

Novel surgical technique and efficacy analysis of donor pancreas preparation without vascular reconstruction in pancreas transplantation

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Abstract

Objective: Because of the complicated blood supply and vascular structure of the pancreas, blood vessel reconstruction and reshaping are generally required during pancreas transplantation. We modified the vascular preparation procedure for the donor pancreas (i.e., no vascular reconstruction was performed) based on experiences in our department and in other domestic and international transplantation centers.

Methods: Twelve donor pancreas preparations without vascular reconstruction were performed. The patch (Carrel patch), celiac trunk, and superior mesenteric artery were preserved as arterial inflow channels for the donor pancreas. The common hepatic artery and the gastroduodenal artery were transected at a site 0.5 cm away from the bifurcation. The bifurcated portion was preserved for the donor liver. The stumps of the gastroduodenal artery and common hepatic artery were then ligated. The portal vein was transected in the middle of the hepatoduodenal ligament during separation of the liver and pancreas. The partial portal vein preserved with the pancreas was used as the outflow channel of the donor pancreas.

Results: The transplanted pancreas functioned well in the recipients, and no vascular complications were reported.

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Conclusion: The overall efficacy of pancreas transplantation without vascular reconstruction has been improved.

Keywords

Donor pancreas, vascular reconstruction, pancreas transplantation, surgical technique, efficacy analysis, preparation

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Introduction

Pancreas transplantation, particularly simultaneous pancreas–kidney transplantation, has become a radical treatment for patients with type 1 diabetes mellitus (T1DM), patients with T1DM with end-stage renal disease, and some patients with type 2 diabetes mellitus (T2DM).^{1–4} As of 2014, approximately 40,000 cases of pancreas transplantation had been performed worldwide, with an average of 900 cases per year. The recipient and graft survival rates have continually improved, with an overall 5-year survival rate of 90%.^{5,6} Considering the substantial number of patients with DM in the general population, the number of transplant cases and the graft survival rate are considerably lower than those for kidney or liver transplantation. Possible reasons for these differences include concerns about higher surgical risk in pancreas transplantation and the availability of the procedure, which is limited to a few domestic and foreign transplant centers. After pancreas transplantation, vascular complications such as thrombosis and hemorrhage are mainly responsible for pancreatic graft failure.^{7–9}

At most pancreas transplantation centers, the donor pancreas is procured only with the splenic artery and the superior mesenteric artery. The celiac trunk is preserved for the donor liver. Thus, the pancreas transplant must be prepared *ex situ* before transplantation with a Y-graft

between the splenic artery and superior mesenteric artery using the donor's external, internal, or common iliac artery.⁴ In China, *en bloc* removal of the pancreas and liver is a common practice and is followed by *ex situ* separation of the donor pancreas from the donor liver. The celiac trunk, superior mesenteric artery, and partial abdominal aorta from which these two arteries arise are preserved for the donor pancreas, and the common hepatic artery is preserved for the donor liver. Anastomosis of the proximal hepatic artery to the distal gastroduodenal artery is performed to reconstruct the arterial arch of the pancreatic head. In terms of vein management, the donor's common iliac vein is anastomosed to the portal vein preserved in the donor pancreas to lengthen the pancreatic vein outflow channel and facilitate surgery in the recipient. These vascular anastomoses and reconstructions not only prolong the duration of pancreas preparation but inevitably increase the incidence of postoperative vascular complications because of the increased number of vascular anastomoses.

To reduce the vascular complication rate and improve the comprehensive efficacy of pancreas transplantation, we modified the vascular preparation of the donor pancreas based on the experiences in domestic and international transplantation centers; i.e., no vascular reconstruction was performed. This novel procedure can theoretically

reduce the incidence of vascular complications caused by thrombosis, hemorrhage, and prolonged cold ischemia.

Materials and methods

Recipient data

All recipients in this study were diagnosed with DM complicated with renal failure and scheduled to undergo simultaneous pancreas-kidney transplantation. All patients received insulin treatment to control their blood glucose levels and presented with varying degrees of DM-related complications. The detailed patient data are shown in Table 1.

Donor data

None of the donors had a history of DM or hyperglycemia before donation. The organ donation procedure was performed in accordance with the "Chinese Guidance of Donation after Cardiac Death." All donor donations were performed after circulatory death.¹⁰ The organs were procured via the rapid procure approach for abdominal organs (5 minutes after cardiac death). The detailed data of the donors are shown in Table 2.

Donor pancreas procure

The *en bloc* removal technique for multiple abdominal organs was used to procure the donor pancreas. *Ex situ* separation of the donor pancreas from the donor liver was performed on the organ preparation table. The hepatoduodenal ligament was dissected. The common bile duct was excised close to the duodenum. The portal vein was transected in the middle of the hepatoduodenal ligament. The common hepatic artery and the gastroduodenal artery were transected at a site 0.5 cm from the bifurcation after separation. The bifurcated portion was preserved for the donor liver. The

stumps of the preserved common hepatic artery and the gastroduodenal artery in the donor pancreas were marked with 6-0 Prolene sutures. At this point, the pancreas was separated from the liver.

Preparation of donor pancreas

For artery preparation, the patch was preserved simultaneously with the celiac trunk and superior mesenteric artery. Heparin saline was injected into the superior mesenteric artery, and an overflow sign from the stump of the gastroduodenal artery (which was excised during separation from the liver) indicated that the arterial arch of the pancreatic head was intact. Anastomosis was not required; the stumps of the gastroduodenal artery and common hepatic artery only needed to be ligated. The Carrel patch served as the inflow artery; a Y-graft was not required. For vein preparation, the portal vein was transected in the middle of the hepatoduodenal ligament to ensure a sufficient length of the anastomosis in the recipient, as previously described; lengthening of the portal vein was not required. At this point, pancreas preparation without *ex situ* blood vessel anastomosis was completed (Figure 1 (a) and (b)).

Surgical procedure in recipients

A para-rectus abdominis incision was made in the right lower abdomen to mobilize the external iliac artery and vein. The prepared donor pancreas was longitudinally placed in the right iliac fossa within the abdominal cavity, with the pancreatic head toward the head side. End-to-side anastomosis of the donor Carrel patch to the recipient's external iliac artery was performed. The portal vein of the donor pancreas was anastomosed end-to-side to the recipient's external iliac vein. A lateral incision was made in the side wall of the preserved duodenum in the donor pancreas, and leakage of pancreatic juice was

Table 1. Preoperative characteristics of recipients undergoing simultaneous pancreas-kidney transplantation.

Patient number	Age (years)	Sex	Diabetes type	Major comorbidities	Hemoglobin level (g/L)	Albumin level (g/L)	Blood glucose level (mmol/L)	Creatinine level (μ mol/L)	Fasting C-peptide level (mmol/L)	Blood insulin level (mmol/L)
1	60	Male	II	Renal failure	123	38.2	4.4	668	0.399	36.7
2	27	Male	I	Renal failure Retinopathy	83	29.5	9.5	656	0.003	5.50
3	49	Male	II	Renal failure	80	25.4	5.2	1338	4.010	27.94
4	40	Female	I	Renal failure	83	36.0	9.0	302	0.079	3.65
5	44	Male	II	Renal failure	103	32.3	12.4	390	0.758	44.80
6	48	Male	II	Retinopathy	115	42.7	7.7	563	0.015	22.10
7	30	Male	I	Renal failure	92	34.9	7.7	583	0.312	5.80
8	48	Male	II	Renal failure	116	38.6	5.1	1180	3.99	26.30
9	41	Female	II	Renal failure	91	35.5	6.2	856	0.513	19.80
10	54	Male	II	Renal failure	105	33.6	7.1	578	0.087	33.60
11	56	Male	II	Renal failure	98	28.4	6.8	680	0.629	28.60
12	47	Male	II	Retinopathy Renal failure	88	37.1	4.7	591	0.037	21.70

Table 2. Characteristics of donors for simultaneous pancreas–kidney transplantation.

Donor No.	Sex	Age (years)	Cause of death	Pathogenic examination	Liver and kidney function	Blood sugar level (mmol/L)	Weight, height, BMI (kg, cm, kg/m ²)	Presence of low blood pressure and low blood oxygen	Application of ventilator
1	Male	19	Brain trauma due to car accident	Negative	Normal	5.07	70, 180, 20	None	Yes
2	Male	42	Extremely severe craniocerebral trauma	Negative	normal	5.69	60, 168, 21	None	Yes
3	Male	21	Brain trauma due to car accident	Negative	Normal	6.00	55, 173, 19	None	Yes
4	Male	27	Extremely severe craniocerebral trauma	Negative	Normal	5.34	70, 170, 24	None	Yes
5	Male	8	Ganglion neuroblastoma	Negative	Normal	9.00	28, 120, 19	None	Yes
6	Male	19	Brain injury due to gunshot Cerebral hernia	Positive sputum smear	Normal	15.56	50, 168, 18	None	Yes
7	Male	25	Spontaneous intracerebral hemorrhage	Negative	Normal	5.69	60, 168, 21	Presence of low blood pressure/no hypoxia	Yes
8	Male	22	Severe craniocerebral trauma	Negative	Normal	6.80	66, 174, 22	None	Yes
9	Female	16	Brain trauma due to car accident	Negative	Normal	5.80	40, 150, 17	None	Yes
10	Female	26	CO poisoning	Negative	Normal	5.95	63, 168, 22	None	Yes
11	Male	50	Severe craniocerebral trauma	Negative	Normal	7.62	71, 176, 24	None	Yes
12	Female	25	Brain trauma due to car accident	Negative	Normal	3.89	46, 162, 18	None	Yes

BMI, body mass index; CO, carbon monoxide.

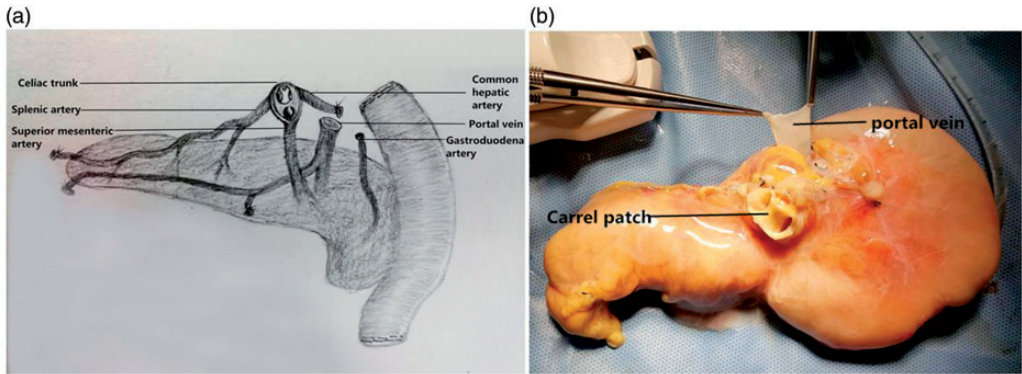


Figure 1. (a) Diagram and (b) photograph of pancreas preparation.

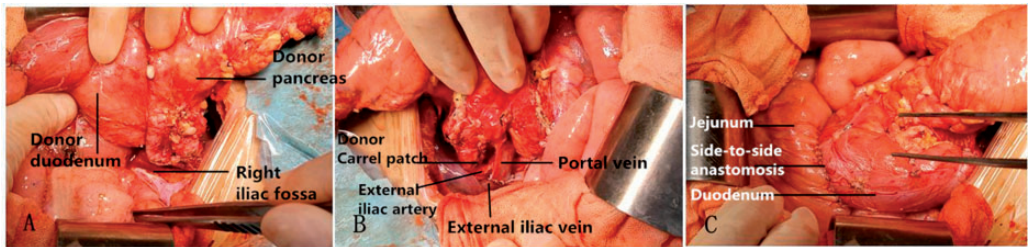


Figure 2. Operative photographs of a pancreas transplant.

observed. Side-to-side anastomosis of the donor duodenum and the recipient's jejunum was performed to establish a channel for the pancreatic secretions (Figure 2(a)–(c)).

Ethics statement

This study was approved by the Ethics Committee of the First Affiliated Hospital of Sun Yat-sen University (No. 2018-0096).

Results

The recipients comprised 12 patients (10 men and 2 women); 3 were primarily diagnosed with T1DM, and 9 were diagnosed with T2DM. Twelve donors were also included in the study. Pancreas preparation without vascular reconstruction was used in all 12 patients undergoing pancreas

transplantation. Anastomosis of the donor portal vein and recipient external iliac vein was performed in the recipients; the donor Carrel patch was anastomosed to the external iliac artery of the recipient. The anastomosis procedure went smoothly. When the clamp was removed, the pancreatic blood inflow and outflow appeared normal. All 12 patients returned to consciousness 4 to 6 hours after the end of anesthesia. The patients were weaned from mechanical ventilation 8 to 14 hours after surgery. The patients stayed in the surgical intensive care unit for 2 to 3 days after surgery and were then transferred to the regular ward for routine rehabilitation. Flatus and defecation were reported 5 to 6 days after surgery. The serum C-reactive peptide levels returned to normal limits within 1 to 2 weeks, and the

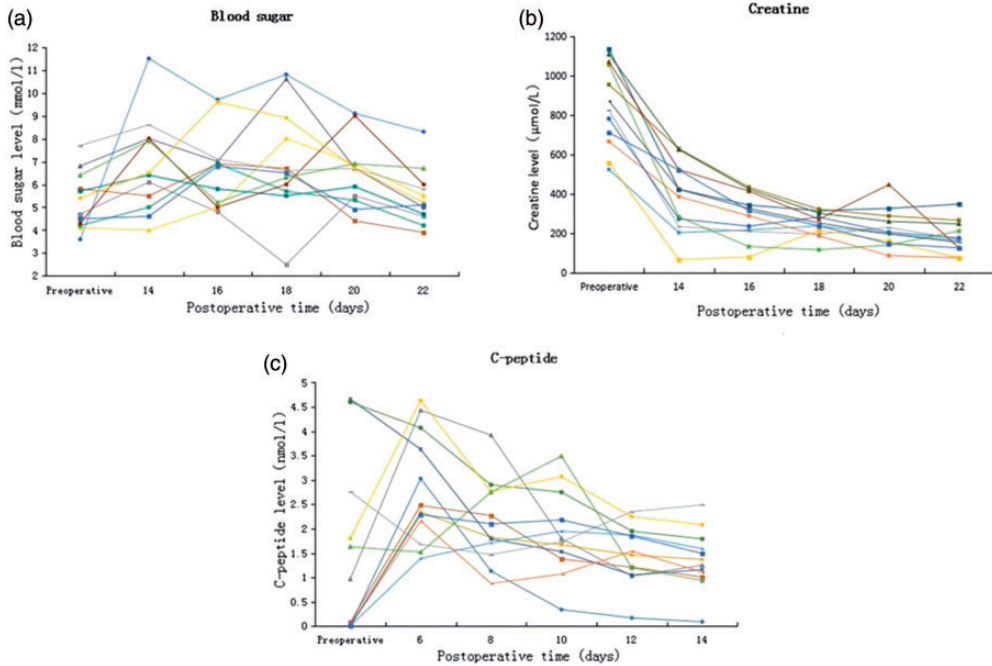


Figure 3. Early changes in the pancreas and renal function in patients undergoing pancreas transplantation.

blood glucose and creatinine levels returned to normal limits within 2 to 3 weeks (Figure 3(a)–(c)). The transplanted pancreas functioned well in all recipients, and no vascular complications were reported.

Discussion

Pancreas transplantation is an effective method for the treatment of end-stage DM.^{11–13} The difficulty of pancreas transplantation is mainly due to the anatomical and physiological characteristics of the pancreas itself. The pancreatic blood supply and structure are complicated by the multiple blood vessels involved. Furthermore, the pancreatic tissues are fragile, easily damaged, and sensitive to ischemia. Therefore, pancreas procurement and preparation are keys to successful transplantation.

A successful pancreas transplantation depends largely on the surgical techniques used.^{14,15} Separation of the pancreas from the liver and performance of an isolated transplantation was historically considered impossible because the liver and pancreas share blood vessels.¹⁶ The arterial blood supply of the pancreas mainly comes from three arteries: the superior mesenteric artery, the gastroduodenal artery, and the splenic artery. The pancreatic head is supplied by two arterial arches: (1) the anterior arterial arch, which includes the superior-anterior pancreaticoduodenal artery arising from the gastroduodenal artery and the inferior-anterior pancreaticoduodenal artery arising from the superior mesenteric artery, and (2) the posterior arterial arch, which includes the superior-posterior pancreaticoduodenal artery arising from the gastroduodenal artery and the inferior-posterior pancreaticoduodenal artery

arising from the superior mesenteric artery. The two arterial arches supply the pancreatic head, the uncinate process, and the portion of the duodenum around the pancreatic head. The pancreatic body and tail are supplied by the splenic artery and its branches, especially the dorsal pancreatic artery and transverse pancreatic artery. Surgeons historically recommended preservation of the celiac trunk, splenic artery, and superior mesenteric artery for transplantation of the whole pancreas.¹⁷ Separation and isolated transplantation of the liver and pancreas are relatively difficult because both transplants require use of the celiac trunk. In the late 1980s, these procedures became feasible after development of arterial reconstruction techniques.^{18,19}

In pancreas transplantation, arterial and venous reconstruction increases both the time required for pancreas preparation and the incidence of complications, including postoperative thrombosis, hemorrhage, pancreatic leakage, and intestinal leakage. A prolonged preparation time leads to a prolonged cold ischemia time, which causes corresponding complications such as pancreatic edema and pancreatitis. According to a study by Sutherland et al.,²⁰ the incidence of surgical complications in pancreatic transplantation ranges from 8% to 45%. A study by Harbell et al.²¹ involving 112 patients undergoing pancreas transplantation with vascular reconstruction revealed postoperative thrombosis in 30 (27%) patients, graft loss in 5 patients, and venous thrombosis in 4 patients during the 5-year period following transplantation. Surgical complications often led to removal of the transplanted pancreas.

To address these problems, the portal vein was transected in the middle of the hepatoduodenal ligament to ensure a sufficient length for transplantation. Lengthening of the portal vein was not necessary. In addition, heparin saline was

injected into the superior mesenteric artery to test the integrity of the arterial arches of the pancreatic head. An overflow sign from the stump of the gastroduodenal artery indicated that anastomosis of the gastroduodenal artery and common hepatic artery was not required, but the stumps of the gastroduodenal artery and common hepatic artery needed to be ligated. The Carrel patch served as an inflow artery, and a Y-graft was not required.

Conclusions

The modified donor pancreas preparation without vascular anastomosis used in this study can significantly improve surgical efficiency. Theoretically, the omission of vascular anastomosis can greatly reduce the incidence of hemorrhage and thrombosis (no complications were reported in 12 patients in this study), promote patient recovery, and improve the comprehensive efficacy of pancreatic transplantation. However, the limitations of this study included its small sample size and short observation period. Thus, further studies are needed to improve pancreas transplantation.

Abbreviations

DM: diabetes mellitus.

T1DM: type 1 diabetes mellitus.

T2DM: type 2 diabetes mellitus.

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Contributors

WW L and AB H contributed to the conception and experimental design. WW L, C Z, FR L, XC L, and AB H contributed to the data acquisition, analysis, and interpretation. All authors contributed to the various elements of intellectual content. The manuscript was drafted, edited,

and revised by WW L. All authors read and approved the final manuscript.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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