Published in final edited form as:
Surgery. 2007 May ; 141(5): 619–625. doi:10.1016/j.surg.2006.09.020.

Distal pancreatectomy with splenic preservation revisited

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Abstract

Background—Splenic preservation (SP) during distal pancreatectomy can be accomplished by ligating the main splenic artery and vein relying on blood supply from the short gastric vessels. The purpose of this study was to examine the short-term implications of this operation, comparing it to the outcomes following distal pancreatectomy with splenectomy.

Methods—The records of 259 patients who underwent distal pancreatectomy with and without SP at Massachusetts General Hospital from 1994 to 2004 were reviewed.

Results—A total of 29% of patients underwent SP with this technique. These patients were more likely to be women (74% vs 56%, **P** = *.008) and to have benign disease (93% vs 54%*, **P** < .0001). Their operative times were shorter (2.5 vs 3.1 h, **P** < *.0001), they had less blood loss (300 vs 500 ml*, **P** < .0001) and a shorter duration of stay (6 days [interquartile range, 5 to 7] vs 7 days [interquartile range, 5 to 8], **P** = .001). SP was not a significant predictor of complications in either univariate (**P** = *.445) or adjusted analysis (***P** = .543). One patient (1.4%) in the SP group was reoperated for splenic infarction and two patients (1.1%) in the splenectomy group for abscess and hemorrhage. There were 2 (0.8%) postoperative deaths, both in the splenectomy group.

Conclusions—Splenic preservation relying on blood supply from the short gastric vessels is reliable and safe and does not have a higher incidence of postoperative complications when compared to traditional distal pancreatectomy with splenectomy. The current series validates this approach and provides further evidence of its feasibility and safety.

In 1988, Andrew L. Warshaw[1] described an alternative approach to splenic preservation during distal pancreatectomy, which involved ligating the main splenic artery and vein, relying on blood supply from the short gastric vessels for perfusion. Since then, this has been the technique of choice at Massachusetts General Hospital (MGH) for patients with benign tumors in the body or tail of the pancreas with favorable anatomic relationships to the spleen, vessels, and surrounding structures.

The short-term implications of this operation have not been examined in depth. The purpose of this study is to describe a large single institutional experience with this surgical technique and, specifically, to determine whether distal pancreatectomy with splenic preservation (SP) relying on perfusion from the short gastric vessels results in a higher rate of postoperative morbidity compared with traditional distal pancreatectomy with splenectomy (DPS).

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Presented at the 66th Annual Meeting of the Society of University Surgeons, San Diego, California, February 7-11, 2006.

PATIENTS AND METHODS

A total of 259 patients who underwent distal pancreatectomy from January 1, 1994 through August 31, 2004 at MGH were identified from a prospectively entered pancreatic surgery database. During that time period, 74 of the 259 patients underwent SP (29%). Comparisons were made between these patients and those who underwent DPS. The patients' postoperative clinical courses were reviewed and detailed retrospectively through computer, hospital, and clinic records to include 30 postoperative days. This study was approved by the MGH Institutional Review Board.

Definitions

Baseline data were collected, including age, sex, body mass index (BMI, kg/m^2), history of cardiac disease (defined as previous myocardial infarction, stent placement, or coronary artery bypass grafting), history of chronic obstructive pulmonary disease (COPD), history of chronic renal insufficiency (defined as creatinine ≥2.0 mg/dL), history of preoperative diabetes mellitus (defined as current use of oral hypoglycemic agents or insulin), documented history of prior pancreatitis, and history of previous pancreatic surgery. Operative data including operative time, estimated blood loss (as recorded in the anesthesia record), performance of splenectomy (our primary predictor of interest), performance of additional procedures, final diagnosis, and presence of locally invasive disease on pathologic analysis of the specimen.

The primary outcome of interest was the presence or absence of any perioperative complication. Perioperative complications were defined as any medical adverse event occurring within 30 days of the surgical procedure. Because complications after distal pancreatectomy are largely due to those resulting from pancreatic leakage (PL) from the stump,[2-5] complications were further subdivided into those that were identified as PL-related and those that were not. Complications identified as being related to PL were categorized using previously published criteria.[5] In brief, these complications included: (1) *pancreatic fistula*, defined as daily output of at least 30 ml of amylase-rich fluid (3 times the serum concentration) from the surgically placed drain after postoperative day 5; (2) *sterile collection*, defined as a 3 × 3-cm or greater accumulation of fluid identified radiologically and prompting interventional radiology drainage yielding amylase-rich fluid; (3) *abscess*, defined as a collection of fluid that upon aspiration and culture grew bacteria (although amylase concentration was not measured in all of these, they were considered to be a result of PL); (4) *wound disruption*, considered an indirect complication of a PL when ongoing drainage of thick fluid through the incision was present, and the patient had a documented pancreatic fistula, collection, or abscess. Other complications not related to PL that met universally accepted definitions also were recorded. These complications included ileus, delirium, urinary tract infection, pneumonia, atelectasis, pulmonary embolus, and myocardial infarction.

Operative technique

Splenic preservation using the technique of ligation of the splenic artery and vein relying on collateral circulation from the short gastric vessels was performed for benign tumors and when technically feasible in the absence of locally advanced disease or splenomegaly. This technique has been described in detail elsewhere.[1] In brief, the lesser sac is entered through the gastrocolic omentum outside the gastroepiploic arcade while carefully sparing the short gastric arteries and veins and, when possible, the communicating vessel between the splenic hilum and the left gastroepiploic artery. It is important to assess whether splenic size is greater than normal and to recognize vascular anatomic variations, such as a paucity of short gastric vessels. These assessments are done by computed tomography (CT) and

intraoperative assessment. Surgical judgment also must be applied as to whether the spleen will survive. If either of these conditions is present, splenic preservation using splenic artery and vein ligation should not be attempted. The pancreas is then mobilized by incising the retroperitoneum along the left inferior margin and opening the avascular plane behind it. Dissection is carried to the left, past the tip of the pancreas. The splenic artery and vein are ligated as close as possible to the pancreas to leave collaterals in the hilum untouched and at the point of pancreatic transection. The spleen is left undisturbed in its bed (Fig 1, *A* and *B*). The pancreas routinely is transected with electrocautery, the pancreatic duct is ligated if identified, and the stump closed with silk sutures. In fewer than 5% of cases, a TA-55 reticulating stapler (United States Surgical Corp, Norwalk, Conn) is used to divide the pancreas. A closed suction drain (Jackson-Pratt, Dublin, Ohio) is left in the vicinity of the pancreatic stump, and removed on postoperative day 4 or 5 (once the patient has resumed oral intake) if the output is <30 ml/day and/or the amylase is <3 times the normal serum concentration. There were no laparoscopic resections in this cohort.

Statistical methods

For comparisons between the SP and DPS groups with respect to baseline and surgical characteristics, the Fisher exact test and the Wilcoxon rank sum test were used. Median values of the continuous variables and interquartile ranges are presented. A P value ≤.05 was considered statistically significant. Univariate logistic regression was used to determine if there was an association between SP and postoperative complications and to examine other variables to assess their effects as potential confounders. Odds ratios with the appropriate confidence intervals for each of these factors were calculated. A multiple logistic regression was modeled, which included variables identified in the univariate analysis as potential confounders and variables identified a priori as related to the exposure and outcome. Other factors were added to the model if there was a 10% change in the odds ratio of the exposure.

RESULTS

Characteristics of patients who had SP and patients who underwent DPS are shown in Table 1. As expected, patients selected to undergo SP were more likely to have benign disease as an indication (93% vs 54%, $P < .0001$) and to be women (74% vs 56%, $P < .008$). The SP and DPS groups were otherwise similar in regard to their clinical characteristics. Table II depicts the indications for surgery in the entire cohort.

Table III compares operative factors and postoperative morbidity between the groups. Patients who underwent SP had shorter operative times (2.5 h vs 3.1 h, $P < .0001$), less blood loss (300 vs 500 ml, $P < .0001$) and a shorter duration of stay (6 days [interquartile range, 5 to 7] vs 7 days [interquartile range, 5 to 8], $P = .001$). They also were less likely to undergo additional procedures and to have locally advanced disease.

No significant differences between the SP and DPS groups were found for pancreatic leak-related complications (36% vs 33%, $P = .668$) or for other complications not related to PL (18% vs 25%, $P = .191$). Table IV describes the breakdown of the PL-specific complications between groups. As expected, significant overlap existed between patients that experienced PL-related complications, with many of the pancreatic leaks manifesting as combinations of fistula, collection, abscess, and/or wound disruption.

SP was not identified as a significant predictor of postoperative complications on univariate analysis (Table V). The odds ratio of having a complication comparing splenectomy to splenic preservation was 1.23 ($P = .445$). The odds of having a complication were slightly higher in the splenectomy group, but this result was not significant. To gain further insight into other factors that might be related to postoperative complications, other variables were

assessed as potential predictors or confounders. Male sex was identified as being significantly associated with the occurrence of a postoperative complication ($P = .011$). Additional procedures ($P = .006$), operative time ($P = .001$), locally advanced disease ($P = .031$), and blood loss ($P < .001$) also were significant predictors of a postoperative complication on univariate analysis. A history of pancreatitis did not reach statistical significance ($P = .08$).

Multiple logistic regression models were used to control for potential confounders. BMI and a history of pancreatitis were included in all models because previous reports have identified them as being factors related to PL.[6,7] Sex also was included in all models based on results from Tables 1 and III. Operative time, blood loss, locally advanced disease, and additional procedures also were included in different combinations in the models because these factors were considered indirect measures of a more difficult operation, a principal confounder that cannot be directly measured. Operative time and blood loss were found to be significantly correlated ($P < .0001$), and so only 1 of these was included in the final model because of colinearity. The model that best fit the data with the above constraints is shown in Table VI. No additional variables significantly improved the fit of the model. These results indicate that, on adjusted analysis, SP was again not identified as a predictor of morbidity ($P = .5$). The only significant preditors of morbidity in the multivariate model were increased blood loss (odds ratio, 1.62) and additional procedures (odds ratio, 1.9).

One patient (1.4%) in the SP group had to be reoperated for splenic infarction. Another patient was reexplored out of concern for infarction. On the fourth postoperative day, this patient developed left upper quadrant pain and a CT scan was interpreted as showing absence of perfusion. Upon exploration, the spleen was found to be normal. Two patients (1.1%) in the DPS group were reoperated for abscess and hemorrhage. Overall mortality was 0.8% (2 patients); both deaths occurred in the DPS group.

DISCUSSION

Friedrich Trendelenburg[8] is credited as the first surgeon to resect a solid tumor of the tail of the pancreas in 1882 at the University of Bonn, Germany. For decades, concomitant splenectomy was considered a necessity in distal pancreatectomy until splenic preservation was formally described by Mallet-Guy and Vachon in 1943.[9] These authors described a technique whereby the multiple small branches that connect the splenic vessels to the pancreas are individually dissected and ligated.[10] Since then, several authors have reported their experience with this operation with minimal mortality and acceptable morbidity.[11-14]

In a large series of distal pancreatectomy (n = 235) from Johns Hopkins, this traditional splenic preservation was possible in 16% of patients.[15] The authors of this study found no difference in operative time, blood loss, morbidity, or mortality between the 2 groups, but they did report an unexplained longer duration of stay in the SP group (15 vs 10 days, $P = .008$).[15]

In another large series of distal pancreatectomy (n = 125) from Memorial Sloan Kettering (which excluded patients with adenocarcinoma), 37% of patients had SP using the traditional technique.[14] The authors of this study demonstrated a lower incidence of what they considered severe complications in the SP group compared to the DPS group and concluded that, in their hands, SP using the traditional technique was the operation of choice for distal pancreatic disease other than adenocarcinoma.[14]

In this paper, we described the largest single-institution series of distal pancreatectomy. Further-more, we illustrated that SP relying on the short gastric vessels applied to 29% of patients, although associated with a small need for reexploration related to splenic infarct

(2.7%), did not have a higher incidence of postoperative complications when compared to DPS. We also found that patients who underwent SP with this technique had shorter operative times (2.5 h vs 3.1 h, $P < .0001$), less blood loss (300 vs 500 ml, $P < .0001$) and a shorter duration of stay (6 days [interquartile range, 5 to 7] vs 7 days [interquartile range, 5 to 8], $P = .001$).

The original report describing this technique for SP[1] included 1 patient who was reexplored for splenic infarction in a series of 22 patients. Consequently, radionuclide spleen scans were performed routinely in all patients undergoing SP at our institution. This practice has since been abandoned secondary to its low yield. We currently do not recommend routine imaging for these patients and rely only on close clinical follow-up. To avoid splenic infarction, it is important to select patients without a large spleen. Perfusion from the short gastric vessels has proven to be inadequate to support more than the usual volume of parenchyma.[1] Consequently, the surgeon must also inspect the color of the spleen at the outset and again at the conclusion of the operation. The spleen will usually appear a darker gray than it was, but it will retain at least a burgundy red hue showing through, indicating sufficient perfusion. Sometimes a demarcated geographic area may clearly be differentially underperfused relative to the rest of the organ. If this is small (for example, only the lower pole), it has not proven to be a problem. If more than a third of the spleen appears to be underperfused, it is safer to resect it. Presence of acute inflammation is also a contraindication for this technique, because the patency of the short gastric vessels cannot be ascertained.

Caution also must be used when interpreting the results of postoperative imaging studies when this technique is performed. In the current series, 1 patient who underwent reexploration on postoperative day 4 in the SP group was incorrectly identified as having massive splenic infarction by CT. She was experiencing pain in the left upper quadrant, but intraoperative findings included a viable spleen that was left in situ. In retrospect, the apparent lack of splenic perfusion by CT was in reality an overreaction to hypoperfusion and a “delayed” arrival of the bolus of contrast via the short gastric vessels instead of the splenic artery. The second patient that was reexplored on postoperative day 3 for left upper quadrant pain and fever did have splenic infarction requiring splenectomy. It is important to note that reoperation rates were no different in the DPS group compared with the SP group (2.7% vs 1.1%, $P = .70$). The 2 reoperations in the DPS group were for abscess and hemorrhage.

The mortality in this series of distal pancreatectomy was 0.8%, but the overall complication rate remained high, particularly complications associated to PL. We sought to identify factors associated with development of postoperative complications and found that SP was not associated with a higher likelihood of developing complications by univariate and multivariate analysis. The only factors that were found to be significantly and independently associated with a higher complication rate were increased blood loss and additional procedures.

The benefits of SP are well documented. Asplenia confers a modest lifetime risk for developing overwhelming postsplenectomy infection (OPSI) of 1% to 5% in general populations, and OPSI is associated with a mortality of up to 50%.[16-21] In addition, concern for an increased risk of malignancy in later years also has been raised in patients undergoing elective splenectomy.[22] It is for this reason that we concur with others that splenic preservation should be carried out, when anatomically feasible, for benign lesions of the body and tail of the pancreas.[10,14]

It is important to reiterate that the present study focuses on the short-term outcomes of this operation, and there is only scant information on the long-term consequences of splenic

vessel ligation. Although splenic function and circulation after splenic vessel ligation have been well documented, the appearance of gastric and perigastric varices on subsequent imaging as the short gastric and gastroepiploic vessels accommodate to the increased blood flow is to be expected.[23-25] Miura et al,[25] in fact, reported the presence of perigastric varices seen on CT in 7 of 10 patients who underwent SP and a 20% frequency of submucosal varices. In our experience, upper gastrointestinal bleeding as a result of SP has not occurred. However, there has been a single case report of gastrointestinal bleeding from gastric varices occurring 6.5 years after middle segment pancreatectomy after SP with excision of the splenic artery and vein.[25]

The current series confirms that distal pancreatectomy with splenic preservation can be accomplished by ligating the splenic artery and vein, relying on the short gastric vessels for splenic perfusion in selected patients. When feasible, the technique is reliable and, as attested to by the shorter operative time and less blood loss, simpler. We propose that this technique provides an attractive alternative to the more tedious, traditional approach of ligating the branches between the splenic vessels and the pancreas. As laparoscopic distal pancreatic resections are becoming more commonplace, this simplified method of SP is being increasingly utilized.[26-31] The current series validates this approach and provides further evidence of its feasibility and safety.

Acknowledgments

Supported in part by the Claude E. Welch, MD, Resident Research Fellowship, Massachusetts General Hospital, Boston, Mass (J.R.R.)

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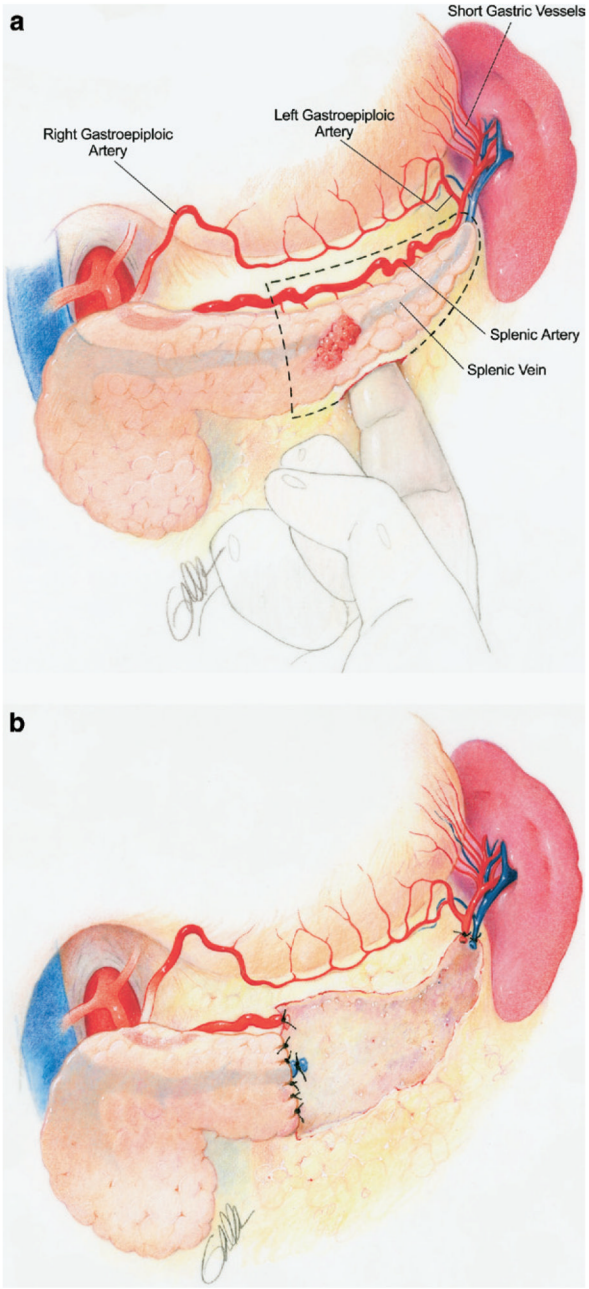

Figure.

a, Technique of mobilization of the left pancreas by incising the retroperitoneum along the pancreatic margins. **b**, The splenic vessels are then ligated as close as possible to the pancreas and also at the point of pancreatic transection. The collateral circulation to the spleen via short gastric vessels is preserved.

Table I

Characteristics of patients who underwent distal pancreatectomy with splenic conservation vs. traditional splenectomy

	SP *n = 74 (29%)*	*DPS* *n = 185 (71%)*	P *value*
Demographics			
Female	74%	56%	.008 †
Median age (y)	54.5 (IQR,pve 44-68)	58 (IQR, 47-70)	.30 *
Median BMI (kg/m^2)	25 (IQR, 22-30)	25 (IQR, 22-30)	.48 *
Clinical Hx			
Cardiac history	10.3%	11.6%	.83 †
COPD	1.3%	2.8%	.67 †
Chronic renal insufficiency	2.6%	3.9%	.73 †
Preoperative diabetes	9%	13.3%	.41 †
History of pancreatitis	19.2%	22.1%	.74 †
History of pancreatic surgery	10.3%	8.3%	.64 †
Benign disease	93.2%	53.5%	<.001 †

SP, Splenic preservation; *DPS*, distal pancreatectomy with splenectomy; *BMI*, body mass index; *IQR*, interquartile range; *COPD*, chronic obstructive pulmonary disease.

* Fisher exact test.

† Wilcoxon rank sum test.

Table II

Indications for distal pancreatectomy in 259 patients

Indication	*%*
Mucinous cystic neoplasm	20
Adenocarcinoma	17
Neuroendocrine tumor	17
Chronic pancreatitis	10
Serous cystadenoma	7
Pseudocyst	5
[†]Other	16

[†]Intraductal papillary mucinous neoplasm, sarcoma, metastatic cancer, acinar carcinoma, lymphoma, solid pseudopapillary tumor, dermoid tumor, simple cyst.

Table III

Operative factors and postoperative complications of patients who underwent distal pancreatectomy with splenic conservation vs traditional splenectomy

	***SP* *n* = 74 (29%)**	***DPS* *n* = 185 (71%)**	**P *value***
Median OR time (h)	2.5	3.1	<.001 *
Additional procedures	24.4%	39.7%	.02 †
Blood loss (ml)	300	500	<.001 *
Locally advanced	6.4%	32.6%	<.001 †
Median LOS (d)	6 (IQR, 5-7)	7 (IQR, 5-8)	.001 *
Pancreatic leak	36%	33%	.67 †
Fistula	27%	17%	.09 †
Collection	8%	9%	1.00 †
Abscess	8%	14%	.21 †
Wound disruption	8%	10%	.65 †
Other (complication not related to leak)	18%	25%	.20 †
Reoperation	2.7%	1.1%	.70 †
Mortality	0	1.1%	.90 †

SP, Splenic preservation; *DPS*, distal pancreatectomy with splenectomy; *OR*, operating room; *LOS*, length of stay; *IQR*, interquartile range.

* Fisher exact test.

† Wilcoxon rank sum test.

Table IV

Comparison of PL-related complications and other complications not related to PL between patients who underwent SP and patients who underwent traditional DPS

Complication	*SP(%)*	*DPS (%)*
Fistula	27	17
Collection	8	9
Abscess	8	14
Wound disruption	8	10
Other	18	25

PL, Pancreatic leakage; *SP*, splenic preservation; *DPS*, distal pancreatectomy with splenectomy.

All differences failed to reach statistical significance.

Table V

Univariate analysis between predictor and occurrence of any postoperative complication following distal pancreatectomy, These results are the odds of having a complication

Factor[*]	*Odds ratio (95% CI)*[†]
Operation performed	
Splenectomy	1.23 (0.721, 2.11)
Splenic preservation	1
Sex	
Male	**1.98 (1.17, 3.36)**
Female	**1**
History of pancreatitis	
Yes	1.76 (0.935, 3.33)
No	1
Additional procedures	
Yes	**2.15 (1.25, 3.71)**
No	**1**
Operative time (h)	**1.46 (1.18,1.82)**
Locally advanced disease	
Yes	**1.95 (1.06, 3.57)**
No	**1**
Blood loss (/1000)	**3.14 (1.72, 5.73)**

CI, Confidence interval.

Results shown are the odds of a patient experiencing a complication.

[*]Other variables including age, body mass index, cardiac history, chronic obstructive pulmonary disease, renal failure, preoperative diabetes, and history of pancreatic surgery did not reach statistical significance.

[†]Continuous predictors were not categorized, and so the odds ratios for these predictors correspond to a 1-unit increase in each predictor.

Table VI

Multiple logistic regression model of predictors of morbidity following distal pancreatectomy

Predictors	*Odds ratio (95% CI)*
Type of operation	
Splenectomy	0.814 (0.451, 1.47)
Splenic preservation	
BMI (kg/m^2)	1.01 (0.955, 1.06)
History of pancreatitis	
Yes	1.53 (0.767, 3.06)
No	
Sex	
Male	1.43 (0.796, 2.56)
Female	
Blood loss (/1000)	2.62 (1.39,4.95)
Additional procedures	
Yes	1.90 (1.05, 3.44)
No	

BMI, Body mass index.