ORIGINAL ARTICLE

Laparoscopic Spleen-Preserving Distal Pancreatectomy

Splenic Vessel Preservation Compared With the Warshaw Technique

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Objective: To compare preservation with the division of the splenic vessels in the surgical management of laparoscopic spleen-preserving distal pancreatectomy.

Design: Bicentric retrospective study.

Setting: Prospectively maintained databases.

Patients: Between January 1997 and January 2011, 140 patients who underwent laparoscopic spleen-preserving distal pancreatectomy for benign or low-grade malignant tumors in the body/tail of the pancreas were included. Patients treated with the attempted splenic vessel preservation were compared with patients treated with the attempted division of the splenic vessels (Warshaw technique).

Main Outcome Measures: Operative outcomes and postoperative morbidity were evaluated.

Results: The outcomes of 55 patients in the splenic vessel preservation group were compared with those of 85 patients in the Warshaw technique group. The clinical characteristics were similar in both groups, except for tumor size, which was significantly greater in the Warshaw technique group (33.6 vs 42.5 mm; $P<.001$). The mean operative time, mean blood loss, and rate of conversion to the open procedure did not differ between the 2 groups. The rate of successful spleen preservation was significantly improved following the splenic vessel preservation technique (96.4% vs 84.7%; $P=.03$). Complications related to the spleen only occurred in the Warshaw technique group (0% vs 10.5%; $P=.03$), requiring a splenectomy in 4 patients (4.7%). The mean length of stay was shorter in the splenic vessel preservation group (8.2 vs 10.5 days; $P=.01$).

Conclusions: The short-term benefits associated with the preservation of the splenic vessels should lead to an increased preference for this technique in selected patients undergoing laparoscopic spleen-preserving distal pancreatectomy for benign or low-grade malignant tumors in the body/tail of the pancreas.

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Over the last 2 decades, laparoscopic pancreatic surgery has become increasingly popular owing to improvements in surgical skills and research regarding minimally invasive procedures. Distal pancreatectomy is the most commonly reported laparoscopic pancreatic procedure in the literature and is generally considered to be safe and practical.[1-7]

Spleen conservation during laparoscopic distal pancreatectomy remains controversial based on the indications of pancreatic resections.[8] However, in patients with benign or low-grade malignant tumors in the body/tail of the pancreas, conservation of the spleen eliminates the risk for overwhelming postsplenectomy sepsis and other complications related to a splenectomy.[9-11]

Two surgical techniques are available to preserve the spleen. First, Warshaw[12] described a technique in which splenic vessels are ligated with the preservation of the short gastric and left gastroepiploic vessels. Second, the operation can also be performed by sparing the splenic vessels, which assures increased blood supply to the spleen.[13]

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Neither one of these techniques is favored over the other, and the reasons for selection remain unclear. Ligation of the splenic vessels is known to have potential risks including postoperative infarction of the spleen and the need for a reoperation.[14,15] To our knowledge, only a

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few studies with a small number of patients have compared both laparoscopic techniques.

The objective of this study was to compare splenic vessel preservation (SVP) with the Warshaw technique (WT) in the surgical management of patients undergoing laparoscopic spleen-preserving distal pancreatectomy (LSPDP).

METHODS

STUDY DESIGN

A retrospective analysis of prospectively maintained databases from 2 academic medical centers was performed. Data from patients undergoing LSPDP for benign or low-grade malignant tumors in the body/tail of the pancreas between January 1997 and January 2011 were included. Patients with suspected malignant tumors or planned preoperative splenopancreatectomies were excluded. Patients were divided into 2 groups. In the SVP group, SVP was performed on an intention-to-treat basis. In the WT group, division of the splenic vessels was performed on an intention-to-treat basis.

Both medical centers (University of Bordeaux Segalen and University of Barcelona) provided specified preoperative, operative, and postoperative data parameters using a common menu-driven database file. Informed consent was obtained from each patient, and the study was approved by the local ethics committee.

OPERATIVE TECHNIQUE

Patient selection, choice of procedure, technical operative course, and use of surgical equipment were independently determined by each surgeon based on the patients' preoperative findings and surgical experience. Both approaches were performed in the 2 centers throughout the study. The protocols for all of the surgical procedures were notably similar between the institutions, as described in previous publications.[16,17]

In general, the patient is positioned supine with the legs apart and arms tucked beside the body. The surgeon stands between the patient's legs, with an assistant on the patient's left side and a scrub nurse on the right side. A video monitor is placed to the left of the patient's head. The procedure requires 4 trocars. A 10-mm port is placed at the umbilicus for the 30° telescope, a second 10-mm port is located along the left costal margin with a 5-mm right subcostal port and a 5-mm subxiphoid epigastric port. The table is placed in a reverse Trendelenburg position to facilitate displacement of the transverse colon and small bowel from the operative field. The lesser sac is opened by the lysis of the avascular plane between the transverse colon and the greater omentum to expose the isthmus, body, and tail of the pancreas. The posterior aspect of the stomach is grasped and elevated with a fenestrated grasper introduced through the subxiphoid port to enable exploration of the entire left side of the pancreas. Localization of the tumor and delineation of its extent is performed using intraoperative ultrasonography. The inferior border of the pancreas is dissected at the level of the isthmus. After identification of the mesentericoportal venous axis, the avascular plane between the posterior aspect of the isthmus and the anterior wall of the portal vein is dissected. After the upper edge of the pancreas has been freed, the anterior wall of the portal vein lies within the triangle formed by the common hepatic artery above, the gastroduodenal artery to the right, and the upper edge of the pancreas below. The retro-isthmic tunnel is completely dissected, and the pancreatic isthmus is encircled and retracted with tape. The isolated isthmus is divided using a cutting linear stapler or ultrasonic scissors (harmonic scalpel) to identify and ligate the Wirsung duct separately.

The splenic artery and vein are isolated at their origins and encircled with tape.

Left Pancreatectomy With Preservation of the Splenic Vessels

The splenic vein and splenic artery are progressively dissected and freed from the tail of the pancreas from right to left. Small venous branches supplying the pancreas must be clipped and divided with ultrasonic scissors. Arterial branches are also clipped and divided (Video 1, http://www.jamasurg.com).

Left Pancreatectomy With Sacrifice of the Splenic Vessels

After the splenic artery has been clipped and divided, the inferior border of the pancreas is freed from the transverse mesocolon all the way to the tip of the pancreatic tail. The tail of the pancreas is dissected and freed from the splenic hilum. The splenic artery and vein appear above the upper edge of the pancreas at the junction of the body and tail. The short gastric vessels must be identified such that the splenic vessels can be divided immediately before the first short gastric branches (Video 2). At this stage, the vascularization of the spleen depends entirely on the short gastric vessels. The tail and body of the pancreas can now be easily freed from their posterior attachments. The pancreas is reflected to the right on its splenic vein pedicle, which is subsequently divided between ligatures or clips. Dividing the splenic vein as the final step avoids venous hypertension in the resected pancreas, although it is possible to divide the splenic vein at an earlier stage after division of the isthmus and the splenic artery.

The specimen is placed in a sack and removed from the abdomen, which may require enlargement of the left subcostal trocar site with a transverse incision. A suction drain remains in the pancreatic bed.

OUTCOME MEASURES

Clinicopathologic characteristics and operative and postoperative outcomes were examined. Tumor size and pathologic diagnoses were obtained from the final histologic report. The type of procedure was defined on an intention-to-treat basis. Blood loss and operative times were obtained from the patient record. The need for an open conversion and the occurrence of intraoperative complications were also reported.

Morbidity was defined as a complication occurring within 30 days after surgery or during the hospital stay. Complications were graded using Dindo classification.[18] A pancreatic fistula (PF) was defined as an amylase concentration—as measured in the fluid collected at days 3 and 5 after a drain was placed intraoperatively—that was more than 3 times greater than the serum concentration. Pancreatic fistulas were classified according to the clinical impact on the patient's course (grade A, B, or C) using the definition from the International Study Group of Pancreatic Fistula.[19]

Postoperative management differed between the 2 academic medical centers. One institution performed color Doppler ultrasonography on all patients during the postoperative period. The second institution conducted diagnostic imaging (color Doppler ultrasonography and/or computed tomography) when patients were suspected of developing medical or surgical complications.

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Table 1. Patient Population

Variable	Mean (SD)			
	SVP (n = 55)	WT (n = 85)	LSPDP (n = 140)	SVP vs WT, *P* Value
Age, y	52.9 (12.2)	56.9 (13.1)	55.3 (12.9)	.07
Female, No. (%)	44 (80)	75 (88)	119 (85)	.18
ASA score	2.1 (0.7)	1.9 (0.7)	2.0 (0.7)	.30
BMI	25.1 (4.6)	24.9 (5.1)	24.9 (4.9)	.82
Tumor size, mm	33.6 (19.7)	42.5 (29.9)	39.0 (26.8)	<.001[a]
Final histologic diagnosis, No. (%)				
Cystic neoplasm	18 (32.7)	35 (41.2)	53 (37.9)	.37
Neuroendocrine tumor	21 (38.2)	23 (27.0)	44 (31.4)	.19
Solid pseudopapillary neoplasm	5 (9.1)	2 (2.3)	7 (5.0)	.11
Intraductal papillary mucinous neoplasm	2 (3.6)	20 (23.5)	22 (15.7)	<.001[a]
Inflammatory neoplasm	8 (14.5)	0	8 (5.7)	<.001[a]
Intraductal adenocarcinoma	1 (1.8)	0	1 (0.7)	.39
Other	0	5 (5.9)	5 (3.6)	.16

Abbreviations: ASA, American Society of Anesthesiology; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); LSPDP, laparoscopic spleen-preserving distal pancreatectomy; SVP, splenic vessel preservation; WT, Warshaw technique.
[a] Statistically significant.

Table 2. Intention-to-Treat Analysis of Intraoperative Outcomes

Variable	No. (%)			
	SVP (n = 55)	WT (n = 85)	LSPDP (n = 140)	SVP vs WT, *P* Value
Operative time, mean (SD), min	214.7 (66.7)	199.2 (46.7)		.11
Blood loss, mean (SD), mL	342.8 (223.5)	288.9 (172.6)		.11
Conversion to laparotomy	5 (9)	11 (13)	16 (11)	.48
Success of spleen preservation	53 (96.4)	72 (84.7)	125 (89.3)	.03[a]
Conversion to WT	12 (21.8)			

Abbreviations: LSPDP, laparoscopic spleen-preserving distal pancreatectomy; SVP, splenic vessel preservation; WT, Warshaw technique.
[a] Statistically significant.

STATISTICAL ANALYSES

Continuous data were expressed as means and standard deviations. Categorical variables were analyzed with the chi-squared test or Fisher exact test, and continuous variables were analyzed with the *t* test. Two-tailed $P < .05$ was considered statistically significant.

All statistical analyses were performed using GraphPad Prism version 4 for Macintosh (GraphPad Software).

RESULTS

From January 1997 through January 2011, 140 LSPDPs were performed (University of Bordeaux Segalen, n = 64; University of Barcelona, n = 76).

Fifty-five patients (University of Bordeaux Segalen, n = 25; University of Barcelona, n = 30) underwent LSPDP on an intention-to-treat basis with SVP. Eighty-five patients (University of Bordeaux Segalen, n = 39; University of Barcelona, n = 46) underwent LSPDP with WT.

CLINICOPATHOLOGIC CHARACTERISTICS

The clinical and pathologic characteristics of all the patients are shown in **Table 1**.

No statistical differences were found between the SVP and WT groups regarding patient age, sex, body mass index (calculated as weight in kilograms divided by height in meters squared), and American Society of Anesthesiology score. However, the mean (SD) tumor size was significantly higher in the WT group (33.6 [19.7] mm vs 42.5 [29.9] mm; $P < .001$).

Of the 140 LSPDPs performed, the most common diagnoses were cystic neoplasms in 53 patients (37.9%) and neuroendocrine neoplasms in 44 patients (31.4%), followed by intraductal papillary mucinous neoplasms in 22 patients (15.7%). One patient in the SVP group had an in situ intraductal adenocarcinoma. Other histologic diagnoses in the WT group were epithelial cysts (n = 2), an intrapancreatic spleen (n = 1), nesidioblastosis (n = 1), and intraductal dystrophy (n = 1).

OPERATIVE OUTCOMES

Between the SVP and WT groups, the mean (SD) operative time (214.7 [66.7] minutes vs 199.2 [46.7] minutes; $P = .11$) and mean (SD) blood loss (342.8 [223.5 mL vs 288.9 [172.6] mL; $P = .11$) did not differ (**Table 2**). The rates of conversion to laparotomy were also similar (9% vs 13%; $P = .48$).

Splenic preservation represented 89.3% of all the LSPDPs. The success rate of spleen preservation was significantly higher with the SVP procedure (96.4% vs 84.7%;

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Table 3. Intention-to-Treat Analysis of Postoperative Outcomes Related to Mortality and Morbidity

Variable	No. (%) SVP (n = 55)	WT (n = 85)	LSPDP (n = 140)	SVP vs WT, *P* Value
Mortality	0	0	0	
Patients with ≥1 complications				
Overall complications	15 (27.3)	33 (38.8)	48 (34.3)	.16
Minor complications (Dindo grades I-II)	11 (20.0)	27 (31.7)	38 (27.1)	.17
Major complications (Dindo grades III-IV)	4 (7.3)	6 (7.1)	10 (7.1)	
Pancreatic fistula				
Overall	9 (16.3)	22 (25.9)	31 (22.1)	.18
Grade				
A	7 (12.7)	16 (18.8)	23 (16.4)	.34
B	2 (3.6)	4 (4.7)	6 (4.2)	
C	0	2 (2.3)	2 (1.4)	
Spleen-related complications	0	9 (10.5)		.03[a]
Reoperation	3 (5.4)	5 (5.9)	8 (5.7)	>.99
Length of hospital stay, mean (SD), d	8.2 (3.1)	10.5 (6.6)		.01[a]

Abbreviations: LSPDP, laparoscopic spleen-preserving distal pancreatectomy; SVP, splenic vessel preservation; WT, Warshaw technique.
[a] Statistically significant.

P = .03). The splenic vessels could be preserved in 41 patients (75%). Two patients (3.6%) required splenectomy for splenic decapsulation (n = 1) and adhesions (n = 1), and 12 patients (21.8%) required conversion to WT owing to splenic vessel injuries (n = 8) and adhesions of the tumor to the splenic vessels (n = 4). In the WT group, the reasons for splenectomy included splenic infarction (n = 4), bleeding (n = 3), adhesions (n = 3), tumor located close to the splenic hilum (n = 2), and tumor with an unknown location (n = 1). The occurrence of intraoperative complications requiring splenectomy (bleeding and splenic infarction) did not differ between both groups (2% vs 8%; *P* = .15).

POSTOPERATIVE OUTCOMES

A summary of the morbimortality data of the cohort is shown in **Table 3**. No deaths were recorded during the 30-day period after surgery. The overall morbidity rate related to all of the LSPDP procedures was 34.3%, and the rate of PF was 22.1%.

Postoperative complications occurred in 15 patients (27.3%) in the SVP group and 33 patients (38.8%) in the WT group (*P* = .16). The rate of minor and major complications did not differ between the groups (*P* = .17).

The rate of PF was similar between the SVP and WT groups (16.3% vs 25.9%; *P* = .18).

Spleen-related complications occurred only in the WT group. Nine patients (10.5%) presented with symptomatic postoperative splenic infarction in the WT group compared with none of the patients in the SVP group (*P* = .03). Of the 9 patients who presented with symptoms such as fever, abdominal pain, and/or abscess, 4 (4.7%) required a splenectomy. In the institution that performed systematic postoperative imaging examinations, 7 asymptomatic patients were diagnosed and treated conservatively.

Three patients from the SVP group required a reoperation owing to a small bowel perforation on day 1, bleeding of an inferior pancreatic artery on day 2, and perforated duodenal ulcer on day 4 after surgery. Five patients from the WT group required reoperation. A splenectomy was performed owing to splenic infarction in 3 patients on day 7 and in 1 patient on day 45. One patient required a reoperation 10 days after surgery because of hemorrhagic shock owing to a grade C PF.

The mean (SD) hospital stay was statistically shorter for patients who underwent LSPDP with SVP (8.2 [3.1] days vs 10.5 [6.6] days; *P* = .01).

Based on a nonintention-to-treat analysis of actual procedures performed, the postoperative complications were also compared between the 41 patients treated with SVP and the 84 patients treated with WT (**Table 4**). The overall morbidity rate (24.4% vs 38.1%; *P* = .16), the rate of PF (14.6% vs 25%; *P* = .25), and the rate of reoperation (7.3% vs 5.9%; *P* = .72) were similar. This analysis confirmed that patients treated with WT had more spleen-related complications (0% vs 10.7%; *P* = .03) and an increased length of hospital stay (7.9 [2.8] days vs 10 [6.4] days; *P* < .05).

COMMENT

The purpose of this study was to compare the short-term outcomes between the preservation and the division of the splenic vessels during LSPDP in patients with benign or low-grade malignant tumors in the body/tail of the pancreas. This study represents one of the largest series of distal pancreatectomies with splenic conservation performed using a laparoscopic approach and, to our knowledge, the first study to compare the division procedure with the preservation of the splenic vessels using an intention-to-treat analysis and with a significant number of patients.

Data related to this laparoscopic procedure and conservation of the spleen are scarce. Our results from 140 LSPDPs confirm the feasibility, safety, and efficiency previously described in the literature.[17,20-24] The overall rates of morbidity and PF (34.3% and 22.1%, respectively), as

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Table 4. Postoperative Outcomes of Procedures Performed Related to Mortality and Morbidity

Variable	No. (%) SVP (n = 41)	WT (n = 84)	DSP (n = 15)	SVP vs WT, *P* Value
Mortality	0	0	0	
Patients with ≥1 complications				
Overall complications	10 (24.4)	32 (38.1)	6 (40.0)	.16
Minor complications (Dindo grades I-II)	7 (17.1)	26 (31.0)	5 (33.3)	
Major complications (Dindo grades III-IV)	3 (7.3)	6 (7.1)	1 (6.7)	
Pancreatic fistula				
Overall	6 (14.6)	21 (25.0)	4 (26.7)	.25
Grade				
A	4 (9.7)	16 (19.0)	3 (20.0)	
B	2 (4.9)	3 (3.6)	1 (6.7)	
C	0	2 (2.4)	0	
Spleen-related complications	0	9 (10.7)		.03[a]
Reoperation	3 (7.3)	5 (5.9)	0	.72
Length of hospital stay, mean (SD), d	7.9 (2.8)	10 (6.4)		<.05[a]

Abbreviations: DSP, distal splenopancreatectomy; SVP, splenic vessel preservation; WT, Warshaw technique.
[a] Statistically significant.

Table 5. Outcomes of LSPDP

Source, y	No. LSPDP	Spleen-Preserving Procedure	% Spleen Salvage[a]	Morbidity	Pancreatic Fistula	Splenic Infarction	Hospital Stay, d[b]
Fernández-Cruz et al,[17] 2004	19	11 SVPs	91	27	18	0	5.5
		8 WTs	100	37	12	17	5.6
Melotti et al,[2] 2007	32	27 SVPs				0	
		5 WTs				20	
Beane et al,[26] 2011	86[c]	45 SVPs		18	2	5	4.5
		41 WTs		38	12	39	6.3
Song et al,[7] 2011	178	150 SVPs				0	
		28 WTs				46	
Butturini et al,[27] 2012	43	36 SVPs		58	29	3	7 (6-22)
		7 WTs		43	36	14	8 (5-24)
Choi et al,[28] 2012	40[c]	29 SVPs	69	25	25	0	7.1 (2.3)
		11 WTs					
Current study	140	55 SVPs	96	27	16	0	8.2 (3.1)
		85 WTs	85	39	26	11	10.5 (6.6)

Abbreviations: LSPDP, laparoscopic spleen-preserving distal pancreatectomy; SVP, splenic vessel preservation; WT, Warshaw technique.
[a] Results based on an intention-to-treat splenic conservation.
[b] Results expressed as the mean (SD) or median (range).
[c] Some procedures were performed robotically.

well as the rate of conversion to laparotomy (11.4%) were similar to the rates described for laparoscopic distal pancreatectomy.

In patients with nonmalignant lesions in the body/tail of the pancreas, the preservation of the spleen is preferable for avoiding long-term complications related to a splenectomy,[9-11] and several studies have reported the benefits of LSPDP compared with laparoscopic distal pancreatectomy in terms of intraoperative outcomes, postoperative collections and infections, and length of hospital stays.[20,25]

Between both techniques available to preserve the spleen, WT was reported to be faster and easier,[3,17,20] but few studies are available in the literature to determine which technique is the most preferable for LSPDP (**Table 5**). Most of these studies included a small number of patients, described results from both open and laparoscopic approaches, and only reported outcomes from procedures that actually succeeded in preserving the spleen. To our knowledge, our study is the largest to compare WT with laparoscopic SVP with respect to the intention-to-treat principle.

Based on our study, both techniques were similar regarding the rates of overall morbidity, PF, and reoperation. Blood loss and operative times were also similar contrary to what has been previously reported.[17]

The rate of spleen conservation was significantly higher in patients who underwent the intention-to-treat SVP. Preservation of the splenic vessels was successful in 75% of the cases. In 22% of cases, splenic vessel injuries or difficulties during the dissection required a conversion to WT. This procedure is technically challenging and may

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not be possible if the tumor is located close to the splenic hilum, the vessels are embedded in the pancreatic gland, or local inflammation is present. However, failing to spare the splenic vessels does not necessarily compromise the conservation of the spleen. The spleen was able to be salvaged in a large proportion of patients by conversion to WT. Regarding the intraoperative complications that might have been attributable to surgical differences, the occurrence of bleeding or splenic infarction, requiring en-bloc splenectomy, did not differ between the 2 techniques.

Similarly to previous reports, spleen-related complications were recorded after undergoing WT (Table 5). The division of the splenic vessels represents a potential risk for splenic infarction when the blood supply to the spleen is not sufficiently recovered from the short gastric and left gastroepiploic vessels. With this procedure, 10.7% of our patients developed symptomatic splenic infarcts, which required reoperation for splenectomy in around half of these patients (4.7%). In a recent retrospective analysis with long-term follow-up on 158 patients who had undergone open spleen-preserving distal pancreatectomies using WT, the rate of reoperation for splenectomy owing to splenic infarction was 1.9%. Among the 65 patients with postoperative imaging, 23% had splenic infarcts and 25% had perigastric varices.[29] It is still unclear whether postoperative control of splenic perfusion must be performed in asymptomatic patients undergoing LSPDP with WT. The occurrence of perigastric varices owing to the excision of the splenic artery and vein with the potential risk for bleeding could represent an additional argument for delayed systematic postoperative imaging controls. Sinistral portal hypertension[30] has been reported in other publications that evaluated hemodynamic changes in splenogastric circulation after ligation of the splenic vessels.[31,32] Miura et al[31] reported a 70% rate of perigastric varices and a 20% rate of submucosal varices after WT, as well as 1 patient with gastrointestinal bleeding.

The length of hospital stay was significantly shorter in patients who underwent WT. This was already mentioned in a previous study[26] and could be partially explained by the occurrence of spleen-related complications associated with WT. Other complications, especially PFs, did not differ between the techniques. Furthermore, patients with splenic infarcts sometimes required a readmission and reoperation for splenectomy, which increased the overall length of hospital stay and affected the cost-effectiveness of the procedure.

Regarding the adverse events related to division, preservation of the splenic vessels appears to be the preferable technique. Both techniques are comparable in terms of intraoperative and postoperative morbidity, but the SVP procedure provided the best chance to conserve the spleen. We think that this procedure should be attempted when possible and switched to WT in cases of accidental bleeding or difficulties during dissection.

Biases cannot be excluded based on the retrospective nature of this study. The mean tumor size was significantly higher in patients who underwent sacrifice of the splenic vessels, which suggests that preservation of the vessels might have been more technically challenging in these cases. Prospective studies are necessary to confirm and validate these results through long-term follow-up.

In conclusion, this large, bicentric retrospective study confirms that LSPDP is safe, feasible, and efficient. The comparison of both techniques for spleen conservation showed that the preservation of the splenic vessels was associated with an improved rate of spleen conservation and a reduced hospital stay without increased morbidity. The spleen-related complications related to WT should lead to a surgical preference for the laparoscopic spleen and splenic vessel-preserving distal pancreatectomy in selected patients with benign or low-grade malignant tumors in the body/tail of the pancreas.

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Online-Only Material: The videos are available at http://www.jamasurg.com.

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