscopic distal pancreatectomy (LDP) provides outcome advantages compared with open distal pancreatectomy (ODP).

**Design:** Single-institutional, retrospective review from January 1, 2004, to May 1, 2009.

**Setting:** Tertiary referral center.

**Patients:** Patients undergoing LDP (n=100) were matched by age, pathologic diagnosis, and pancreatic specimen length to a cohort undergoing ODP (n=100).

**Main Outcome Measures:** Perioperative outcomes and overall 30-day morbidity and mortality. Univariate and multivariate analyses were performed using logistic or linear regression as appropriate.

**Results:** Patients in the LDP group did not differ from those in the ODP group in age (mean, 59.0 vs 58.6 years;  $P=.85$ ), sex (60% vs 50% female;  $P=.16$ ), body mass index (calculated as weight in kilograms divided by height

in meters squared) (mean, 27.4 vs 27.9;  $P=.44$ ), or American Society of Anesthesiologists score of 3 or higher (58% vs 52%;  $P=.39$ ). Tumor size was greater in the ODP group than in the LDP group (mean, 4.0 vs 3.3 cm;  $P=.02$ ). The LDP group as compared with the ODP group demonstrated decreased blood loss (mean, 171 vs 519 mL;  $P<.001$ ) and shorter duration of hospital stay (mean, 6.1 vs 8.6 days;  $P<.001$ ). There were no differences between the LDP and ODP groups in operative time (mean, 214 vs 208 minutes;  $P=.50$ ), pancreatic leak rate (17% vs 17%;  $P>.99$ ), overall 30-day morbidity (34% vs 29%;  $P=.45$ ), and 30-day mortality (3% vs 1%;  $P=.62$ ).

**Conclusions:** The laparoscopic approach to distal pancreatectomy appears to provide advantages of reduced blood loss and length of hospital stay in selected patients compared with the open approach. Overall complication rates appear similar. Patient selection bias and limits of a retrospective analysis warrant prospective validation.

*Arch Surg.* 2010;145(7):616-621

WITH THE ADVANCES IN instrument and video technology, laparoscopic approaches have gained favor in many procedures and across most surgical disciplines. These approaches have demonstrated advantages over open approaches with regard to blood loss, operative time, pain, wound morbidity, and length of hospital stay in several procedures. In addition to cholecystectomy, herniorrhaphy, colectomy, and bariatric procedures, many advantages are also suggested in solid organ resection such as that of the liver and spleen.<sup>1,2</sup> Laparoscopic pancreatic resection has been approached more cautiously and with less enthusiasm because of the retroperitoneal location, proximity to major vasculature, and propensity for postoperative complications. Despite the apprehensive use and

acceptance of laparoscopic distal pancreatectomy (LDP), several case series and comparative cohort studies have suggested that laparoscopic approaches to distal pancreatic resection provide similar advantages that have been demonstrated for other minimally invasive procedures.<sup>3-5</sup> However, limitations of selection bias, small sample size, and pooling of multi-institutional data have prevented a meaningful comparative trial of LDP and open distal pancreatectomy (ODP).<sup>6-9</sup> We report a large, single-institutional, comparative study of these 2 approaches within a case-matched cohort design, attempting to better elucidate the benefits of laparoscopy.

## METHODS

We conducted a retrospective review of all patients who underwent a distal pancreatec-

**Author Affiliations:** Division of Gastroenterologic and General Surgery (Drs Vijan, Que, Reid-Lombardo, Nagorney, Donohue, Farnell, and Kendrick and Mr Ahmed) and Department of Biostatistics and Epidemiology (Mr Harmsen), Mayo Clinic, Rochester, Minnesota.

tomy from January 1, 2004, to May 1, 2009, at our institution (n=582).

All pancreatectomies were performed by experienced hepatopancreatic and biliary surgeons at a single institution. Following institutional review board approval, 100 patients undergoing LDP were matched by patient age ( $\pm 8$  years), pathologic diagnosis (benign vs malignant), and pancreatic specimen length ( $\pm 2$  cm) to a cohort (n=100) undergoing ODP. For most, we were able to appropriately match cystic vs noncystic neoplasms and primary vs metastatic malignant neoplasms. The hand-assisted technique was used selectively in 2 patients and is included in the LDP group.

Clinicopathologic features were evaluated by comparing these 2 groups, and perioperative outcomes were sought. We reviewed each patient's history for age, sex, body mass index (BMI; calculated as weight in kilograms divided by height in meters squared), American Society of Anesthesiology (ASA) score, previous abdominal surgery, pathologic diagnosis, tumor size, pancreatic specimen length, and concomitant operations. Specific outcomes that were addressed included operative time (in minutes), operative blood loss (in milliliters), wound morbidity, 30-day major morbidity and mortality, pancreatic leak rate (in percentage), and grade of leak (A, B, or C).

## DEFINITIONS

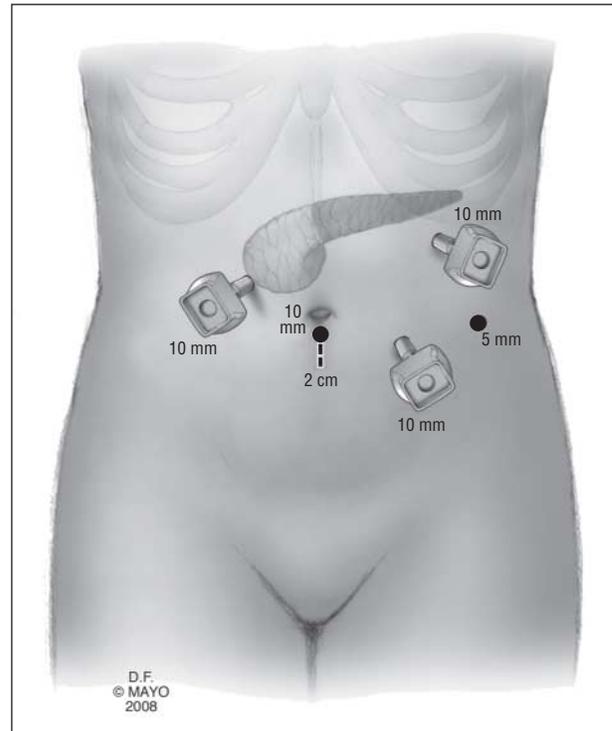
Wound morbidity included superficial wound infections, subcutaneous hematomas, and seromas. Major morbidity included pancreatic leak, intra-abdominal abscess, postoperative ileus, venous thromboembolism, cardiac ischemia or arrhythmias, reoperation, and any complication with a net effect to significantly prolong hospital stay within 30 days from pancreatectomy.

Per International Study Group on Pancreatic Fistula<sup>10</sup> recommendations, pancreatic leak is defined as any measurable volume of fluid output from a surgical or radiologically placed drain on or after postoperative day 3 that has an amylase level 3 times greater than the serum level. The presence of a peripancreatic fluid collection on axial imaging with clinical suspicion for leak is included.

Grade of pancreatic leak is also in accordance with International Study Group on Pancreatic Fistula definitions. A grade A leak is one that has no major clinical effect on the patient's clinical course. Its management involves the use of oral antibiotics and slow withdrawal of surgical drains. The patient is fed orally and remains clinically well. A grade B leak is one that entails manipulation of surgical drains or radiologic placement of a percutaneous drain into a peripancreatic fluid collection. Patients may or may not be kept withholding oral food and fluids and supported with enteral or parenteral feeds. These scenarios include hospital readmissions and delays in discharge. A grade C leak is one that involves major change in the patient's management. This may necessitate intensive care unit monitoring, intravenous antibiotics, use of somatostatin analogues, and/or reoperation. There is typically evidence of clinical sepsis and resultant extended duration of hospital stay.

## STATISTICAL ANALYSIS

Preoperative and clinicopathologic features were compared between the LDP and ODP groups using a *t* test or  $\chi^2$  test as appropriate. The outcomes of 30-day morbidity, major morbidity, pancreatic leak, mortality, operative blood loss ( $\leq 350$  mL vs  $>350$  mL), operative time ( $\leq 5$  hours vs  $>5$  hours), and hospital length of stay ( $\leq 7$  days vs  $>7$  days) were assessed using logistic regression. Multivariable models included group status, age, sex, BMI, ASA score (1 or 2 vs 3 or 4), additional or-



**Figure.** Trocar placement for laparoscopic distal pancreatectomy. Reproduced with permission from the Mayo Foundation for Medical Education and Research. All rights reserved.

gan resection or hernia repair, and specimen length. The  $\alpha$  level was set at .05 for statistical significance.

## OPERATIVE TECHNIQUE

Although some intersurgeon variability exists, we perform LDP in the following manner. Under general endotracheal anesthesia, in the supine position, pneumoperitoneum is established through a 10/12 left subcostal trocar placed under direct vision using the Optiview system (Ethicon Endo-Surgery, Inc, Cincinnati, Ohio). After initial abdominal exploration to rule out peritoneal or visceral metastasis, a total of 3 additional 10/12 trocars are placed. A 10-mm port in the infraumbilical location and 2 other 10-mm ports in the midclavicular lines, slightly above the umbilical line on the left and slightly below on the right, are placed (**Figure**). The Harmonic Ace scalpel (Ethicon Endo-Surgery, Inc) is used for most of the tissue dissection. The gastrocolic ligament is transected and the lesser sac is widely exposed. The mesocolon is dissected off the inferior border of the pancreas and the pancreas is dissected off the retroperitoneum. The splenic vessels are dissected away from the pancreas near the proposed site of pancreatic transection and an umbilical "shoestring" noose is placed around the pancreas. This is secured on the specimen side and is used for retraction during the remainder of the procedure. The pancreatic parenchyma is then divided with the harmonic scalpel (preferred) or with an Endo GIA stapler (Autosuture, Norwalk, Connecticut). If splenic preservation is indicated, the pancreas is dissected off the splenic vessels; tributary vessels are treated with the harmonic scalpel or clips. When simultaneous splenectomy is being performed, the splenic artery and vein are ligated and divided or are transected with the Endo GIA stapler. The pancreas is then retracted anteriorly and laterally with lateral dissection off the retroperitoneum. All peripancreatic lymphatic tissue is taken en bloc with the speci-

**Table 1. Preoperative Features of Patients Undergoing Open and Laparoscopic Distal Pancreatectomy**

Variable	ODP (n = 100)	LDP (n = 100)	P Value
Age, mean (SD), y	58.6 (15.2)	59.0 (17.3)	.85
Female, No. (%)	50 (50)	60 (60)	.16
BMI, mean (SD)	27.9 (5.0)	27.4 (5.2)	.44
Prior abdominal surgery, No. (%)	30 (30)	44 (44)	.04
ASA score $\geq$ 3, No. (%)	52 (52)	58 (58)	.39

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy.

men. The short gastric vessels are divided with the harmonic scalpel, and the splenic attachments are lysed. The specimen is then placed in an Endocatch II bag (Tyco Health Group, Autosuture) and removed via the periumbilical trocar site, which is extended just enough to accommodate the specimen, typically 3 to 5 cm in length. The pancreatic stump is then treated with the TissueLink device (TissueLink, Dover, New Hampshire). Closed suction drains are used selectively.

## RESULTS

A total of 104 consecutive patients in the LDP group were evaluated. In 4 cases, the procedure was converted to laparotomy due to extensive intra-abdominal adhesions (n=3) or bleeding (n=1), yielding a 4% conversion rate. These patients were subsequently excluded from further analysis.

Preoperative features of all 200 patients are reported in **Table 1**. Notably, the patients in the ODP group did not differ from those in the LDP group in age (mean, 58.6 vs 59.0 years;  $P=.85$ ), sex (50% vs 60% female;  $P=.16$ ), BMI (mean, 27.9 vs 27.4;  $P=.44$ ), or ASA score of 3 or higher (52% vs 58%;  $P=.39$ ). Previous abdominal operations were more common in the LDP group (44%) compared with the ODP group (30%) ( $P=.04$ ).

Clinicopathologic features of patients are outlined in **Table 2**. Of the 100 patients undergoing LDP, 25 (25%) underwent a spleen-preserving pancreatectomy. This was accomplished only when a diagnosis of having a malignant neoplasm was not entertained preoperatively or intraoperatively. Twenty percent of the ODP group had simultaneous adjacent organ resection or hernia repair vs 21% of the LDP group ( $P=.86$ ). Operative drains were used in 82% of ODP cases and 36% of LDP cases.

Univariate and multivariate analyses are reported in **Table 3**. For the LDP group as compared with the ODP group, operative time was not different (mean, 214 vs 208 minutes;  $P=.50$ ); however, blood loss was less (mean, 171 vs 519 mL;  $P<.001$ ). When outcome data were dichotomized, a patient in the ODP group relative to a patient in the LDP group had increased odds of a blood volume loss greater than 350 mL (Table 3). This association persisted in the multivariable models that also included the variables age, sex, BMI, ASA score (1 or 2 vs 3 or 4), additional organ resection or hernia repair, and specimen length.

**Table 2. Clinicopathologic Features of Patients Undergoing Open and Laparoscopic Distal Pancreatectomy**

Variable	ODP (n = 100)	LDP (n = 100)	P Value
Additional organ resection or hernia repair, No. (%)	20 (20)	21 (21)	.86
Specimen length, mean (SD), cm	9.4 (3.2)	9.3 (3.4)	.90
Tumor size, mean (SD), cm	4.0 (2.9)	3.3 (1.9)	.02
Histologic diagnosis, No. (%)			$>.99$
Benign	77 (77)	77 (77)	.31 <sup>a</sup>
Pancreatitis	4 (4)	1 (1)	
Cystic	43 (43)	49 (49)	
Solid	30 (30)	27 (27)	
Malignant	23 (23)	23 (23)	$>.99$ <sup>a</sup>
Primary	21 (21)	20 (20)	
Metastatic	2 (2)	3 (3)	

Abbreviations: LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy.

<sup>a</sup>Comparisons are between ODP and LDP groups by histologic diagnosis among patients with a benign diagnosis ( $P=.31$ ) and among patients with a malignant diagnosis ( $P>.99$ ).

The histologic diagnosis of benign vs malignant was not different between the 2 groups (Table 2). However, tumor size was greater in the ODP group than in the LDP group (mean, 4.0 vs 3.3 cm;  $P=.02$ ). Pancreatic adenocarcinoma represented the most common malignant tumor in both the LDP group (n=17) and the ODP group (n=19), followed by neuroendocrine carcinoma (LDP, n=3; ODP, n=2) and metastatic renal cell carcinoma (LDP, n=3; ODP, n=2). Malignant neoplasms were expected or biopsy proven preoperatively in all patients with adenocarcinoma. All patients in both groups had an R0 resection performed, and there was no difference in the number of lymph nodes harvested.

Overall 30-day major morbidity was not different between the LDP (34%) and ODP (29%) groups (odds ratio=0.8;  $P=.45$ ). Specifically, in the LDP vs ODP group, there was no difference in the wound morbidity (0% vs 5%;  $P=.06$ ) or pancreatic leak rate (17% vs 17%;  $P>.99$ ). In the LDP group, there were 2 grade A (2%), 14 grade B (14%), and 1 grade C (1%) pancreatic leaks, while in the ODP group, there were 1 grade A (1%) and 16 grade B (16%) pancreatic leaks.

The 30-day or in-hospital mortality rate was not statistically different between the LDP group (3 cases [3%]) and the ODP group (1 case [1%]) ( $P=.62$ ). Three patients in the LDP group died postoperatively of pulmonary embolus (n=2) or complications of pancreatic leak (n=1), and 1 patient in the ODP group died of pulmonary embolus.

The length of hospital stay was shorter in the LDP group (mean [SD], 6.1 [2.4] days) compared with the ODP group (mean [SD], 8.6 [5.9] days) ( $P<.001$ ). A patient who underwent ODP relative to a patient who underwent LDP had increased odds that their hospital stay would exceed 7 days (odds ratio=3.5; 95% confidence interval, 1.8-6.8); this association remained significant in the multivariable model (odds ratio=3.9; 95% confidence interval, 2.0-7.8).

**Table 3. Univariate and Multivariable Analyses of Perioperative Outcome Measures of Patients Undergoing Open and Laparoscopic Distal Pancreatectomy**

Outcome	Patients, No. (%)	Univariate		Multivariable <sup>a</sup>	
		OR (95% CI)	P Value	OR (95% CI)	P Value
Operative blood loss >350 mL					
ODP	52 (52)	9.8 (4.6-20.9)	<.001	10.6 (4.7-23.6)	<.001
LDP	10 (10)				
Operative time >3.5 h					
ODP	40 (40)	0.8 (0.5-1.4)	.47	0.7 (0.4-1.3)	.30
LDP	45 (45)				
Wound morbidity					
ODP	5 (5)	∞	.06	NA <sup>b</sup>	NA
LDP	0				
Major morbidity					
ODP	29 (29)	0.8 (0.4-1.4)	.45	0.8 (0.4-1.5)	.48
LDP	34 (34)				
Pancreatic leak					
ODP	17 (17)	1.0 (0.5-2.1)	>.99	1.0 (0.4-2.1)	.94
LDP	17 (17)				
Mortality					
ODP	1 (1)	0.3 (0.03-3.2)	.62	NA <sup>b</sup>	NA
LDP	3 (3)				
Length of hospital stay >7 d					
ODP	42 (42)	3.5 (1.8-6.8)	.002	3.9 (2.0-7.8)	<.001
LDP	17 (17)				

Abbreviations: CI, confidence interval; LDP, laparoscopic distal pancreatectomy; NA, not applicable; ODP, open distal pancreatectomy; OR, odds ratio.

<sup>a</sup>Multivariable model included patient age, sex, body mass index, American Society of Anesthesiologists score (1 or 2 vs 3 or 4), additional organ resection or hernia repair, and specimen length.

<sup>b</sup>Multivariable model not performed owing to low number of events.

## COMMENT

Despite the lack of level 1 evidence for LDP, more centers are adopting this technique. Current supporting evidence for this approach exists only in retrospective case series<sup>6,8,9</sup> and a few case-control studies.<sup>3,4,7</sup>

Notable is the recent work of Kooby et al,<sup>3</sup> a large multi-institutional case-control study in which 142 LDPs were compared with 200 ODPs. Patients were matched based on age, pathologic findings, ASA criteria, and pancreatic specimen length. Similar to our findings, Kooby and colleagues documented a significant decrease in blood loss (mean [SD], 357 [497] mL) and hospital stay (mean [SD], 5.9 [3.8] days) for patients undergoing LDP. However, operative time was not different between the 2 groups, and there was no increase in major morbidity (40%) or pancreatic leak rate (28%) with the laparoscopic approach; reported mortality was 0%. This study is limited by its multi-institutional, retrospective nature and the variability in experience of one center to another. Only 3 institutions in this study were considered high-volume centers, performing more than 30 LDPs per year; the overall conversion rate to laparotomy was 13%.

Eom et al<sup>4</sup> also published case-matched analyses with 31 LDPs and 62 ODPs. Eom and colleagues reported shorter hospital stay (11.5 days for LDP vs 13.5 days for ODP) but no difference in operative time, transfusion requirement, or overall morbidity. The pancreatic leak rate was 9.7% for LDP. This study may not be directly comparable to published Western series, however, due to the ambiguous definition of pancreatic

leak and differences in practice patterns with regard to duration of hospital stay.

The only other 2 comparative series to our knowledge are by Velanovich<sup>11</sup> and Teh et al.<sup>12</sup> In both studies, the LDP group again demonstrated a shorter hospital stay and lower overall morbidity. Unfortunately, both of these studies are small and underpowered, and the latter is based on an unmatched cohort and is therefore most susceptible to selection bias.

To our knowledge, our study is the largest single-institution experience comparing LDP with ODP. While this study suggests that the laparoscopic approach reduced blood loss and length of hospital stay, there are several limitations and outcomes that warrant further discussion. The observed 30-day mortality rate was 3% in our LDP group and 1% in the ODP group. While this did not reach statistical difference, the rate for LDP appears higher than that reported by others.<sup>3,4,11,12</sup> The 3 patient deaths in this study were due to pulmonary embolism (n=2, confirmed by autopsy in one and clinically suspected in the other) and uncontrolled pancreatic leak (n=1). Fatal pulmonary emboli occurred in 2 patients who underwent LDP with splenectomy for malignancy, one with ductal adenocarcinoma and the other with neuroendocrine carcinoma. Both had an initial uncomplicated course without evidence of pancreatic leak or deep venous thrombosis and were dismissed home on postoperative days 7 and 13; deaths occurred on postoperative days 14 and 15 while the patients were at home. Both patients received subcutaneous unfractionated heparin and mechanical compression for deep venous thrombosis prophylaxis during hospitalization, had

no history of venous thromboembolic disease, and did not demonstrate postsplenectomy thrombocytosis. Both patients had a 3- to 4-hour drive home after discharge. It has been suggested that increased intra-abdominal pressure enhances venous stasis, reduces intraoperative portal venous blood flow, and enhances the activation of coagulation and fibrinolysis<sup>13-15</sup>; however, appropriate deep venous thrombosis prophylaxis as was used in these patients should minimize this risk.<sup>16</sup> Both of these patients had been diagnosed as having malignancy and 1 had obesity (BMI of 38), which are known risk factors for postoperative thromboembolism. It remains unclear and unlikely that these deaths were directly attributable to the laparoscopic approach. In the ODP group, the single death was also in a patient undergoing ODP for pancreatic ductal adenocarcinoma. Additionally, 3 other patients in the ODP group had thromboembolic complications, suggesting that these patients are at high risk irrespective of the approach used. The third patient who died in the LDP group had undergone a spleen-preserving pancreatectomy for intraductal papillary mucinous neoplasm. The patient was dismissed on postoperative day 4 when clinically well. On postoperative day 7, he called with abdominal pain and was referred to his local hospital for initial evaluation and potential transfer. Unfortunately, contact with the patient was lost and the patient was admitted with a presumed bowel obstruction. After several days of observation, a computed tomographic scan identified a fluid collection in the pancreatic resection bed and a decision was made for laparotomy on postoperative day 12. The fluid collection was evacuated and, by report, the pancreatic stump was débrided. The procedure was complicated by a portal vein injury and the patient died of massive hemorrhage with exsanguination.

The overall morbidity in our study was not different between LDP and ODP. The incidence of postoperative pancreatic leak, the most common major morbidity after distal pancreatectomy, was not different. Encompassing all grades of leak, we observed a leak rate of 17%, which is comparable or favorable to that reported by others.<sup>3,17</sup> When excluding clinically insignificant leaks (grade A), the leak rate was also similar between groups. The use of prophylactic surgical drains was more common in the ODP group (82%) than in the LDP group (36%). This difference is largely attributed to a single surgeon's preference (M.L.K.), where drains are rarely used. Because grade A leaks may be based solely on the level of amylase from drain effluent, undetection of some grade A leaks may have occurred in patients without prophylactic drains. It is our impression, however, that clinically significant leaks will not be missed as it is our practice to image patients with any clinical suspicion of pancreatic stump leak. Several methods of transecting the pancreas and treating the pancreatic stump have been reported in an effort to reduce this serious complication after pancreatic resection. The method of pancreatic transection varied between the LDP and ODP groups. In most patients in the LDP group, the pancreas was transected by harmonic scalpel (75%) or Endo GIA stapler (25%) and the remnant stump was treated with TissueLink (75%), whereas in the ODP group, pancreatic transection was performed with electrocautery (60%) or Endo GIA stapler (40%) and, when deemed necessary, the rem-

nant stump was sutured closed (80%). Inevitably, the search continues for a better technique of pancreatic division and stump treatment to significantly reduce or ameliorate the complication of pancreatic fistula.

Tumor size was statistically different between the 2 groups in this study, albeit the mean difference was only 7 mm (4.0 mm for the ODP group vs 3.3 mm for the LDP group). We did not match for tumor size but rather chose to match for factors we felt would directly affect operative time and outcome such as indication (benign or malignant) and extent of operation (pancreatic specimen length).

Although we attempted to circumvent selection bias through cohort matching, a certain degree of bias is inherent with any study outside of a randomized controlled design. However, it is our opinion that some selection bias is necessary and appropriate when evaluating a new approach or technology to improve the likelihood of success and reduce patient risk for such novel advances. While this study confirms the advantages and success of the laparoscopic approach for distal pancreatectomy in these matched patients, it does not imply that all patients will achieve superior results; such a broad statement will require a randomized controlled trial.

The laparoscopic approach to distal pancreatectomy appears to provide advantages of less blood loss and shorter length of hospital stay in selected patients compared with the open approach. Overall complication rates, however, appear similar between the 2 groups. Patient selection bias and limits of a retrospective analysis warrant prospective controlled trials to validate the advantages of the laparoscopic approach in distal pancreatectomy.

**Accepted for Publication:** February 19, 2010.

**Correspondence:** Michael L. Kendrick, MD, Division of Gastroenterologic and General Surgery, Mayo Clinic, MA-W12, 200 First St SW, Rochester, MN 55905 (kendrick.michael@mayo.edu).

**Author Contributions:** *Study concept and design:* Vijan, Reid-Lombardo, and Kendrick. *Acquisition of data:* Vijan, Ahmed, and Kendrick. *Analysis and interpretation of data:* Vijan, Harmsen, Que, Nagorney, Donohue, Farnell, and Kendrick. *Drafting of the manuscript:* Vijan, Ahmed, Harmsen, Reid-Lombardo, and Kendrick. *Critical revision of the manuscript for important intellectual content:* Harmsen, Que, Reid-Lombardo, Nagorney, Donohue, Farnell, and Kendrick. *Statistical analysis:* Vijan and Harmsen. *Administrative, technical, and material support:* Vijan, Ahmed, Reid-Lombardo, and Kendrick. *Study supervision:* Que, Farnell, and Kendrick.

**Financial Disclosure:** None reported.

**Previous Presentation:** This paper was presented at the 117th Scientific Session of the Western Surgical Association; November 9, 2009; San Antonio, Texas; and is published after peer review and revision. The discussions that follow this article are based on the originally submitted manuscript and not the revised manuscript.

## REFERENCES

1. Katkhouda N, Hurwitz MB, Rivera RT, et al. Laparoscopic splenectomy: outcome and efficacy in 103 consecutive patients. *Ann Surg.* 1998;228(4):568-578.

2. Kaneko H. Laparoscopic hepatectomy: indications and outcomes. *J Hepatobiliary Pancreat Surg.* 2005;12(6):438-443.
3. Kooby DA, Gillespie T, Bentrem D, et al. Left-sided pancreatectomy: a multicenter comparison of laparoscopic and open approaches. *Ann Surg.* 2008;248(3):438-446.
4. Eom BW, Jang JY, Lee SE, Han HS, Yoon YS, Kim SW. Clinical outcomes compared between laparoscopic and open distal pancreatectomy. *Surg Endosc.* 2008;22(5):1334-1338.
5. Mabrut JY, Fernandez-Cruz L, Azagra JS, et al; Hepatobiliary and Pancreatic Section (HBPS) of the Royal Belgian Society of Surgery; Belgian Group for Endoscopic Surgery (BGES); Club Coelio. Laparoscopic pancreatic resection: results of a multicenter European study of 127 patients. *Surgery.* 2005;137(6):597-605.
6. Melotti G, Butturini G, Piccoli M, et al. Laparoscopic distal pancreatectomy: results on a consecutive series of 58 patients. *Ann Surg.* 2007;246(1):77-82.
7. Nakamura Y, Uchida E, Aimoto T, Matsumoto S, Yoshida H, Tajiri T. Clinical outcome of laparoscopic distal pancreatectomy. *J Hepatobiliary Pancreat Surg.* 2009;16(1):35-41.
8. Pryor A, Means JR, Pappas TN. Laparoscopic distal pancreatectomy with splenic preservation. *Surg Endosc.* 2007;21(12):2326-2330.
9. Laxa BU, Carbonell AM II, Cobb WS, et al. Laparoscopic and hand-assisted distal pancreatectomy. *Am Surg.* 2008;74(6):481-487.
10. Bassi C, Dervenis C, Butturini G, et al; International Study Group on Pancreatic Fistula Definition. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery.* 2005;138(1):8-13.
11. Velanovich V. Case-control comparison of laparoscopic vs open distal pancreatectomy. *J Gastrointest Surg.* 2006;10(1):95-98.
12. Teh SH, Tseng D, Sheppard BC. Laparoscopic and open distal pancreatic resection for benign pancreatic disease. *J Gastrointest Surg.* 2007;11(9):1120-1125.
13. Milic DJ, Pejicic VD, Zivic SS, et al. Coagulation status and the presence of postoperative deep vein thrombosis in patients undergoing laparoscopic cholecystectomy. *Surg Endosc.* 2007;21(9):1588-1592.
14. Lord RV, Ling JJ, Hugh TB, Coleman MJ, Doust BD, Nivison-Smith I. Incidence of deep vein thrombosis after laparoscopic vs minilaparotomy cholecystectomy. *Arch Surg.* 1998;133(9):967-973.
15. Garg PK, Teckchandani N, Hadke NS, Chander J, Nigam S, Puri SK. Alteration in coagulation profile and incidence of DVT in laparoscopic cholecystectomy. *Int J Surg.* 2009;7(2):130-135.
16. Richardson W, Apelgren K, Earle D, Fanelli R. Guidelines for deep venous thrombosis prophylaxis during laparoscopic surgery. *Surg Endosc.* 2007;21(12):2331-2334.
17. Alexakis N, Sutton R, Neoptolemos JP. Surgical treatment of pancreatic fistula. *Dig Surg.* 2004;21(4):262-274.

## DISCUSSION

Jeffrey E. Lee, MD, Houston, Texas: Drs Vijan, Kendrick, and their colleagues from the Mayo Clinic emphasize that minimally invasive distal pancreatectomy is being increasingly performed, yet randomized trials of this procedure have not been done and there have been relatively few high-quality comparison studies published. The results presented here confirm that laparoscopic distal pancreatectomy can generally be performed safely in selected patients and that one can anticipate benefits similar to those achieved in patients who undergo other minimally invasive abdominal operations, including a shorter hospital stay. I have 3 questions.

First, the authors report that they excluded 4 patients who required conversion from a laparoscopic to an open procedure. From the intent-to-treat standpoint, it would be preferable to describe the outcomes of these patients. Did any of these patients suffer a postoperative complication?

Second, is there any change in management recommended as a result of the deaths that occurred in 3 patients who underwent laparoscopic distal pancreatectomy? Since the only deaths in this series occurred following discharge and since a pancreatic leak often does not manifest itself until on or after

postoperative day 7, was early discharge a factor and does this imply that patients should stay close at hand for a few days after discharge before heading home? Should the pancreatic duct be handled differently from a technical standpoint to minimize the risk of leak? Could venous thromboembolism be prevented by continuing Lovenox through a long car ride home?

Third, the authors performed a laparoscopic spleen-preserving procedure in 25% of patients. How often was laparoscopic splenic preservation attempted unsuccessfully? How common is spleen preservation at the authors' institution when the operation is done open? What are the current indications at the Mayo Clinic in adults for considering splenic preservation (for example, IPMN [intraductal papillary mucinous neoplasm], small mucinous or neuroendocrine tumors, anticipated benign histology)?

**Dr Kendrick:** First, with respect to the 4 patients who were excluded from the laparoscopic group, 3 of those patients were converted to an open procedure for adhesions; they all had significant prior abdominal operations. One patient was converted for bleeding from the splenic vein during the procedure. As far as intention to treat, to my knowledge none of them developed a pancreatic leak or prolonged hospital stay.

Your second question was regarding our change in management based on our experience with thromboembolic complications. As mentioned, we had 2 deaths that were directly attributed to pulmonary embolism. In both of these patients, this complication occurred 2 weeks postoperatively and these patients had no other evidence of complications during their hospital stay or afterwards. Because of these events, we also looked at the open group, and interestingly 4 of those patients had significant thromboembolic complications, 3 of them with pulmonary embolus. The 1 death that occurred in the open group was also a patient who died of a pulmonary embolus after resection for adenocarcinoma. This has raised our concern with respect to patients who undergo pancreatectomy for ductal adenocarcinoma irrespective of whether it is performed laparoscopically or open. These patients had routine perioperative DVT [deep venous thrombosis] prophylaxis and we feel that consideration should be given to prophylaxis or full anticoagulation for up to 1 month postoperatively in these selected patients.

You had asked whether early discharge may be a factor in the perioperative deaths. Pulmonary embolus occurred in asymptomatic patients 2 weeks postoperatively without any other complications noted during their hospital stay or after discharge. Because of this, it is not clear whether the timing of discharge is a significant factor in these patients. The third death occurred in a patient who was dismissed on postoperative day 4 who remained asymptomatic until day 7. This patient was managed elsewhere for a leak and unfortunately underwent surgical débridement complicated by hemorrhage that caused his death. Although we see or contact our patients routinely after discharge to avoid this type of problem, this patient underscores the importance of close follow-up and communication with their local health care providers.

Finally, in terms of indications for spleen-preserving distal pancreatectomy, we feel that any patient without an invasive malignancy is a potential candidate for spleen preservation. Mucinous cyst adenomas and side-branch IPMNs are the most frequent indications for spleen preservation in our experience. In our laparoscopic experience, we have had 1 patient who was intended to undergo a spleen-preserving procedure where bleeding from the splenic vein necessitated splenectomy.

**Financial Disclosure:** None reported.