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A Novel Technique for Reducing Graft Thrombosis in Pancreas Transplantation by Creating a Distal Splenic Arteriovenous Shunt

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List of Abbreviations

SPK: Simultaneous pancreas-kidney transplantation.

HCA: Hypertonic citrate adenine.

UW: University of Wisconsin.

CTA: Computed tomography angiography.

CTP: Computed tomography perfusion.

OPO: Organ procurement organization.

IRB: Institutional review board.

IACUC: Institutional animal care and use committee.

AV: Arteriovenous.

Abstract

This study aimed to evaluate the efficacy and safety of a novel surgical technique involving the creation of a distal splenic artery-to-vein shunt for reducing the incidence of graft arteriovenous thrombosis in pancreas transplantation. This was a single-center retrospective analysis. Between November 2023 and August 2025, a modified procedure was performed in 35 patients undergoing pancreas transplantation. Graft function and shunt patency were assessed by monitoring blood glucose, serum enzymology, color Doppler ultrasonography, and computed tomography perfusion imaging. All 35 procedures were completed successfully. No graft arteriovenous thrombosis was observed during follow-up. Patent shunts were confirmed by imaging in all cases. Two non-thrombotic postoperative complications occurred (one case of gastrointestinal bleeding and one case of intestinal leakage), both of which were successfully managed with conservative treatment. Endocrine and exocrine functions of all pancreatic grafts remained normal throughout follow-up. Creation of a distal splenic arteriovenous shunt during pancreas transplantation is a safe and feasible technical innovation. By modifying splenic arteriovenous hemodynamics, this

technique significantly reduces the risk of early arteriovenous thrombosis without increasing surgical complications or the complexity of anticoagulation management, demonstrating promising clinical application prospects.

Keywords: Pancreas transplantation; Splenic artery-to-vein shunt; Thrombosis.

1. Introduction

Simultaneous pancreas-kidney transplantation (SPK) and sequential pancreas transplantation after kidney transplantation are currently the most effective treatments for patients with diabetes mellitus complicated with end-stage renal disease [1]. The main cause of early pancreatic graft loss is pancreatic graft thrombosis, which mostly occurs within the first 3 months after transplantation. The incidence of this complication ranges from 7% to 20% in most transplant centers [2-3], and the historical thrombosis rate of pancreas transplants in our center was 4.8% [4]. Once thrombosis occurs, the probability of pancreatic graft resection is almost 100%.

The main causes of pancreatic graft thrombosis are: (1) The low perfusion blood flow of the pancreas, which is exacerbated by the traditional surgical approach of ligating the distal splenic artery and vein. This ligation alters physiological hemodynamics, resulting in slow blood flow within these vessels and a high propensity for thrombosis. (2) The presence of risk factors, e.g., ischemia-reperfusion injury, rejection, and a hypercoagulable state [5]. Consequently, developing a surgical method that can avoid slow blood flow is challenging but beneficial in pancreas transplantation surgery.

The present study reports a novel surgical technique to create a splenic artery-to-vein shunt, with the splenic vein serving as the outflow tract of the splenic artery for pancreatic transplantation in diabetic patients. This technique is designed to effectively avoid thrombosis and has achieved good outcomes during a follow-up period of 3 to 23 months.

2. Subjects and Methods

2.1 Study Subjects

Since November 2023, surgeons in the Department of Organ Transplantation at the Second Affiliated Hospital of Guangzhou Medical University have performed a modified surgical procedure involving the creation of a distal splenic arteriovenous shunt in pancreatic grafts. By August 2025, this technique had been applied in 30 cases of simultaneous pancreas-kidney transplantation and 5 cases of sequential pancreas transplantation after kidney transplantation.The clinical data of donors and recipients are shown in Table 1.This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of The Second Affiliated Hospital of Guangzhou Medical University (Approval No.: 2024-hs-69-02). This study was registered in the Chinese Clinical Trial Registry (ChiCTR2500109609；registration date: 23 September 2025). Written informed consent was obtained from all recipients or their legal representatives before enrollment.All organs are sourced from posthumous organ donations by citizens. Organ procurement surgeries are only performed with the signed consent of all immediate family members and upon approval by the ethics committee. none of the organs were procured from executed prisoners.

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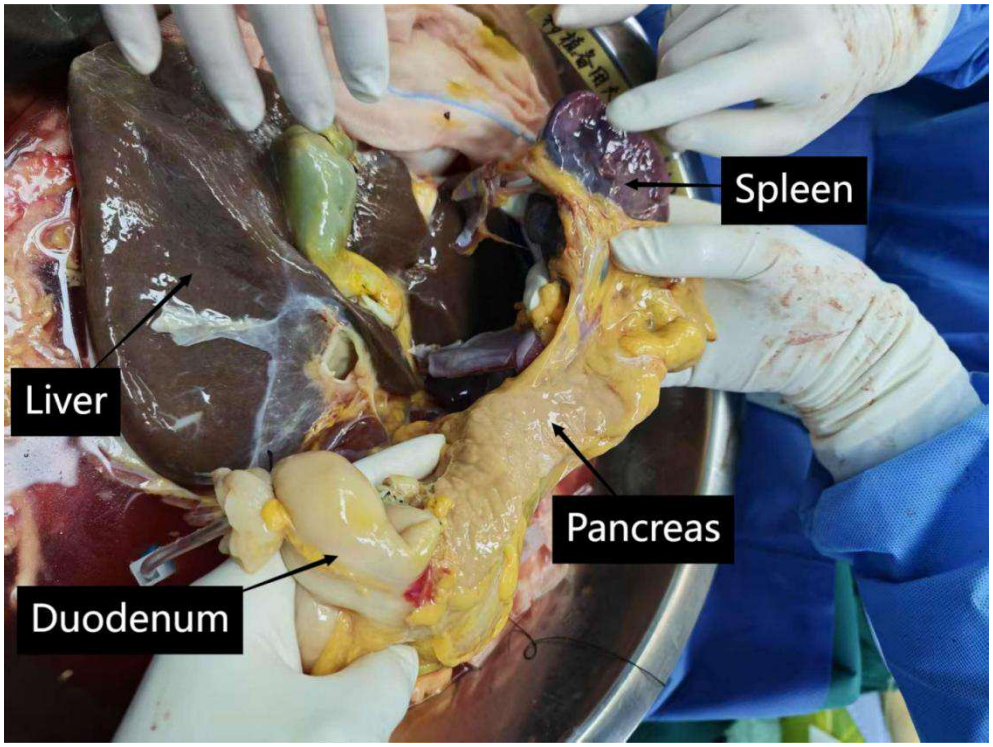
Table 1 Demographics of donors and recipients with a splenic arteriovenous shunt (35 cases)

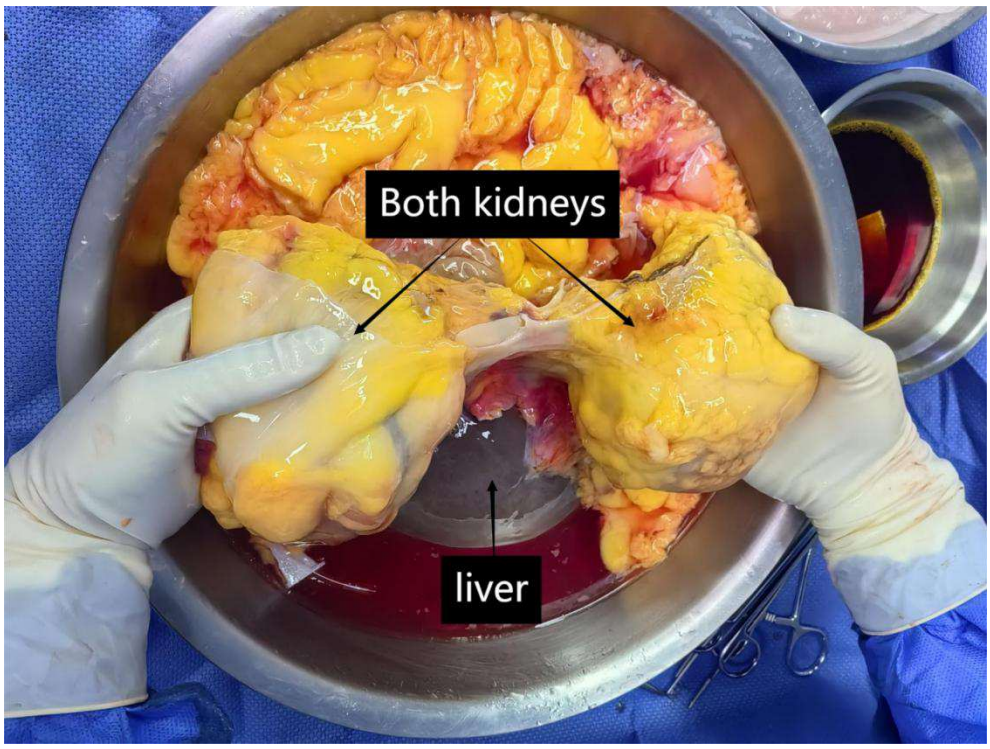
Study parameters	**Splenic arteriovenous shunt (35 cases)**
Donors	
Gender (Male/Female，cases)	28/7
Age (years, χ±s)	41.31±13.31
Body Mass Index (kg/m², χ±s)	27.81±11.15
Serum Creatinine (μmol/L, χ±s)	89.48±26.56
Amylase (U/L, χ±s)	124.9±106.27
Lipase (U/L, χ±s)	101.9±156.81
Glycated Hemoglobin (%, χ±s)	5.57±0.35
Fasting Blood Glucose (mmol/L, x±s)	11.90±6.47
Recipients	
Gender (Male/Female, cases)	30/5
Age (years, χ±s)	52.07±8.96
Body Mass Index (kg/m², χ±s)	23.45±3.67
Type of Diabetes (cases)	
Type 1	6
Type 2	29
Time from Diabetes Diagnosis to Surgery (months, χ±s)	16±6.8
Dialysis Type (cases)	
Peritoneal Dialysis	8
Hemodialysis	27
Blood Type (cases)	
Type A	12
Type B	11
Type O	10
Type AB	2

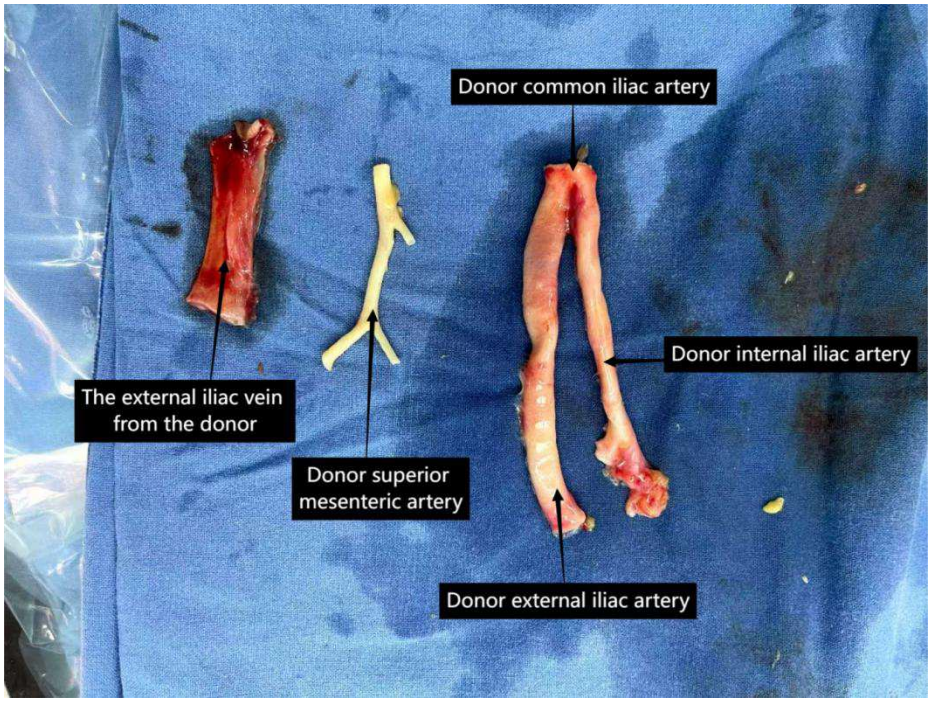
2.2 Organ Procurement

Donors were heparinized (Heparin Sodium Injection 2 ml: 12,500 units × 5 ampoules) before organ procurement, and an in-situ perfusion and en-bloc retrieval method was used for organ procurement [6]. Briefly, perfusion catheters were inserted into the distal abdominal aorta and the portal vein, and 3000 ml of 4°C low-viscosity hypertonic citrate adenine (HCA) solution and 1000 ml of high-viscosity University of Wisconsin (UW) solution were rapidly perfused in sequence. An outflow tube was inserted into the inferior vena cava to allow blood and perfusate to flow out. After the organs had been fully perfused, the liver, pancreas, an attached segment of duodenum, spleen, both kidneys, and related arteries and veins (required for reconstruction) were excised (Figures 1、2 and 3).

Figure 1–3: En-bloc procurement of liver, kidney, pancreas related arteries and veins.





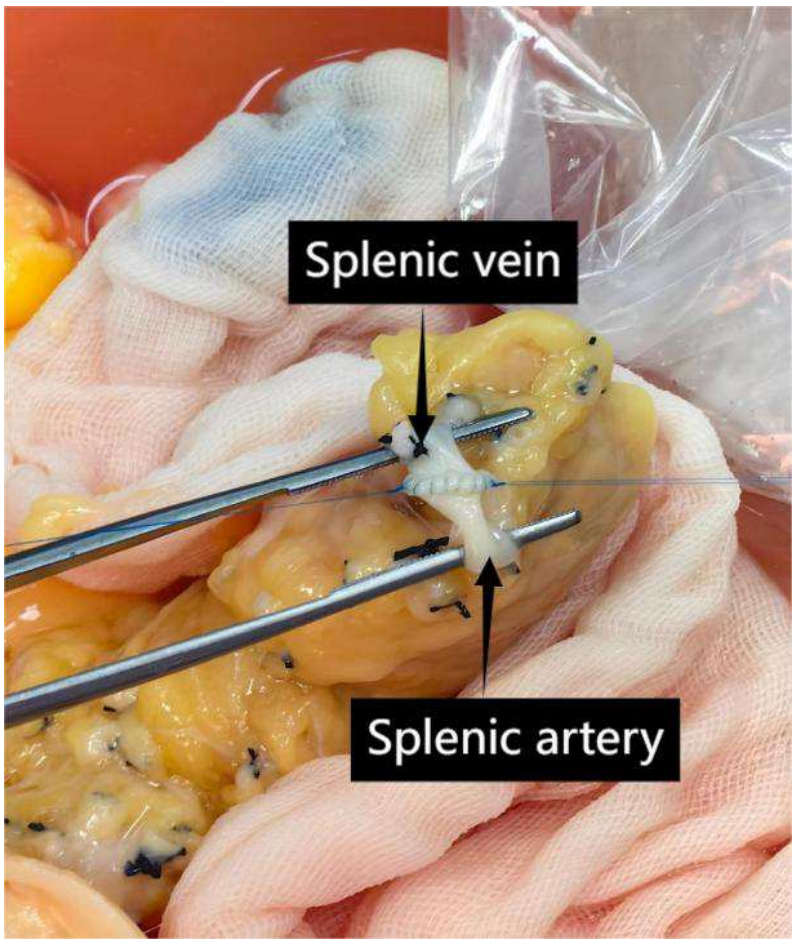


2.3 Pancreas Preparation

The procured organs were transferred to a preparation basin and immersed in 4°C high-viscosity UW solution. The liver and kidneys were separated, and the excess fat and connective tissue around the pancreas were carefully dissected and any small vessels were ligated. A splenic artery branch with an inner diameter of 2–3 mm and a suitable splenic vein branch were selected at the tail of the pancreas. An end-to-end anastomosis between the artery and vein was performed using 7–0 polypropylene monofilament suture to form an arteriovenous shunt, and the remaining terminal

branches of the splenic artery and vein were ligated(Figure 4). After preparation was completed, the blood vessels were checked for bleeding, and the duodenal segment was prepared for implantation.

Figure 4: Intraoperative formation of splenic arteriovenous shunt at the tail of the donor pancreas.



2.4 Pancreas Transplantation

2.4.1 Simultaneous pancreas-kidney transplantation

The surgical site was located in the right abdomen. Heparin anticoagulation was not routinely administered to the recipient prior to surgery. The unilateral common iliac artery, internal iliac artery, and external iliac artery of the donor were fashioned into a "Y"-shaped structure(Figure 5). The donor renal artery was anastomosed end-to-end to the donor internal iliac artery(Figure 5), and the donor common iliac artery was anastomosed end-to-side to the recipient external iliac artery (Figure 6). The donor renal vein was anastomosed end-to-side to the recipient external iliac vein to establish the renal blood flow outflow tract (Figure 7). The donor ureter was anastomosed end-to-end to the recipient ureter or embedded and anastomosed into the recipient bladder. The donor external iliac artery was anastomosed to the donor common arterial trunk (Carrel arterial trunk) formed by the superior mesenteric artery and celiac trunk of the transplanted pancreas to establish the arterial blood inflow tract

(Figure 8). The donor portal vein was anastomosed end-to-side to the recipient inferior vena cava to establish the venous outflow tract(Figure 9). The donor duodenum was anastomosed side-to-side to the recipient ileum to form an enteric exocrine drainage channel (Figure 10).

Figure 5: End-to-end anastomosis of donor renal artery to donor internal iliac artery.

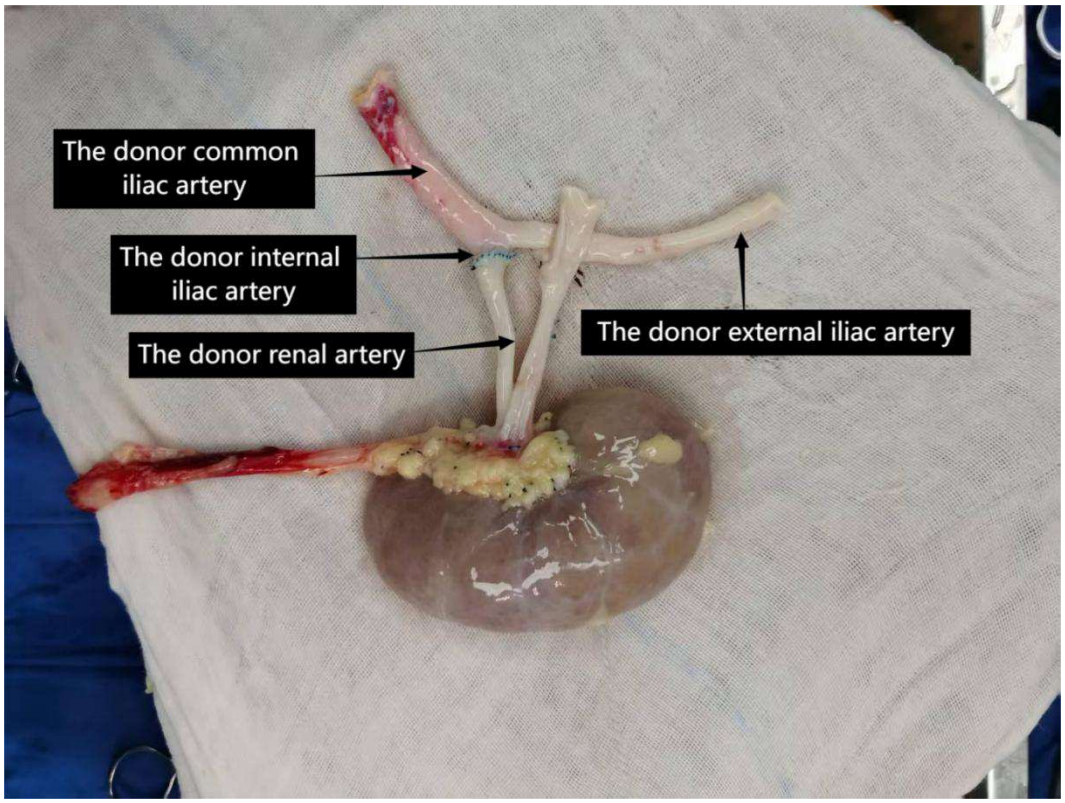


Figure 6: Donor common iliac artery anastomosed end-to-side to recipient external iliac artery.

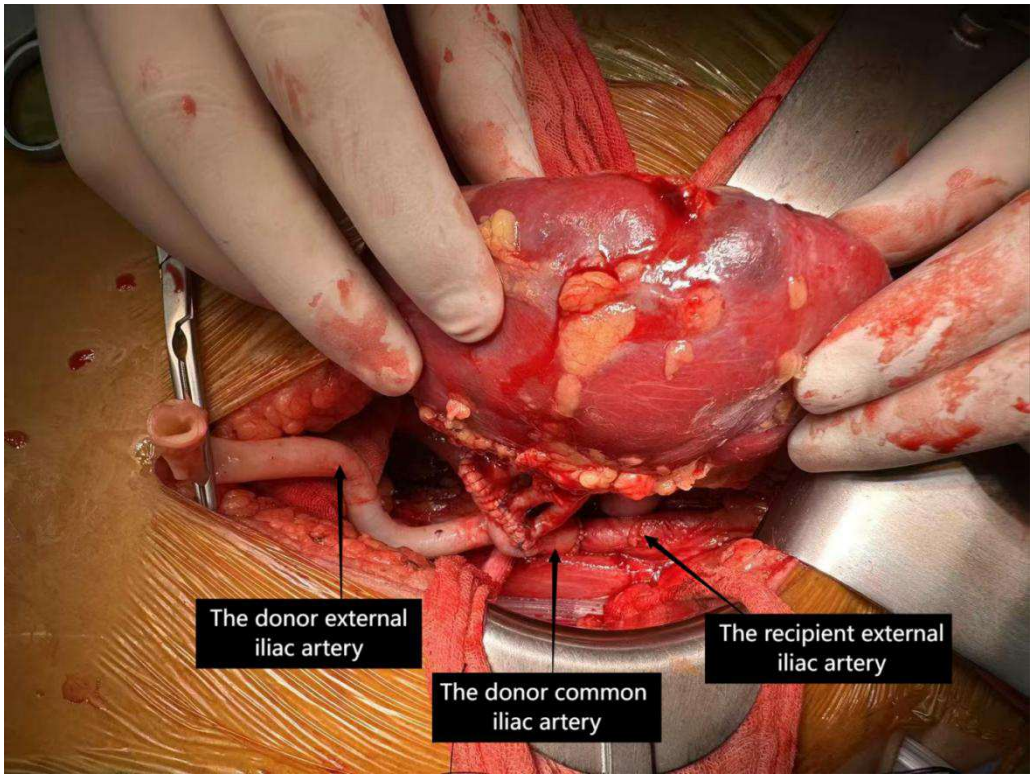


Figure 7: Donor renal vein anastomosed end-to-side to recipient external iliac vein.

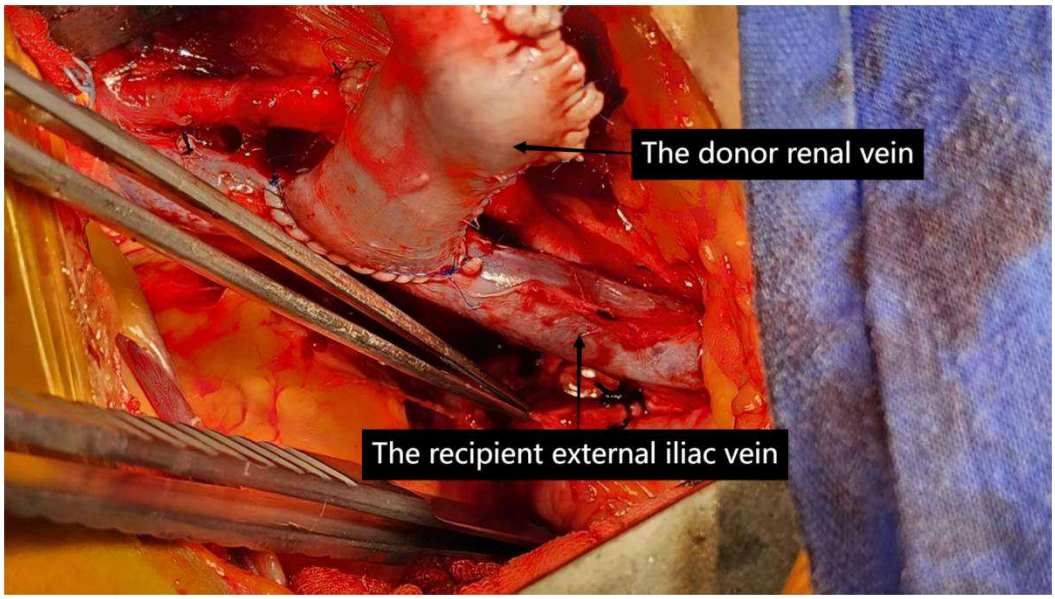


Figure 8: Donor external iliac artery anastomosed to donor common arterial trunk (Carrel arterial trunk).

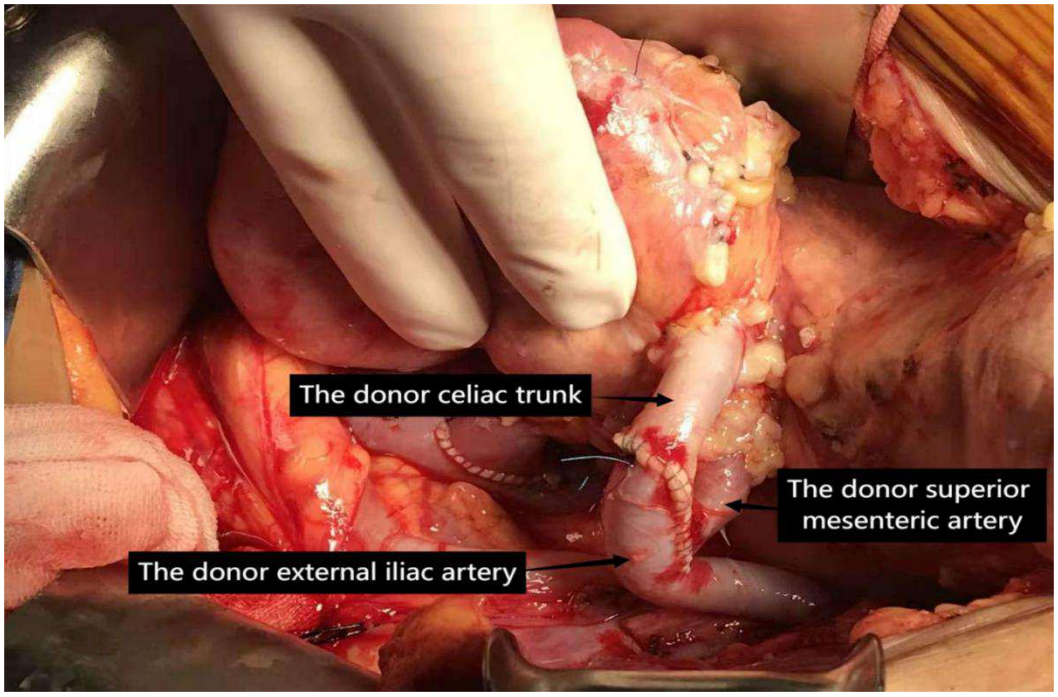


Figure 9: Donor portal vein anastomosed end-to-side to recipient inferior vena cava.

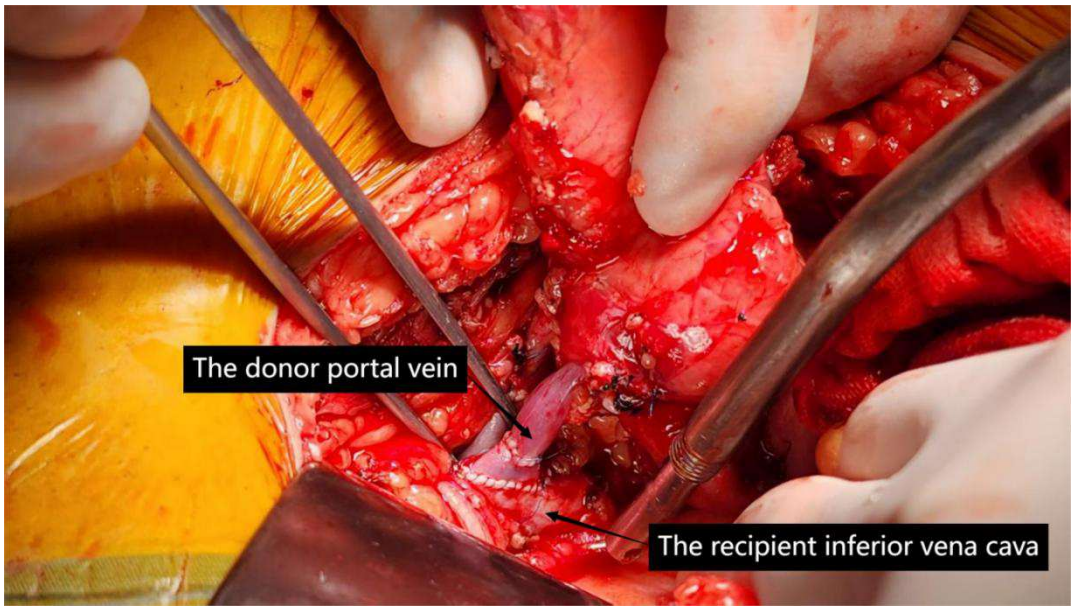
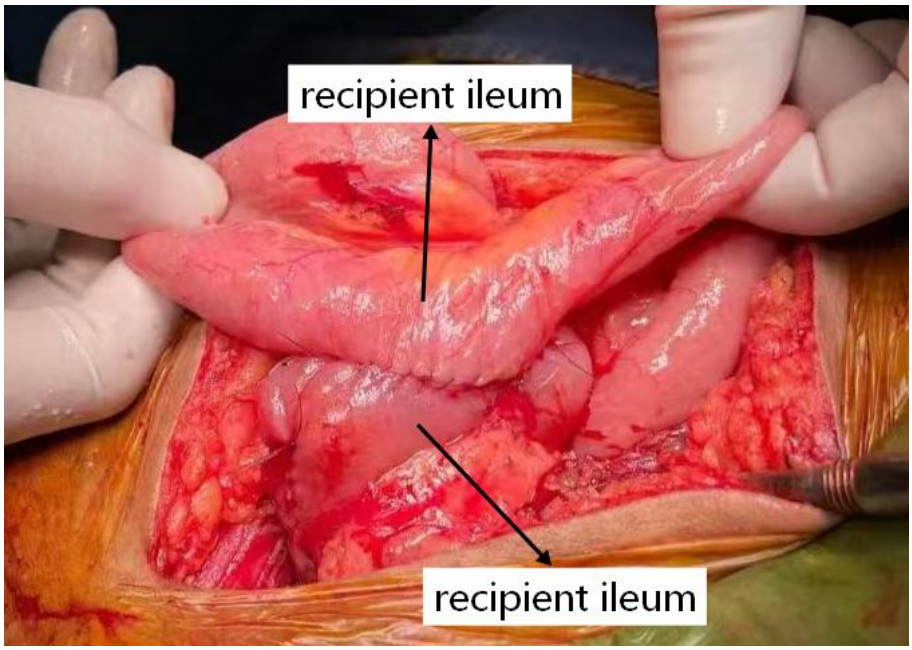


Figure 10: Donor duodenum anastomosed side-to-side to recipient ileum.

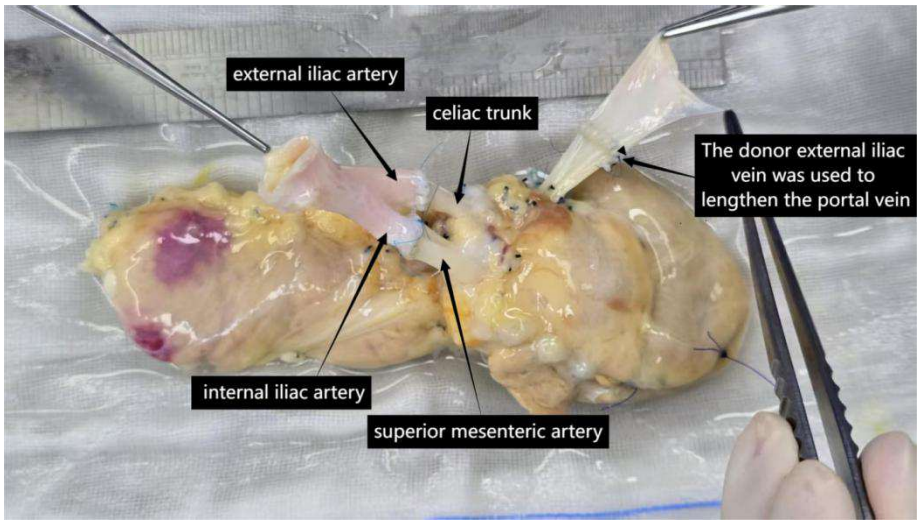


2.4.2 Sequential pancreas transplantation after kidney transplantation

The surgical site was on the opposite side to the kidney transplant. Heparin anticoagulation was not routinely administered preoperatively. The donor common iliac artery, external iliac artery, and internal iliac artery were selected, and the external iliac artery and internal iliac artery were respectively reconstructed with the donor celiac trunk and superior mesenteric artery in a “Y” shape(Figure 11). The donor common iliac artery was anastomosed end-to-side to the recipient external iliac artery to establish the arterial inflow tract. The donor portal vein was anastomosed end-to-side to the recipient inferior vena cava to establish the venous outflow tract. The donor duodenum was anastomosed side-to-side to the recipient jejunum to form an enteric exocrine drainage channel.

For both surgical approaches, robust blood flow filling at the site of the arteriovenous anastomosis was observed after restoration of blood flow, with palpable arterial pulsation. Blood flow signals could be observed via both contrast-enhanced computed tomography and B-ultrasound.

Figure 11: “Y”-shaped reconstruction of donor external iliac artery and internal iliac artery with donor celiac trunk and superior mesenteric artery.



2.5 Postoperative Anticoagulation Regimen

The anticoagulation protocol was consistent with our center's previous regimen for cases with splenic arterial and venous ligation at the pancreatic tail. Enoxaparin sodium injection was routinely used postoperatively, with a daily dose of 100 AXa IU·kg^{-1}·d^{-1} based on body weight, administered in two divided doses. After 7 days, sequential oral administration of aspirin (Bayer) 100 mg/day combined with clopidogrel 75 mg/day was initiated.

3. Results

Among the 35 recipients, the longest follow-up was 23 months and the shortest was 3 months. No recipient developed pancreatic graft arteriovenous thrombosis. One patient had gastrointestinal bleeding on postoperative day 10, and one recipient was diagnosed with intestinal anastomotic/stump leakage on postoperative day 12. Both complications were resolved by conservative medical treatment such as fasting.

All patients were followed monthly. Blood glucose was normal, and serum amylase and lipase were stable. Color Doppler ultrasound of the transplanted pancreas was checked every 2–3 months, and computed tomography angiography (CTA) or computed tomography perfusion (CTP) every 6 months. Color Doppler and CTP confirmed normal blood flow in the splenic arteriovenous shunt at the pancreatic tail in all cases(Figures 12 and 13).

Figure 12: Color Doppler showing blood flow through splenic arteriovenous shunt (red arrow).

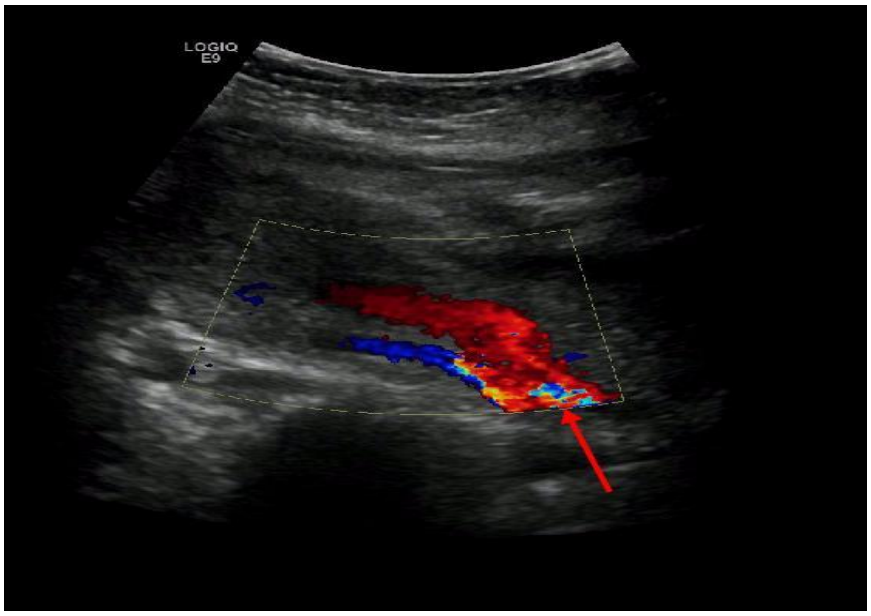
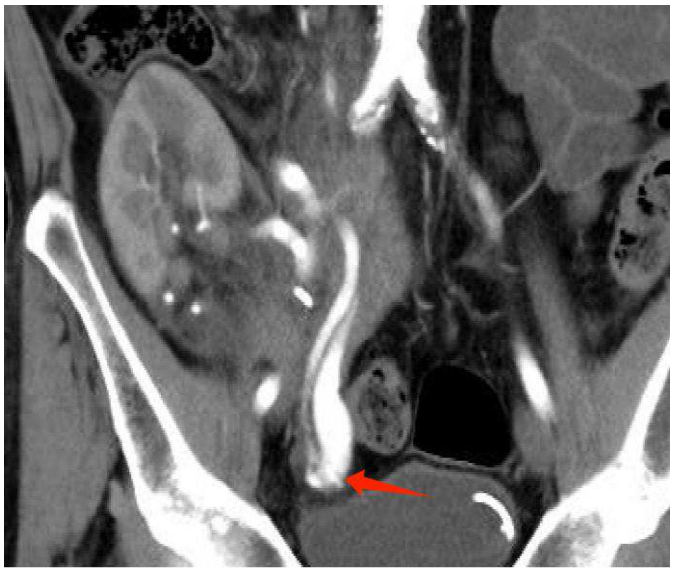


Figure 13: Enhanced CT showing blood flow through splenic arteriovenous shunt (red arrow).



4. Discussion

To date, few studies in China or internationally have reported a surgical method of creating a splenic arteriovenous shunt at the tail of the donor pancreas during pancreas transplantation.

In 1981, Du Toit et al. [7] reported 12 cases of canine autologous segmental pancreas transplantation using a technique similar to the distal splenic arteriovenous anastomosis in this study, with no vascular complications. Unfortunately, similar work by Du Toit et al.[8] in primate models failed. Adding a distal arteriovenous shunt did not reduce graft vascular thrombosis, and 5 animals died of hemorrhagic pancreatitis and venous thrombosis within 24 hours, leading to suspension of this technique in human pancreas transplantation.

In 1987, Duron et al.[9] confirmed in a dog model that an arteriovenous shunt increased blood flow in the splenic artery and vein and prevented thrombosis. Garvin et al.[10] observed that ligation of all splenic artery and vein branches reduced blood flow by 64.8%–78.3%, while a splenic arteriovenous fistula restored blood flow to 60.9%–84.9% of the level with spleen preservation. These reports suggest that restoring physiological blood flow via a splenic arteriovenous shunt may reduce vascular complications of pancreas transplantation.

In human simultaneous pancreas-kidney transplantation, Dafoe et al.[11] anastomosed the donor renal artery and vein to the distal splenic artery and vein of the transplanted pancreas, but the method was too complex for widespread use.

In the 1980s, Xia Suisheng et al.[12] performed 2 cases of intraperitoneal heterotopic allogeneic segmental pancreas transplantation with a distal splenic arteriovenous shunt. The first case developed hyperacute rejection and graft excision; the second survived 8 days with functioning graft before death from hyperkalemia. The team concluded the technique was feasible.

In 2022, Zeng Fanjun et al.[13] successfully performed one total pancreas transplant with a pancreatic tail splenic arteriovenous shunt. After 88 days of observation, no thrombosis or complications occurred, with a satisfactory outcome.

Post-transplant arteriovenous thrombosis is the leading cause of early graft loss in pancreas transplantation. Traditional ligation of distal splenic vessels causes hemodynamic disturbance and significantly increases thrombotic risk. In contrast, creation of a donor pancreatic tail splenic arteriovenous shunt effectively improved local blood flow by establishing a functional shunt between the splenic artery and vein, thus markedly reducing thrombosis. None of the 35 recipients developed pancreatic graft thrombosis, and no thrombosis-related graft loss occurred during 3–23 months of follow-up.

Compared with thrombosis rates of 7%–20% in most centers and 4.8% historically in our center with conventional ligation, our novel technique shows significant advantages. Its key benefit is optimizing hemodynamics in the transplanted pancreas:(1) Maintaining blood flow continuity and avoiding stasis and vortex formation caused by ligation, thus lowering thrombotic risk.(2) Reducing pancreatic perfusion pressure. After ligation, all splenic arterial blood flows into the pancreatic parenchyma, potentially causing hyperperfusion or high pressure. The shunt diverts part of the inflow and may protect the parenchyma by reducing perfusion volume and pressure.

All 35 operations were successful, with no serious procedure-related complications. Only two non-thrombotic complications occurred, both cured conservatively. Color Doppler and CTP confirmed patent shunts in all cases, verifying feasibility and safety. The postoperative anticoagulation regimen was identical to traditional surgery, indicating the new technique does not increase bleeding risk or anticoagulation difficulty. All recipients had stable blood glucose and normal amylase/lipase, indicating preserved endocrine and exocrine function. The shunt may protect the graft by optimizing perfusion, reducing ischemia-reperfusion injury, and lowering metabolic load.

This study reports the clinical outcomes of a donor pancreatic tail splenic arteriovenous shunt in human pancreas transplantation, confirming its effectiveness. We provide detailed surgical technique and perioperative management. Compared with the complex vascular reconstruction of Dafoe et al., our technique is simpler and easier to popularize. Limitations include a single-center retrospective design, moderate sample size, and follow-up up to 23 months. Multi-center, large-sample, randomized controlled trials are needed to verify long-term efficacy and safety. Further studies are also required to evaluate long-term shunt patency, potential flow "stealing", and long-term effects on other organs.

5. Conclusions

Creation of a donor splenic arteriovenous shunt in the pancreatic tail significantly reduces thrombotic risk by optimizing the hemodynamic environment of the transplanted pancreas without increasing surgical complications. This method is a safe, effective, and easily popularized technical innovation that reduces thrombosis-related graft loss after pancreas transplantation.

References

[1] Stratta RJ, Fridell JA, Gruessner AC, et al. Pancreas transplantation: a decade of decline[J]. Curr Opin Organ Transplant, 2016, 21(4): 386-392. DOI:10.1097/MOT.0000000000000319.

[2] Kopp WH, van Leeuwen CAT, Lam HD, et al. Retrospective study on detection, treatment, and clinical outcome of graft thrombosis following pancreas transplantation[J]. Transpl Int, 2019, 32(4): 410-417. DOI:10.1111/tri.13384.

[3] Argente-Pla M, Martínez-Millana A, Espí-Reig J, et al. Results after 13 years of kidney-pancreas transplantation in type 1 diabetic patients in Comunidad Valenciana[J]. Cir Esp, 2021, 99(9): 666-677. DOI:10.1016/j.cireng.2021.10.001.

[4] Yin W, Li M, Fang JL, Li GH, Ma JJ, Guo YH, Zhang WT, Xu L, Liu LH, Chen Z. Clinical efficacy analysis of modified donor pancreatic tail splenic arteriovenous shunt in simultaneous pancreas-kidney transplantation[J]. Chin J Organ Transplant, 2025, 46(3): 219-225. DOI:10.3760/cma.j.cn421203-20250123-00017.

[5] Raveh Y, Ciancio G, Burke GW, et al. Susceptibility-directed anticoagulation after pancreas transplantation: a single-center retrospective study[J]. Clin Transplant, 2019, 33(7): e13619. DOI:10.1111/ctr.13619.

[6] Chinese Society of Organ Transplantation, Chinese Medical Association; Organ Transplant Physicians Branch, Chinese Medical Doctor Association; Xue Wujun. Guidelines for Organ Procurement from Deceased Donors. Chinese Journal of the Frontiers of Medical Science (Electronic Version). 2024, 16(11): 1-16. DOI: 10.12037/YXQY.2024.11-01.

[7] Du Toit DF, Reece-Smith H, McShane P, et al. A successful technique of segmental pancreatic autotransplantation in the dog[J]. Transplantation, 1981, 31(5): 395-396. DOI:10.1097/00007890-198105010-00018.

[8] Du Toit DF, Heydenrych JJ, Louw G, et al. Intraperitoneal transplantation of vascularized segmental pancreatic autografts without duct ligation in the primate[J]. Surgery, 1983, 94(3): 471-477.

[9] Duron JJ, Roux JM, Imbaud P, et al. The arteriovenous fistula in segmental pancreatic transplantation in dogs—a hemodynamic study[J]. Transplantation, 1987, 44(5): 600-601. DOI:10.1097/00007890-198711000-00002.
[10] Garvin PJ, Castaneda MA, Niehoff ML, et al. An in situ evaluation of distal splenic arteriovenous fistula on pancreas function in an isolated pancreas segment[J]. Arch Surg, 1985, 120(10): 1148-1151. DOI:10.1001/archsurg.1985.01390340046009.
[11] Dafoe DC, Ratner LE. Pancreatico-renal composite transplant: a new technique designed to decrease pancreatic graft thrombosis[J]. Clin Transplant, 2005, 19(5): 690-693. DOI:10.1111/j.1399-0012.2004.00295.x.
[12] [Xia SS, Wu ZD, Tang JZ, et al. Report of 2 cases of human allogeneic pancreatic segment transplantation[J]. Chin J Organ Transplant, 1983, 4(4): 162-164. DOI: 10.3760/cma.j.issn.0254-1785.1983.04.007.
[13] Zeng FJ, Guan ZJ, Wu ZH, et al. A case report of modified pancreatic transplantation with a limited splenic arteriovenous fistula to elude thrombosis[J]. Transplant Proc, 2024, 56(2): 456-458. DOI:10.1016/j.transproceed.2024.01.046.