

# Twenty-Three Years of the Warsaw Operation for Distal Pancreatectomy With Preservation of the Spleen

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**Objective:** To describe our series of distal pancreatectomies with preservation of the spleen utilizing the Warsaw operation with a focus on possible long-term complications due to the development of gastric varices.

**Background:** The Warsaw operation was first described in 1988. The splenic vessels are resected and the spleen survives via the short gastric and left gastroepiploic vessels.

**Methods:** Retrospective review of 721 patients who underwent a distal pancreatectomy between February 1986 and February 2009.

**Results:** The spleen was preserved via the Warsaw operation in 158 patients (22%). Median age was 55 years (range 10–85) and 72% were females. Pathologies included: 35 mucinous cystic neoplasms (adenoma 28, borderline 7), 22 intraductal papillary mucinous neoplasms (adenoma 9, borderline 9, cancer 4), 23 serous cystadenomas, 13 other pancreatic cysts, 27 pancreatic endocrine tumors, 16 chronic pancreatitis, 9 ductal adenocarcinomas, and 13 other pathologies. Only 3 (1.9%) patients required a reoperation because of splenic infarction at 3 to 100 days postoperatively because of abdominal pain and/or fever. Median follow-up was 2.7 years (mean 4.5 years, range 0–21 years). There was evidence of perigastric varices in 16 of 65 (25%) patients who had follow-up imaging at a median of 3.4 years, but none of the 158 patients developed gastrointestinal bleeding or hypersplenism.

**Conclusions:** Spleen preservation with the Warsaw operation has a low postoperative failure rate of 1.9%. Radiologic evidence of asymptomatic perigastric varices was identified in 25% of patients. There were no clinical consequences of perigastric varices in any patient during a follow-up period of up to 21 years.

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Traditionally a distal pancreatectomy has often included a splenectomy due to the anatomical proximity of the pancreatic tail to the hilum of the spleen and the close association of the splenic vessels with the pancreas (Fig. 1). The technique of spleen preservation based on conservation of the short gastric vessels and the left gastroepiploic vessels was first described by Warshaw in 1988<sup>1</sup> (Fig. 2). In his original publication the technique was successfully applied to 22 of 25 patients in whom it was attempted, with only 1 complication.

A previous report from our institution utilizing data from 74 patients who underwent spleen preservation via the Warsaw operation concluded that the surgical time, blood loss and hospital length of stay were all significantly shorter compared with patients who underwent distal pancreatectomy and splenectomy.<sup>2</sup> Several publications from other institutions have also verified that preservation of the spleen utilizing the Warsaw operation is associated with a shorter surgical

time, while being safe and effective.<sup>3–5</sup> This technique has also been used laparoscopically<sup>4,5</sup> and may be associated with shorter operative times and lower blood loss compared with laparoscopic preservation of the splenic vessels<sup>4</sup> (Fig. 3). Over the last decades many authors have reported the benefits of open or laparoscopic spleen-preserving distal pancreatectomy.<sup>4–8</sup>

This technique was developed not only because of the shorter operative time and decreased blood loss, but also due to the role of the spleen in the innate and adaptive immune system. The spleen represents the largest filter of blood for removing senescent red blood cells. It is an essential part of the lymphoid system for the defense against encapsulated bacteria. Splenectomized patients are well known to suffer from hematologic disorders, vulnerability to postsplenectomy sepsis, and immune deficiencies.<sup>9–12</sup>

In the Warsaw operation the splenic artery and vein are resected with the body and tail of the pancreas, and the spleen relies on the collateral vasculature via the short gastric and left gastroepiploic vessels to survive. The increased flow via these collaterals results in vascular dilation. This may lead to the development of gastric varices, which could become a source of hemorrhage. Our primary aim was to assess the long-term, clinically significant complications associated with the Warsaw operation. Our second aim was to review the imaging of patients who underwent abdominal contrast-enhanced computed tomography (CECT) scans during follow-up to assess the development of gastric varices and radiologic evidence of splenic infarcts. Our third aim was to assess the need for reoperation for postoperative splenic infarction.

## METHODS

### Study Design

This study was approved by the Institutional Review Board (IRB) of the Massachusetts General Hospital. Review of medical records between February 1986 and February 2009 was performed to identify patients who underwent a distal pancreatectomy. Patients who underwent an operation for nonpancreatic pathologies were excluded from further analysis. The operative reports were carefully examined to identify patients who underwent a distal pancreatectomy with splenic preservation with the Warsaw operation. Clinicopathologic data were collected including gender, age, race, presenting symptoms, radiologic imaging, and pathology. Operative mortality was defined as death within 30 days of the operation.

### Review of Imaging

Those patients who underwent a spleen-preserving distal pancreatectomy utilizing the Warsaw operation who had imaging performed at our institution after hospital discharge were identified. Their imaging studies were reviewed by a single GI radiologist (DVS). The clinical indication for imaging was recorded. Each radiologic study was reviewed to assess for the presence of splenic infarcts and/or vascular complications such as venous thrombosis or perigastric varices. When splenic infarcts were identified, their size relative to the size of the spleen was assessed and categorized into <10% of the splenic size, 10% to 20% of the splenic size and >20% of the splenic size.

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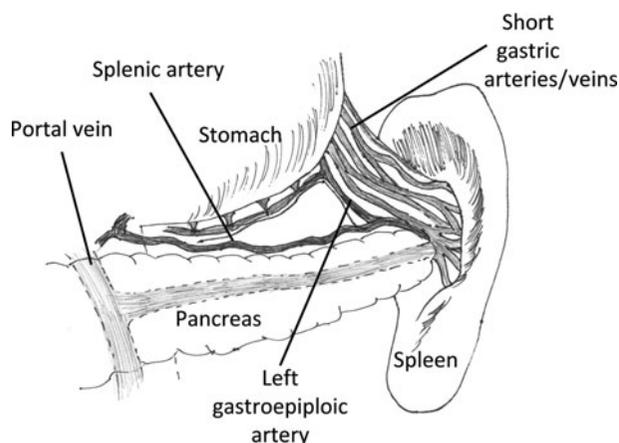


FIGURE 1. Vascular anatomy of the spleen.

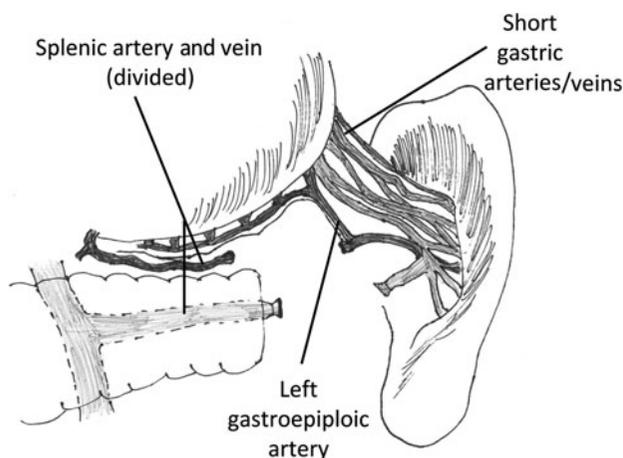


FIGURE 2. The Warsaw operation for distal pancreatectomy with preservation of the spleen on the basis of the short gastric vessels after resection of the splenic artery and vein.

Perigastric varices were defined as tortuous veins larger than 5 mm in diameter along the gastric wall.<sup>13</sup>

### Statistical Analysis

Statistical analysis of the data was done utilizing SPSS 12.0 for windows (Statistical Package for the Social Sciences, Inc., Chicago, IL). Continuous variables were dichotomized at their median values for the purpose of statistical analysis. Comparisons for continuous variables with normal distributions were conducted with the *t*-test and for continuous variables without normal distributions by the Mann-Whitney test or Kruskal-Wallis test. Categorical variables were analyzed using the  $\chi^2$  test. Level of statistical significance was set at  $P = 0.05$ .

## RESULTS

### Clinicopathologic Characteristics

The clinicopathologic data of 830 patients who underwent distal pancreatectomy at the Massachusetts General Hospital between February 1986 and February 2009 were reviewed. We excluded 109 patients who underwent a distal pancreatectomy for nonpancreatic

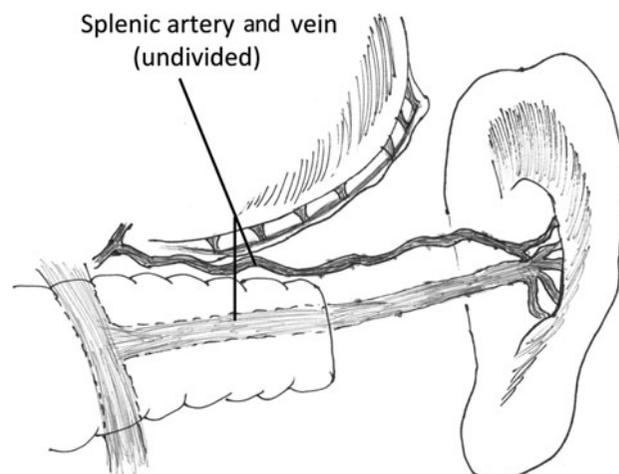


FIGURE 3. Distal pancreatectomy with preservation of the spleen on the basis of the splenic artery and vein.

pathologies because the Warsaw operation was only performed for pancreatic pathologies. Of the remaining 721 patients, 158 (22%) underwent a spleen preserving distal pancreatectomy utilizing the Warsaw operation. The median age of this cohort was 55 years (range 10–85 years), and 72% were females. There were no deaths within 30 days of the operation.

The main indications for which the Warsaw operation was utilized changed over time. In the initial report the majority of operations were performed for chronic pancreatitis (52%), while recently pancreatic cystic lesions have been the main indication (59%). Table 1 represents a comparison of the diagnoses reported in the original article to those for the whole cohort. Follow-up data were available for 125 patients (79%). Median and mean follow-up were 2.7 and

TABLE 1. Pathologies Over Time (Period 2/1986–2/2009)

Original Report	Entire Cohort
(n = 25)	(n = 158)
Chronic pancreatitis 13(52)	Chronic Pancreatitis 16(10)
Acute pancreatitis/necrosis 3(12)	Acute Pancreatitis/Necrosis 3(2)
Cystic neoplasms 4(16)	Cystic Neoplasms 93 (59)
	Mucinous Cystic Neoplasms 35 (22) (adenoma 28, borderline 7)
	Intraductal Papillary Mucinous Neoplasms 22 (14) (adenoma 9, borderline 9, cancer 4)
	Serous Cystadenomas 23 (15)
	Other Cysts 13 (8) (simple cysts 5, pseudocysts 5, enteric duplication cysts 2, solid pseudopapillary tumor 1)
Islet cell tumors 2(8)	Islet cell tumors 27(17)
Pancreatic Ductal adenocarcinoma 3(12)	Pancreatic Ductal adenocarcinoma 9(6)
	Other pathologies 10(6)

4.5 years, respectively (range 0–21 years). Forty-one patients have been followed for more than 5 years.

**Short-Term Outcomes**

Among the 158 patients, 3 (1.9%) required a reoperation due to splenic infarction. These patients presented between 3 and 100 days postoperatively with abdominal pain and/or fever. These 3 patients underwent a distal pancreatectomy with splenic preservation for mucinous cystadenoma (n = 2) and a neuroendocrine tumor. They had an open splenectomy at 3, 14, and 100 days, respectively. Pathologic examination demonstrated hemorrhagic infarction. One additional patient was explored because of left upper-quadrant abdominal pain 2 days after the pancreatectomy when imaging studies were interpreted as nonperfusion of the spleen. At exploration the patient was found to have a normal spleen; no splenectomy was performed. Most likely the apparent splenic hypoperfusion was the result of miscoordination of the imaging with the delayed arrival of contrast via the short gastric vessels. Although we previously noted that the perfusion by the short gastric vessels is likely to be inadequate to keep an enlarged spleen viable,<sup>1</sup> we could not identify any characteristic differences for the 3 patients who required splenectomy in this series when compared with the 155 patients whose spleen survived.

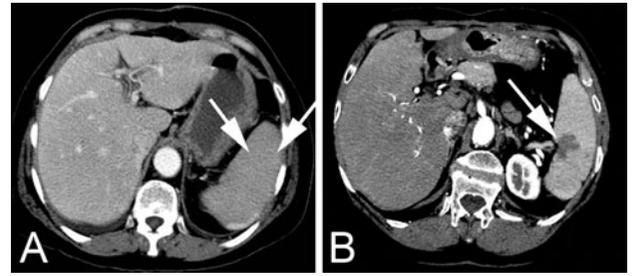
**Long-Term Outcomes**

Follow-up data were available for 125 of the 158 patients (79%). Sixty-five patients (41%) had postoperative CECT scans available for review. Imaging was performed at a median of 3.4 years (range 0.1–18 years). The most common indication for follow-up imaging was for surveillance of the primary pancreatic pathology. However, 28% of the patients had abdominal imaging for GI complaints, mainly abdominal pain (Table 2).

Of the patients who had postoperative imaging studies 23% (15/65) had splenic hypodensities consistent with hypoperfusion or infarcts (Table 3). Most of these areas of malperfusion occupied less than 10% of the spleen. However, hypoperfusion of more than 20% of the spleen did not preclude survival of the spleen (Fig. 4). On later imaging studies, dilated venous collaterals in the perigastric region were identified in 25% (16 of 65) of patients (Fig. 5). Thirteen patients had radiologic imaging at least 10 years postsplenic preservation, of whom only 3 had evidence of perigastric varices. No patient in the entire cohort of 158 developed evidence of gastrointestinal bleeding or hypersplenism. (Table 3)

**DISCUSSION**

The Warshaw operation represents a safe operation for both benign and malignant lesions of the pancreas with a low risk of short- and long-term failure. In a previous report from our institution we demonstrated that this technique compared favorably to distal pancreatectomy with splenectomy with respect to both the operative and postoperative course.<sup>2</sup> The risk of failure requiring reoperation in this series was 1.9%, comparable to other series utilizing the Warshaw



**FIGURE 4.** (A) Hypoperfusion of the spleen (white arrows) on a postoperative CECT after resection of a mucinous cystic neoplasm via the Warshaw operation. (B) CECT scan of the same patient 1 year after the operation. There is a small splenic infarct (white arrow).



**FIGURE 5.** Dilated venous collaterals (varices) in the perigastric region in a patient who underwent a distal pancreatectomy with spleen preservation with the Warshaw operation (white arrow).

operation (Table 4).<sup>3,14-16</sup> Review of postoperative imaging demonstrated evidence of areas of localized splenic malperfusion in 23% of patients. However, clinical signs and symptoms such as abdominal pain and fever were more important indicators of splenic infarction than imaging.

The splenic blood supply seems to recover quickly after the Warshaw operation through the enlargement of collaterals.<sup>8,17</sup> After resection of the splenic artery and vein, the spleen survives on increased blood flow through the short gastric and left gastroepiploic vessels. The increased flow via these collaterals may result in the enlargement of the veins (varices) along the gastric wall, which theoretically can pose a risk for gastric bleeding.<sup>15,16</sup> However, there has been only 1 case of bleeding gastric varices attributed to this method of splenic preservation, and in that case the operation was not a distal

**TABLE 2.** Reasons for Subsequent Abdominal Imaging in 65 Patients who Underwent Distal Pancreatectomy with the Warshaw Operation (range 0.1–18 years postpancreatectomy)

Reason for Abdominal Imaging	Number of Patients, n (%)
Routine follow-up for pancreatic disease	34 (52)
Assessment of abdominal symptoms	18 (28)
Imaging for another disease	13 (20)

**TABLE 3.** Findings on Follow-Up Imaging Studies

Findings	n = 65
Perigastric Varices	16 (25)
Splenic Infarct	15 (23)
<10%	6
10–20%	6
>20%	3

**TABLE 4.** Selected Studies Utilizing the Warsaw operation

Study	Number of Patients	Splenectomy Rate, n (%)
Carrere et al <sup>3</sup>	38	2 (5.2)
Fernandez-Cruz et al <sup>14</sup>	34	1 (2.9)
Miura et al <sup>15</sup>	10	0 (0)
Tien et al <sup>16</sup>	37	0 (0)
Current study	158	3 (1.9)

pancreatectomy but a middle pancreatectomy, leaving the additional vascular load of the distal pancreas on the collateral veins.<sup>18</sup> In our study, 125 patients were followed for up to 21 years with no bleeding from gastric varices. For the 65 patients in whom postoperative radiological imaging was available, only 25% developed demonstrable perigastric varices, and none of these patients developed clinical complications from their varices. Similarly Tien et al found that 30% of patients undergoing the Warsaw operation developed gastric varices on long-term follow-up (median 45 months) with no instances of bleeding.<sup>16</sup>

Preservation of the spleen during a distal pancreatectomy is worthwhile for a variety of reasons.<sup>19</sup> The spleen is a reservoir for monocytes which are key regulators of inflammation.<sup>20</sup> Postsplenectomy reactive thrombocytosis has been implicated as an etiologic factor in myocardial infarction.<sup>21</sup> Splenectomized patients are also at increased risk of malignancy.<sup>11</sup> The most well-known risk is overwhelming postsplenectomy sepsis. Although the risk of overwhelming postsplenectomy sepsis is low (0.18–0.42 cases/100 person years), it carries a mortality of up to 50%.<sup>9,12</sup>

Since the initial description of the Warsaw operation we have emphasized the importance of assessing the number and adequacy of the short gastric vessels, the preservation of the collateral communications in the splenic hilum, and the color and apparent preservation of the perfusion of the spleen upon completion of the operation. The spleen is often darker than normal, but it has a “burgundy” hue rather than a gray color, indicating adequate perfusion. Areas of clear demarcation will presage localized infarction, but that is tolerable if it is less than half the apparent surface. Use of a Doppler or other semi-objective techniques to access viability has not been as helpful as visual inspection. Although the number of short gastric vessels is variable, there is no minimum number of short gastrics required for splenic viability. This approach has been demonstrably effective; in that we are able to save the spleen in the great majority of cases in which we hope to do so, the need for splenectomy due to visibly inadequate perfusion has been on the order of about 10%.

We feel that splenic preservation should be considered in all patients undergoing a distal pancreatectomy for nonmalignant pathologies if they do not have an enlarged spleen. If cancer is the indication for distal pancreatectomy, splenic preservation may not be appropriate due to the potential oncologic advantage of removing the lymph nodes in the splenic hilum and along the splenic vessels.

Our series of 158 patients operated on over the course of 23 years demonstrates that the Warsaw operation carries minimal short-term morbidity, with only 1.9% of patients requiring a reoperation for a splenectomy. After a follow-up of up to 21 years no

clinically relevant long-term adverse events have been documented. Splenic preservation via the Warsaw operation is safe and effective.

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