Surgical Technique

Distal pancreatectomy with partial preservation of the spleen: a new surgical technique

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Abstract: Presently, spleen-preserving distal pancreatectomy is predominantly utilized for benign or low-grade malignant tumors of the pancreatic body and tail. The splenic blood vessel-preserving Kimura technique and non-splenic blood vessel-preserving Warshaw technique represent the two primary procedures. In prior reports, total splenectomy was most frequently performed when splenic blood vessels could not be preserved, and severe splenic congestion and ischemia were identified following the dissection of splenic blood vessels. This paper introduces a new method of spleen-preserving distal pancreatectomy, entailing a distal pancreatectomy with partial spleen preservation, illustrated through the presentation of two surgical cases. During physical examination, two patients were identified to have benign or low-grade malignant masses in the pancreatic tail. Preoperative examination indicated that the lesion was closely associated with the splenic blood vessels or splenic hilum. During surgery, neither the Kimura technique nor the Warshaw technique could be executed. After resecting the pancreatic body and tail, and a portion of the spleen, the superior pole of the spleen was successfully preserved by maintaining the short gastric blood vessels therein. This technical report demonstrates the viability of this novel spleen-preserving distal pancreatectomy, a distal pancreatectomy with partial spleen preservation, for benign and low-grade malignant pancreatic body and tail lesions. The innovative technique achieves partial spleen preservation by effectively preserving the short gastric blood vessels in the superior pole of the spleen.

Keywords: Distal pancreatectomy; laparoscopic surgery; organ preservation; Kimura technique; Warshaw technique

Submitted Aug 28, 2023. Accepted for publication Nov 02, 2023. Published online Nov 17, 2023.
doi: 10.21037/gs-23-355
View this article at: https://dx.doi.org/10.21037/gs-23-355

Introduction

Spleen-preserving distal pancreatectomy predominantly serves to resect benign or low-grade malignant tumors located in the pancreatic body and tail (1-6). Historically, the Kimura and Warshaw techniques have been predominantly employed in routine surgery. Kimura introduced a methodology in 1996 that entailed separating splenic vessels and the pancreas to conserve both the splenic artery and vein. Accordingly, splenic blood supply could be maintained while concurrently resecting lesions in the pancreatic body and tail. Although postoperative risk of splenic necrosis is minimized, the operational difficulty is elevated (7). Furthermore, potential splenic vessel injury during preservation might necessitate a transition to the Warshaw technique. Within the scope of the Warshaw technique, the splenic artery and vein are simultaneously dissected

during resection of the pancreatic body and tail. The short gastric artery, left gastroepiploic artery, and posterior gastric artery serve to sustain splenic blood supply, thereby achieving spleen preservation. Although this technique is less technically challenging, it significantly compromises the entire splenic blood supply. During surgery, splenic ischemia and necrosis may ensue, culminating in a failure to preserve the spleen. The postoperative risk of splenic necrosis and regional portal hypertension also increases, especially in patients with an enlarged spleen, thus escalating the risk of complications (8-13). A modified Warshaw technique that preserves the splenic artery while dissecting the splenic vein was introduced; however, this procedure may cause postoperative regional portal hypertension (14). In instances of pronounced splenic ischemia and congestion following dissection of the splenic artery and vein, total splenectomy was traditionally performed.

Past research has affirmed the safety and feasibility of partial splenectomy for treating splenic lesions (15-17). The gastroepiploic blood vessels, short gastric blood vessels, and posterior gastric blood vessels establish a crucial collateral circulation between the spleen and stomach. The nutrient vessels of the splenocolic ligament contribute to the blood supply of the inferior pole of the spleen, providing an anatomical foundation for partial spleen preservation (18). One publication asserted that spleen function could be maintained by preserving merely 5–10% of the spleen (19). Moreover, the residual spleen exhibited increased compensatory growth within the first postoperative year (20). Consequently, partial spleen preservation has the potential to reinstate normal spleen function. This article is presented in adherence to the SUPER reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-23-355/rc).

Highlight box

Surgical highlights

- This new technique might bring an end to the era of total splenectomy for benign or low-grade malignant tumors of the pancreatic body and tail following unsuccessful Kimura and Warshaw procedures.

What is conventional and what is novel/modified?

- Conventional approaches to benign or low-grade malignant tumors of the pancreatic body and tail primarily utilize two surgical methods: the Kimura and Warshaw procedures. However, when both of these procedures prove unsuccessful, the spleen frequently experiences irreversible ischemic and congestive changes, necessitating total splenectomy.
- This paper is the first to propose partial spleen-preserving distal pancreatectomy as a new surgical technique available to surgeons.

What is the implication, and what should change now?

- Further studies, particularly large multicenter studies, need to be conducted. It is anticipated that this new surgical technique will mature into a globally recognized, spleen-preserving distal pancreatectomy.

Preoperative preparations and requirements

We have proposed an innovative distal pancreatectomy technique with partial spleen preservation in response to the complications reported after spleen-preserving surgery for benign or low-grade tumors in the pancreatic body and tail. The clinical results have proven satisfactory. This innovative technique can be applied and considered in both open surgery and minimally invasive surgery. Moreover, this novel surgical procedure can be executed in both tertiary and secondary hospitals, provided they are equipped with fundamental laparoscopic surgical instruments and anesthesia monitoring devices. It can be accomplished in a level 2 standard clean operating room; the primary operator is positioned on the right side of the patient, with the assistant on the left and the laparoscopic camera holder stationed between the patient's legs. Both the primary operator and the assistant must undergo stringent training in laparoscopic surgery and possess experience in open abdominal and laparoscopic distal pancreatectomy, as well as partial splenectomy. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This retrospective single-center study was approved by the Ethics Committee of Shandong Provincial Hospital Affiliated to Shandong First Medical University (Ethics Committee approval reference number: SWYX: No. 2022-479). Informed consent was obtained from the participants both for the employment of this new surgical procedure and the publication of the article.

Technical practice reports

Technical practice 1

A 66-year-old woman was admitted due to the "identification of a space-occupying lesion in the pancreas for 8 years". Upper abdominal computed tomography (CT) revealed an irregular cystic hypodense lesion in the pancreatic body and tail measuring 10.8 cm × 7.0 cm (*Figure 1A*). Multiple tortuous blood vessels were observed

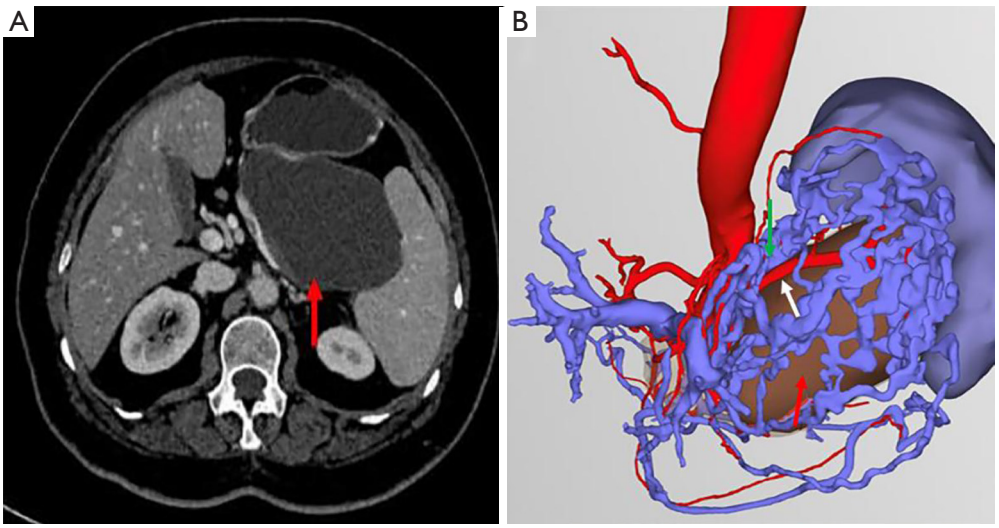

Figure 1 Preoperative computed tomography scan and three-dimensional reconstruction. (A) Computed tomography reveals a cystic lesion (red arrow) in the pancreatic tail, closely associated with splenic vessels; (B) three-dimensional reconstruction illustrating the ambiguous border between the tumor and splenic vessels (green arrow: splenic vein; white arrow: splenic artery; red arrow: pancreatic tail lesion).

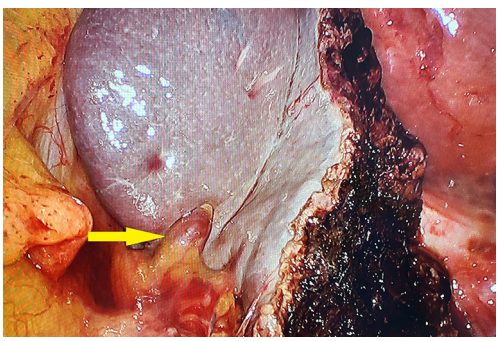

Figure 2 Preservation of the short gastric blood vessels in the superior pole of the spleen is denoted (yellow arrow). The blood supply to the partially preserved spleen remains good.

in the gastric fundus. Preoperative three-dimensional reconstruction revealed an indistinct demarcation between the lesion and splenic vessels (*Figure 1B*). The preoperative diagnosis pinpointed cystadenoma of the pancreatic tail, prompting planned spleen-preserving distal pancreatectomy. Intraoperative exploration determined that the lesion, situated at the pancreatic tail, was intimately associated with the splenic vessels, thus negating the possibility of dissection. Persistent compression of the splenic vessels by the pancreatic tail mass resulted in splenic congestion, splenomegaly, and the development of esophageal and fundal varices. The splenic artery was dissected from the origin, and the splenic vein in the pancreas was excised. Notably, the spleen presented significant ischemia and congestion, similar to the Warshaw technique. A high risk of spleen necrosis was identified, prompting a strategic plan for laparoscopic partial spleen-preserving distal pancreatectomy. The pancreas was excised 1 cm at the proximal end of the pancreatic tumor, ensuring precise preservation of the short gastric blood vessels at the superior pole of the spleen. The middle and inferior poles of the spleen were resected 1 cm below the ischemic line, while conserving the superior pole of the spleen supplied by short gastric blood vessels. The spleen was observed for 15 min to verify the recovery of normal coloration to the residual superior pole (*Figure 2*). Units equipped for indocyanine green (ICG) fluorescence can utilize it to further intraoperatively assess the good supply of the residual spleen. Electrocoagulation was deployed for hemostasis in the splenic stump. The excised pancreatic tumor underwent an intraoperative rapid pathology test, which identified pancreatic cystadenoma. The surgical duration was 240 min, with a blood loss volume of 200 mL, and no blood transfusion was performed. The postoperative pathology test revealed a cystic pancreatic lesion with a pseudocyst predisposition (*Figure 3*). The patient's postoperative recovery was successful, culminating in discharge on day 6. Twelve days after surgery, the patient's platelet count increased to 498×10^9/L, and antiplatelet treatment was not initiated. Retesting 3 months after surgery demonstrated that the platelet count had returned to normal levels. Enhanced CT, conducted 8 months after surgery,

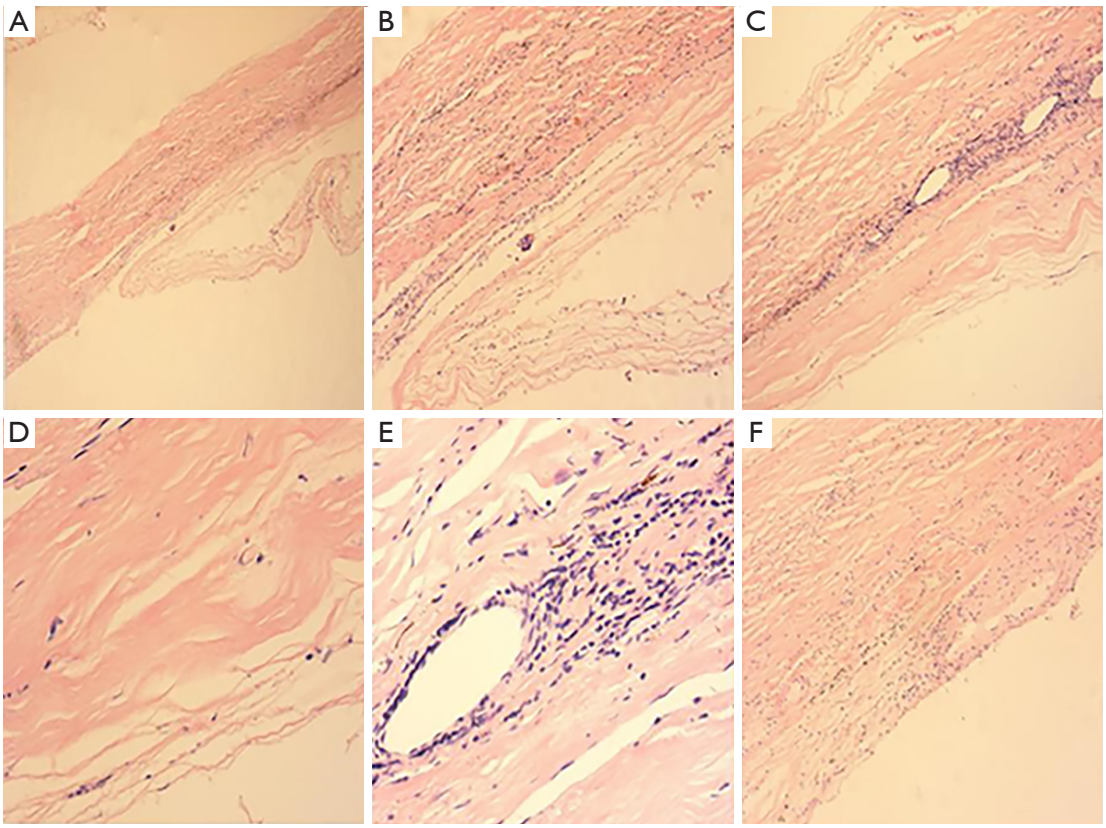

Figure 3 Postoperative pathological examination (hematoxylin-eosin stain). (A) Cyst wall. Top-left figure displays the inner cyst wall; an epithelial lining is not visible, and fibrous collagen degeneration is present in the cyst wall (×40 magnification); (B) cyst wall under ×100 magnification; (C) a proliferation of lymphocytes is observable in the cyst wall (×100 magnification); (D) cyst wall collagen (×400 magnification); (E) lymphocytes (×400 magnification); (F) cyst wall edema space. Hemosiderin deposition is discernible in some regions (×400 magnification).

revealed a robust blood supply to the residual spleen, confirmed the absence of splenic necrosis, and affirmed the success of partial spleen preservation.

Technical practice 2

A 67-year-old man was admitted due to the "discovery of a space-occupying lesion in the pancreas for 3 months". CT scans revealed a cystic hypodense lesion in the pancreatic body and tail measuring 6.0 cm × 3.8 cm. This lesion was connected to the main pancreatic duct and demonstrated a close association with both the splenic artery and vein (*Figure 4A*). Three-dimensional reconstruction highlighted the close proximity of the lesion to the splenic hilum (*Figure 4B*). The preoperative diagnosis suggested the presence of an intraductal papillary mucinous neoplasm (IPMN) in the pancreas. During intraoperative exploration, the lesion was observed to involve the adjacent splenic hilum and was intimately associated with the splenic artery and vein; the splenic hilum, artery, and vein could not be dissociated from the lesion. A laparoscopic partial spleen-preserving distal pancreatectomy, similar to the procedure performed for the aforementioned patient, was planned. After the splenic artery and vein were ligated, significant ischemia and congestion were observed in the middle and inferior poles of the spleen, although the blood supply in the superior pole was relatively satisfactory (*Figure 5*). Consequently, the pancreas was resected 1 cm from the pancreatic lesion, the short gastric blood vessels in the superior pole of the spleen were preserved, and the middle and inferior poles were resected. Intraoperative observation persisted for 15 min. The blood supply to the residual superior pole of the spleen was gradually restored (*Figure 6*), culminating in a successful surgical outcome. The surgery lasted 180 min, entailed a blood loss volume of 150 mL, and did not necessitate

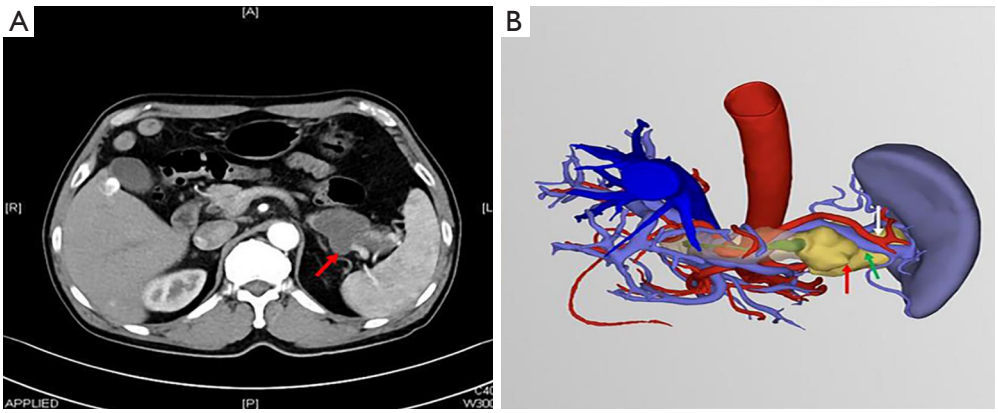

Figure 4 Preoperative computed tomography scan and three-dimensional reconstruction. (A) The lesion (red arrow) could not be clearly separated from the splenic artery and vein; (B) the tumor is situated close to the adjacent splenic hilum (white arrow: splenic artery; green arrow: splenic vein; red arrow: pancreatic lesion).

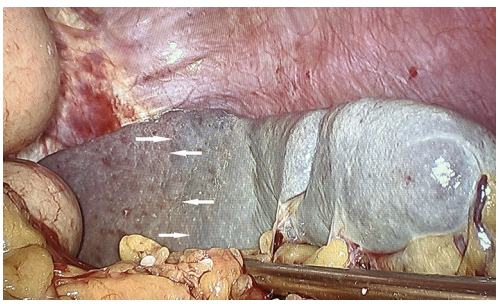

Figure 5 Following dissection of the splenic vessels, a conspicuous ischemic line is visible (white arrows); the blood supply to the superior pole of the spleen is markedly superior to that of other splenic regions.

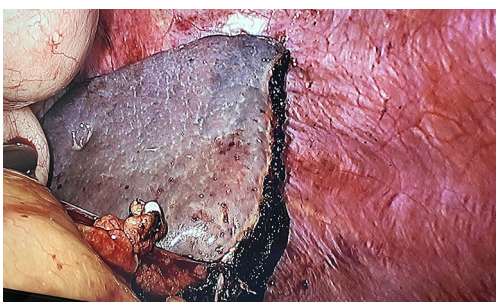

Figure 6 The residual spleen exhibits good blood circulation.

a blood transfusion. Intraoperative rapid pathology and postoperative diagnosis confirmed IPMN (*Figure 7*). The patient experienced a successful postoperative recovery and was discharged on day 7. Enhanced CT reassessment upon discharge indicated that the superior pole of the spleen maintained a good blood supply and did not exhibit splenic necrosis (*Figure 8*). Thirteen days after surgery, the patient's platelet count increased to 668×10^9/L, but antiplatelet treatment was not initiated. Retesting 1 month after surgery demonstrated that the platelet count had spontaneously stabilized within the normal range.

Step-by-step description

(I) Examination of the relationship between the tumor and the splenic hilum: upon accessing the abdomen, a standard examination for potential metastasis is conducted, and the gastrocolic ligament external to the gastroepiploic vessel arch is resected utilizing an ultrasonic knife. Care is taken to preserve the gastrosplenic ligament, ensuring no damage occurs to the short gastric blood vessels. The stomach is suspended, providing full exposure of the pancreatic body and tail to ascertain the tumor's location, position, and relationship with the splenic hilum. If an intimate association between the tumor and the splenic hilum prevents separation, a partial spleen-preserving distal pancreatectomy may be performed directly. Should separation be feasible, the Kimura technique may be applied initially (*Figure 9*). The retroperitoneum is dissected along the pancreas's longitudinal axis within the avascular region of the upper and lower margins of the pancreatic body and tail. The retroperitoneal space and the posterior pancreatic channel are dissected and opened,

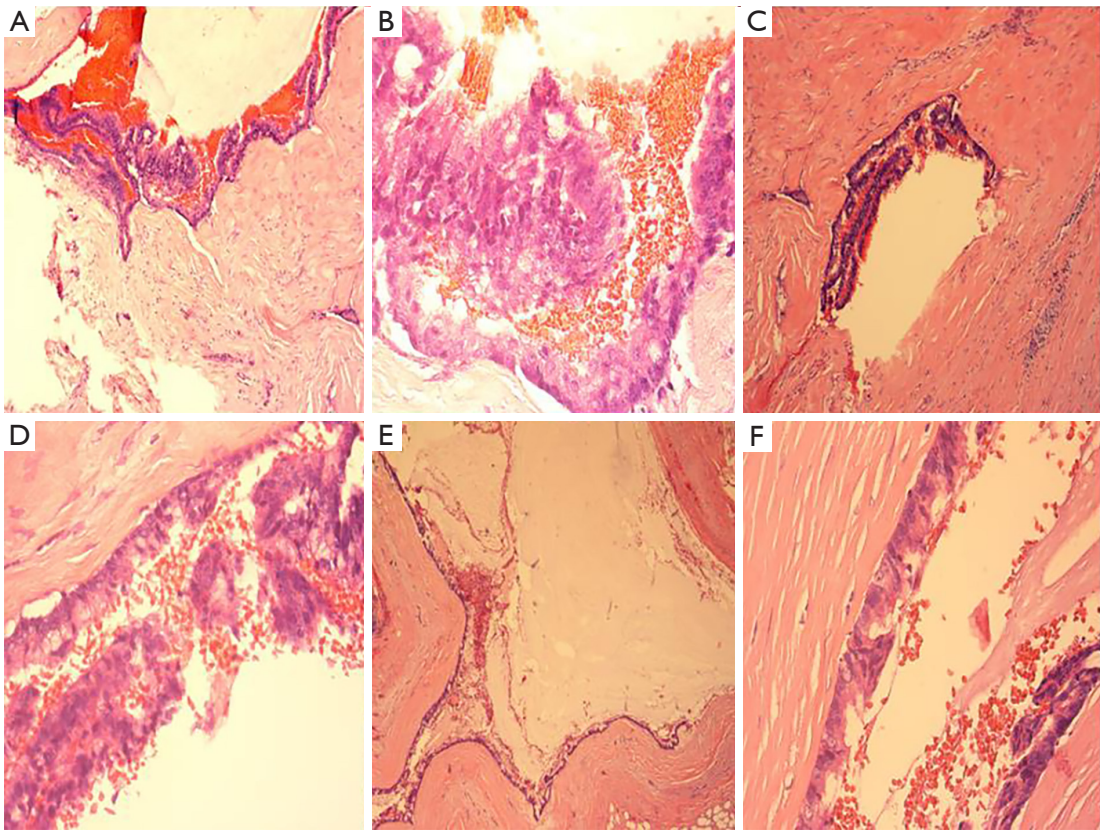

Figure 7 Pathological examination (hematoxylin-eosin stain). (A) Visible papillary structure in the cyst; papillae are clustered, with columnar cilia observed (200× magnification); (B) cystic papillae exhibit a clustered growth pattern; cytoplasm is stained red (400× magnification); (C) the cyst wall demonstrates vitreous changes and fibrosis; some lymphocytes and a papillary structure are visible in the cyst (200× magnification); (D) papillary structure in the cyst (400× magnification); (E) mucus is visible in the cyst; the cyst wall is lined with a monolayer of ciliated columnar epithelium (mucous epithelium) (200× magnification); (F) moderate-to-severe atypia is observed in the lining epithelium, consistent with high-grade intraepithelial neoplasia (400× magnification).

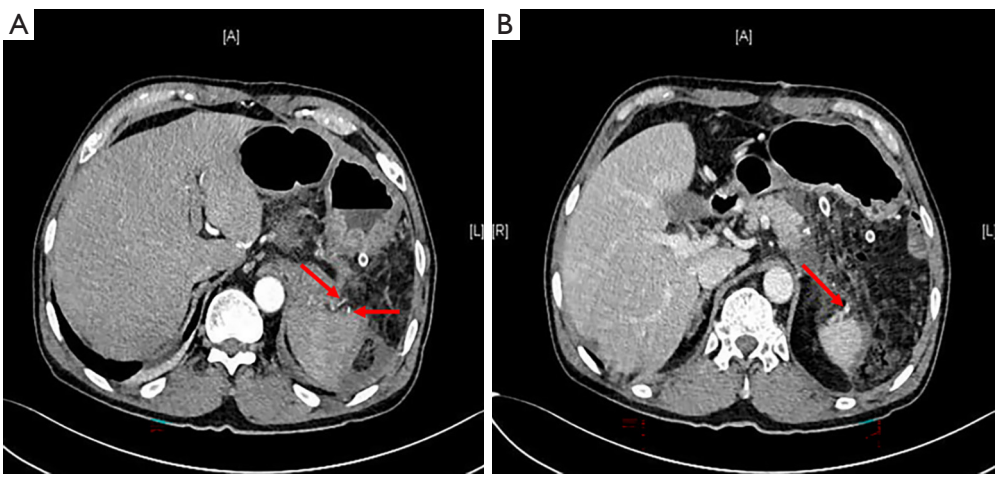

Figure 8 Postoperative computed tomography scan. (A) Multiple branches providing arterial blood supply (red arrows) are visible during the arterial phase of the residual spleen; (B) significant venous backflow (red arrow) is observed in the residual spleen.

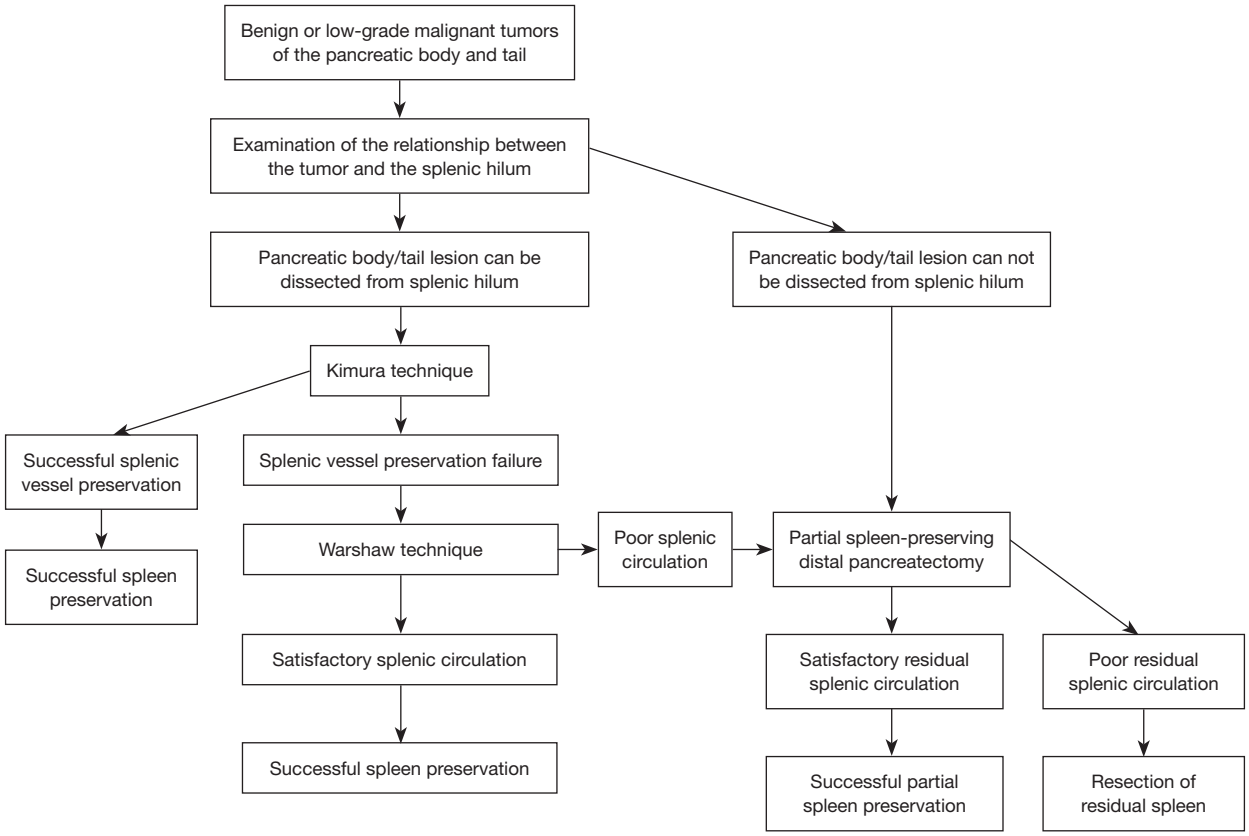

Figure 9 Mind map delineating the spleen-preserving distal pancreatectomy of benign or low-grade tumors in the pancreatic body/tail.

respectively, and the pancreatic body and tail are fully liberated.

(II) Separation of the splenic artery and vein: the splenic artery is isolated at its origin from the celiac trunk. The splenic vein is isolated before its confluence with the superior mesenteric vein. Vascular occlusion bands are separately pre-placed for each. The anatomical interplay of the tumor with the splenic artery and vein is examined. If the vessels can be fully dissociated from the lesion, the Kimura technique is employed. Conversely, should the tumor maintain a close association with the vessels, precluding separation, or if severe damage and bleeding occur during separation, the Warshaw technique is enacted. Typically, laparoscopic cutters and staplers facilitate dissection of the splenic vessels.

(III) Separation of the pancreas: either a laparoscopic cutter and stapler or an ultrasonic knife is utilized to dissect the pancreatic tissues 1–2 cm from the tumor margin at the proximal pancreas. The pancreatic remnant is continuously sutured with vascular sutures.

(IV) Spleen management: after dissection of the splenic artery and vein, the spleen will be in a congested and ischemic state. Splenic blood flow is monitored for 10–15 min. Many patients present with the following conditions, resulting in Warshaw technique failure and a switch to a partial spleen-preserving distal pancreatectomy: pronounced demarcation between regions with sufficient blood supply and obstructed blood flow might be visible in the spleen's superior pole. An ultrasonic knife can resect parts of the spleen with obstructed blood flow 1 cm from the ischemia border; and the entire spleen is congested and ischemic, lacking a clear boundary. Here, we identify the short gastric blood vessels on the spleen's superior pole in the preserved gastrosplenic ligament and resect the middle and inferior poles of the spleen 1 cm below this position to conserve the spleen's superior pole.

(V) Hemostasis: monopolar electrocoagulation at 80 W power may be applied to the splenic section

for hemostasis, and absorbable hemostatic materials can cover the surface to minimize bleeding (21).

(VI) Intraoperative rapid frozen pathology test: the resected pancreatic tumor is subjected to a rapid frozen pathology test. If benign or low-grade malignancy is confirmed, the spleen's superior pole is preserved. If the diagnosis is malignancy or indeterminate, the surgical approach pivots to radical surgery, abandoning preservation of the spleen's superior pole.

(VII) Management of the preserved superior pole of the spleen: the residual spleen is monitored for 10–15 min, during which its red color is restored in most instances. If the residual spleen remains ischemic and congested without significant restoration of the blood supply, resection of the residual spleen is recommended.

(VIII) Final observations: the incised section is reexamined to confirm bleeding absence. An abdominal cavity drainage tube is inserted beneath the pancreatic stump and splenic incised section, concluding the surgery. Throughout the surgical process, the anesthesiologist routinely monitors the patient's vital signs.

Postoperative considerations and tasks

After preservation of the spleen's superior pole, it is advised that blood flow to the residual spleen be confirmed both intra- and postoperatively. Enhanced CT can be utilized after surgery to scrutinize residual splenic blood flow. If splenic circulation is not restored, total splenectomy is recommended. Refer to our procedure for spleen-preserving distal pancreatectomy for benign pancreatic tumors (*Figure 9*). After surgery, 48–72 h bed rest along with meticulous blood pressure and pulse monitoring is recommended to reduce the probability of splenic wound bleeding. Regular postoperative follow-ups are essential to track platelet variations. Ambulation is permitted provided no significant bleeding occurs.

Tips and pearls

The preoperative selection of cases is crucial, and this new surgical approach is suitable for patients with benign or low-grade malignant tumors in the body and tail of the pancreas. Rapid pathological assistance diagnosis is required during the surgery. Intraoperatively, it is necessary to separate the gastrocolic ligament external to the gastroepiploic vessel arch, while preserving the splenogastric ligament and as many short gastric vessels as possible. It is necessary to observe the color changes of the residual spleen sufficiently during surgery to ensure proper blood perfusion of the remnant spleen.

Discussion

Improved understanding of the spleen's pivotal role as an immune organ and the long-term complications arising from total splenectomy has underscored the significance of research on spleen-preserving surgery (22-25). In scenarios where the splenic vessels can be preserved, the Kimura technique ought to be considered the primary choice for spleen-preserving distal pancreatectomy for benign or low-grade lesions in the pancreatic body and tail (6,26,27). In instances where the tumor is intimately related to the splenic vasculature, or vascular damage occurs during the separation of the splenic vessels—precluding the execution of Kimura's operation and necessitating the selection of Warshaw's operation—significant postoperative congestion and ischemia of the spleen may transpire in certain patients once the splenic artery and vein are disconnected, especially in cases with a large spleen. This frequently culminates in spleen necrosis, infection, or regional portal hypertension, which often precipitate failure to preserve the spleen or the development of long-term complications (8-13). Professor Warshaw also noted that splenomegaly might constitute a contraindication for the Warshaw technique in his publication (28). Conversely, overwhelming post-splenectomy infection, thromboembolism, and malignancies in the blood, lung, or ovary may manifest after total splenectomy, necessitating lifelong treatment with antiplatelet drugs (29-33). A partial spleen-preserving distal pancreatectomy could mitigate these adverse outcomes.

To better understand the surgical treatments for benign and low-grade tumors of the pancreatic body and tail, a search of the PubMed database yielded 12 papers on benign tumors in the pancreatic body and tail and spleen-preserving distal pancreatectomy through screening (*Table 1*). Notably, none of these papers reported on partial spleen-preserving distal pancreatectomy. Our proposed surgical procedure, which retains the normal function of part of the spleen and circumvents the contraindications of the Warshaw technique, is pioneering.

Since Franciscus Rosetti first reported partial splenectomy in 1590, numerous studies have confirmed

Table 1 Studies detailing surgical methods for benign and low-grade tumors in the pancreatic body and tail

Study	Year	Disease type	Type of surgery	Number of patients	Was partial spleen preservation carried out?
Zheng Z, *et al.* (34)	2018	Pancreatic serous cystic neoplasm	Kimura	1	No
Antoniou EA, *et al.* (35)	2017	Solid pseudopapillary tumor	Distal pancreatectomy with concomitant splenectomy	4	No
Kang CM, *et al.* (36)	2010	Benign or borderline malignant tumors	Subtotal pancreatectomy	10	No
Yongfei H, *et al.* (37)	2017	Benign or borderline malignant tumors	Warshaw	301	No
			Kimura	644	No
Zeytunlu M, *et al.* (38)	2004	Solid and cystic papillary neoplasm	Tumors included enucleation	1	No
			Distal pancreatectomy with concomitant splenectomy	1	No
			Distal pancreatectomy	2	No
Kim EY, *et al.* (14)	2021	Benign or borderline malignant tumors	Laparoscopic spleen-preserving distal pancreatectomy	86	No
Ikeda T, *et al.* (39)	2013	Benign and low-grade malignant pancreatic neoplasm	Laparoscopic spleen-preserving distal pancreatectomy	6	No
Kimura W, *et al.* (7)	1996	Benign lesions	Kimura	4	No
Warshaw AL, (28)	1988	Benign lesions	Warshaw	25	No
Jain G, *et al.* (11)	2013	Benign tumors	Warshaw	356	No
			Spleen vessel preserving distal pancreatectomy	572	No
Lee SY, *et al.* (40)	2008	Benign tumors	Spleen-preserving distal pancreatectomy	24	No
Korrel M, *et al.* (41)	2023	Benign tumors	Kimura	634	No
			Warshaw	244	No

that the remaining splenic function is satisfactory after partial splenectomy for splenic diseases, and most patients maintain a generally normal condition (42,43). Based upon extensive prior literature, partial splenectomy is regarded as safe and feasible (42,44-47). In comparison with the Kimura technique, partial spleen-preserving distal pancreatectomy retains the short gastric blood vessels on the superior pole of the spleen to ensure normal blood flow in the residual superior pole. This method is appropriate for the resection of benign or low-grade malignant tumors in the pancreatic body and tail when the splenic artery and vein are inseparable. Compared to the Warshaw technique, this approach spares the superior pole of the spleen and corresponding short gastric blood vessels to address issues of ischemia, congestion, splenic necrosis, infection, and regional portal hypertension engendered by preservation of the entire spleen. This innovative surgical method can adeptly resolve the aforementioned problems when the Kimura or Warshaw techniques are not executable because the pancreatic body and tail tumor is extensive or intimately associated with the splenic hilum.

It is clear that our surgical approach should not be decided upon prior to surgery: the Kimura technique remains the preferred method for spleen-preserving distal pancreatectomy when splenic vessels can be conserved. Our new partial spleen-preserving distal pancreatectomy may be considered when splenic vessels are challenging to separate, significant splenic ischemia and congestion are observed

after dissection of splenic vessels, or the tumor and splenic hilum are tightly intertwined and inseparable. The crucial aspect of this technique is preserving the short gastric blood vessels as much as possible. Even in cases where there was a blood transport deficit throughout the spleen, and splenic ischemia and congestion occurred during the dissection of the splenic artery and vein, it was observed that, after complete preservation of the short gastric blood vessels in the spleen's superior pole and resection of the middle and inferior poles, the blood circulation in the residual superior pole of the spleen markedly improved. Possible explanations include the notable decrease in spleen volume and venous backflow following the resection of the middle and inferior poles of the spleen, reducing congestion and increasing spleen supply of the short gastric blood vessels. This establishes an anatomical and technical foundation for this new surgical procedure.

Conclusions

In summation, this is the first paper to propose partial spleen-preserving distal pancreatectomy as a novel surgical technique for surgeons. Our strategy involves a novel approach for treating benign and low-grade tumors located in the pancreatic body and tail. It significantly enhances the success rate of spleen preservation and may reduce the incidence of regional portal hypertension, thus advancing clinical treatment. This new surgical approach has the potential to reduce overall costs associated with complications of total splenectomy, such as elevated platelet levels, during long-term treatment. Despite the small sample size, clinical practice indicates that the procedure is viable and yields positive results. Therefore, additional practical experience is merited. It is anticipated that this technique can become a globally recognized mature spleen-preserving distal pancreatectomy.

Acknowledgments

Funding: This study was supported by Shandong Provincial Natural Science Foundation (No. ZR2019PH070), National Natural Science Foundation of China (No. 82004100) and Taishan Scholars Program of Shandong Province of China (No. tsqn202306374).

Footnote

Reporting Checklist: The authors have completed the SUPER reporting checklist. Available at https://gs.amegroups.com/article/view/10.21037/gs-23-355/rc

Peer Review File: Available at https://gs.amegroups.com/article/view/10.21037/gs-23-355/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-23-355/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study received approval from the Ethics Committee of Shandong Provincial Hospital Affiliated to Shandong First Medical University (Ethics Committee approval reference number: SWYX: No. 2022-479). Informed consent was obtained from the participants both for the employment of this new surgical procedure and the publication of the article.

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Cite this article as: Ni Q, Jia H, Hou D, Chang H. Distal pancreatectomy with partial preservation of the spleen: a new surgical technique. Gland Surg 2023;12(11):1624-1635. doi: 10.21037/gs-23-355