DOI: 10.15825/1995-1191-2020-4-154-161

METHODS OF ARTERIAL RECONSTRUCTION FOR PANCREATIC GRAFT

N.S. Zhuravel, I.V. Dmitriev, A.V. Pinchuk

Sklifosovsky Research Institute of Emergency Care, Moscow, Russian Federation

About 2,400 pancreas transplantations are performed every year worldwide, mainly pancreaticoduodenal transplantations. Most clinics use the classical revascularization technique using a Y-shaped vascular prosthetic implant. However, it is not always possible to restore full blood supply to the graft in this way. Therefore, other options for arterial reconstruction are being developed – from isolated blood supply to the graft via the splenic artery to full blood flow restoration through all the main vessels of the organ to ensure the most physiological blood supply to the pancreas. This review is devoted to analysis of the used arterial reconstruction methods and pancreaticoduodenal graft revascularization techniques.

Keywords: pancreas transplantation, pancreaticoduodenal graft, arterial reconstruction, Y-shaped vascular graft, isolated blood supply via the splenic artery.

INTRODUCTION

According to the World Health Organization (WHO), about 200 million people in the world are currently suffering from diabetes. In Russia, 256,200 patients have type 1 diabetes with an annual increase of about 10,000 new cases [1]. WHO predicts that the number of people living with diabetes will rise to 552 million by 2030. This undoubtedly makes diabetes a pandemic of non-infectious etiology.

Simultaneous pancreas-kidney (SPK) transplantation is one of the options for surgical treatment of diabetes in end-stage diabetic nephropathy. This treatment method allows to arrest kidney failure, achieve true insulin independence and significantly improve the patient's quality of life. According to the Global observatory on donation and transplantation (GODT), 2,338 transplants were performed in the world in 2018, of which only 17 were in Russia [2]. Such a small (in comparison to other solid organs) number of operations is due to shortage of suitable donor organs, very stringent requirements for organ quality, and relatively high frequency of loss of pancreas graft due to surgical and immunological complications.

Hendon was the first to attempt pancreas transplant surgery in 1913 in an animal experiment [3]. The first successful human pancreas transplant was performed by William D. Kelly and Richard C. Lillehei on December 17, 1966 at the University of Minnesota (USA). They performed a single-stage transplant of a kidney and pancreatic segment with a ligated main pancreatic (Wirsung) duct on a 28-year-old female patient with end-stage diabetic nephropathy. They developed and applied a method for arterial graft reconstruction with a Y-shaped vascular alloprosthesis (Y-graft), i.e. a technique still used in most transplant centers as a conventional technique for revascularization of a pancreaticoduodenal graft [4].

Given the fact that the native pancreas gets blood supply from 3 main arteries, some surgeons seek to modify this technique to achieve the most physiological organ revascularization. Others, on the other hand, seek to simplify the arterial reconstruction scheme by proposing to minimize the number of vascular anastomoses during operation. Meanwhile, methods have been proposed that would allow the use of those organs that were previously recognized as non-transplantable due to the impossibility of performing Y-graft reconstruction. There are also cases where surgeons have to modify the conventional technique due to the physiological characteristics of the donor organ or recipient.

This review is devoted to analysis of the types of arterial reconstruction and methods of revascularization of pancreatic grafts from the moment of first transplantation in 1966 to the present time at various transplant centers.

METHODS OF RECONSTRUCTION OF THE SPLENIC AND SUPERIOR MESENTERIC ARTERIES

More than 50 years have passed since the first pancreas transplant was performed, but Y-graft reconstruction of the arterial bed is still relevant today. In this technique, at the preoperative preparation stage, a single arterial suture is formed between the superior mesenteric and splenic arteries of the graft using Y-shaped alloprosthesis. Typically, the Y-graft is the bifurcation site of the donor's common iliac artery. Bifurcation of the common carotid or femoral artery can also be used. At the stage of transplantation, anastomosis is formed between the Y-graft and the common iliac, less often the external, recipient

Corresponding author: Nikita Zhuravel. Address: 3/2, Bolshaya Sukharevskaya Ploshchad, Moscow, 129090, Russian Federation. Phone: (906) 703-05-42. E-mail: zhuravelns@gmail.com

artery. This technique of revascularization of the pancreaticoduodenal segment is considered conventional at most transplant centers. At the University of Minnesota clinic, where pancreas transplant was performed for the first time in the world, about 2256 pancreas transplants were performed from 1966 to 2016 using this technique [5, 6]. According to a published report, the incidence of serious arterial complications at this center was 1.1% (10 arteriointestinal fistulas with gastrointestinal bleeding, 3 arteriovesical fistulas, 3 arteriovenous fistulas, 1 arterioureteral fistula, and 7 false aneurysms) [7].

Agnieszka Surowiecka-Pastewka *et al.* analyzed 200 pancreas transplants performed in a single center. They used a classical graft revascularization technique, with the incidence of arterial complications being 3% (2 deaths). In one patient, the revision revealed a ruptured section of the external iliac artery with massive bleeding. Due to dense infiltration, it was difficult to apply open suturing, so endovascular stenting of this area was performed. Control CT scan revealed no evidence of bleeding. In one case, arteriocystic fistula was formed 6 months after transplantation. Later, the patient developed gastrointestinal bleeding, which could not be stopped by endoscopic method, so the pancreaticoduodenal graft was removed. In another case, a patient with repeated transplantation in the early postoperative period was found to have common iliac artery stenosis proximal to the anastomosis; therefore, endovascular stenting of the artery was performed. No recurrent stenosis was detected in a follow-up study [8].

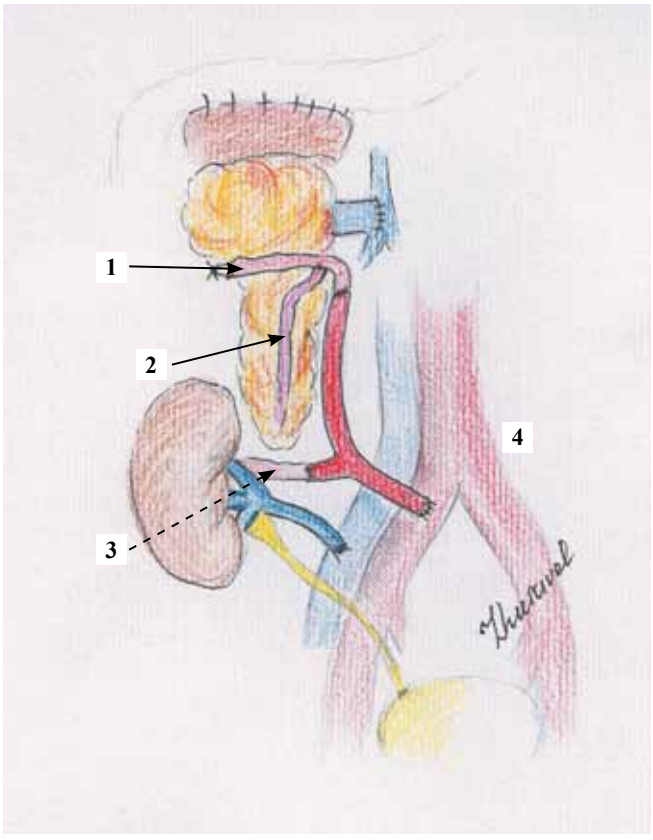

Fig. 1. Graft revascularization in patients with severely calcified iliac arteries: 1 – Donor superior mesenteric artery; 2 – Donor splenic artery; 3 – Donor renal artery; 4 – Aorta

At their center, L. Grabowska-Derlatka *et al.* use the classical graft revascularization technique with abdominal multispiral computed tomography (MSCT) for all recipients at day 6–8 after SPK transplantation. Out of the 60 patients, there were 9 cases of small intragraft vessel thrombosis and 17 cases of large vessel thrombosis. Half of these cases required graft removal [9].

At Brotzu Hospital, from 2005 to 2014, 27 pancreas transplants were performed using the classical revascularization technique. No vascular complications were noted in any case [10].

An interesting surgical technique has been described by Paul L. Tso *et al.* In 5 recipients with total superior vena cava thrombosis and severe iliac calcification, a tunneled central hemodialysis venous catheter was inserted into the left iliac vein. While performing SPK transplantation in these patients, the authors used an original modification of the classical technique: during back table preparation of the kidney, the renal transplant artery was anastomosed in end-to-end fashion to the internal iliac limb of the donor iliac artery Y graft (Fig. 1). The superior mesenteric artery of the pancreatic graft was anastomosed to the external iliac artery Y-graft also in an end-to-end manner. Then, an end-to-side anastomosis was formed between the splenic and superior mesenteric arteries of the graft [11]. Afterwards, an anastomosis was made between the single arterial conduit of the grafts and a small calcification-free area of the recipient's external iliac artery. Out of the 5 patients who underwent transplantation by this method, 1 patient developed a pseudoaneurysm of the allograft at the anastomosis of the splenic and superior mesenteric arteries manifested by gastrointestinal bleeding. This complication required pancreatectomy. The rest of the recipients had no serious complications, and the graft function was satisfactory [12].

In some cases, during pancreas transplantation, the reasons of why it is not possible to use the classical technique are revealed. In such cases, surgeons use various modifications of the classical method. For instance, a curious clinical observation was described by David F. Mercer. During simultaneous transplantation after reperfusion of the pancreaticoduodenal complex, surgeons had to perform immediate transplantatectomy due to ischemia of the donor pancreaticoduodenal segment and abrupt disturbance in blood supply in the recipient's external iliac artery. The cause was an extended atherosclerotic plaque in the anastomotic region. The affected portion of the artery was excised, while the arterial wall defect was repaired with a Gore-Tex® synthetic patch (W.L. Gore and Associates, Flagstaff, AR, USA). Five days later, the patient underwent a pancreas

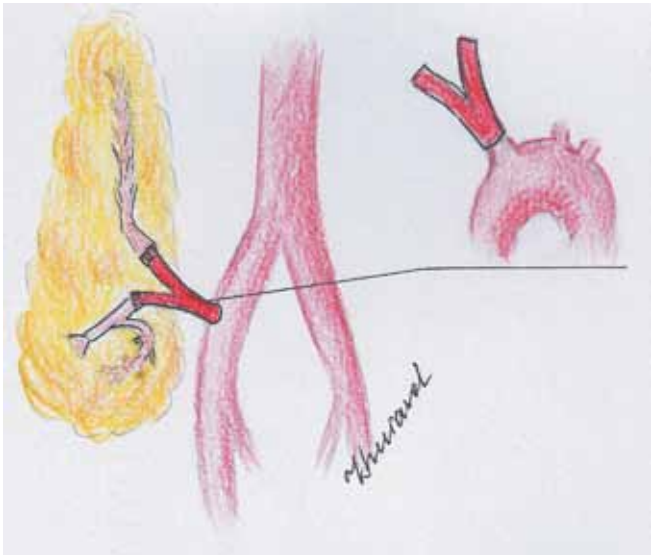

Fig. 2. Formation of a Y-shaped graft using bifurcation of brachiocephalic trunk

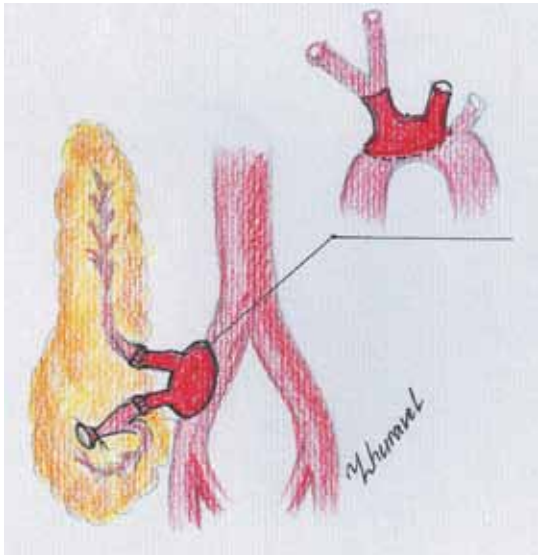

Fig. 3. Formation of a Y-shaped graft using a section of the aortic arch with the brachiocephalic trunk and the left common carotid artery

re-transplantation, during which the synthetic prosthesis was removed. In order to close the arterial defect, the following method was used: the external iliac artery of the donor Y-graft was cut off from the common iliac artery bifurcation and dissected along a linear incision. Thus, from the donor Y-graft, the surgeons obtained a 6-cm allogenic patch, which was used to restore the integrity of the recipient's external iliac artery. In turn, the Y-graft was used to form the common arterial orifice of the pancreatoduodenal graft, which was subsequently successfully anastomosed with an allogeneic arterial patch [13]. Ciancio *et al.* used a section of the brachiocephalic trunk with the subclavian and common carotid arteries as a Y-graft, since the donor's iliac arteries were calcified and unsuitable for reconstruction. At the pre-transplant preparation stage, anastomoses were formed between the superior mesenteric and subclavian arteries, and between the splenic and common carotid arteries (Fig. 2). During transplantation, anastomosis was formed between the base of the donor brachiocephalic trunk and the recipient's common iliac artery [14]. In a similar case, de Miranda *et al.* used as a Y-graft a section of the aortic arch with the brachiocephalic trunk and the left common carotid artery (Fig. 3) [15]. Mizrahi *et al.* performed revascularization of the pancreas without Y-graft. They made an anastomosis between the superior mesenteric artery of the graft and the common iliac artery of the recipient, having previously connected the splenic and superior mesenteric arteries of the pancreatoduodenal complex in an end-to-side manner (Fig. 4) [16]. Troppmann *et al.* reported the possibility of forming separate arterial anastomoses with the external and internal iliac arteries of the recipient, also without the use of Y-graft [17]. In cases where during transplantation, the venous outflow is carried out into the portal vein system, it becomes

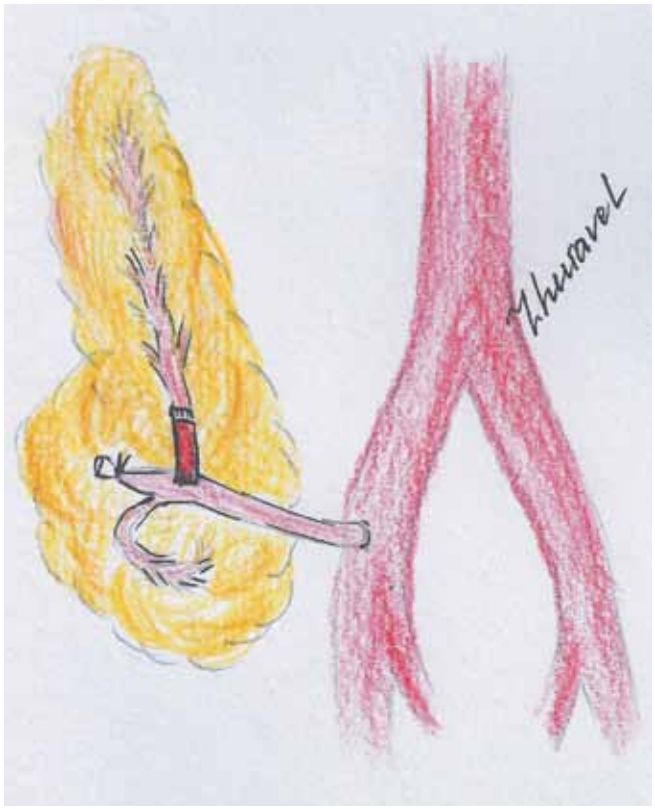

Fig. 4. Graft revascularization through the superior mesenteric artery with preliminary end-to-side connection of the splenic to superior mesenteric artery

difficult to use the Y-graft due to its insufficient length. In such cases, Bigam proposed forming an additional anastomosis between the donor brachiocephalic trunk and the recipient's iliac artery, and then restoring blood supply to the graft using the brachiocephalic joint and Y-graft in an end-to-end manner (Fig. 5) [18].

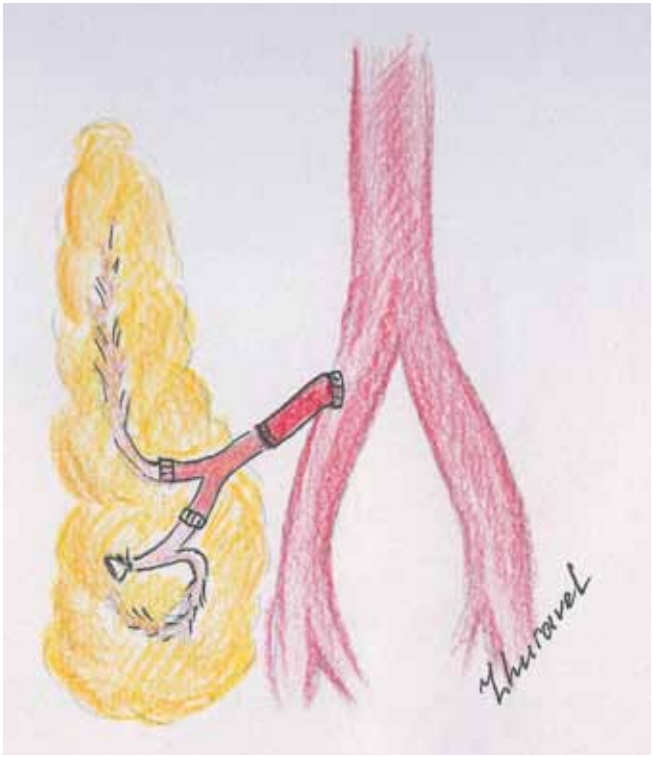

Fig. 5. Using an additional section of the brachiocephalic trunk to lengthen the vascular Y-shaped graft

ARTERIAL REVASCULARIZATION OF PANCREATICODUODENAL GRAFT USING THE CARREL PATCH

To reduce the incidence of vascular complications and the number of arterial anastomoses in pancreatic transplantation, Wen-wei Liao *et al.* modified vascular organ reconstruction based on international experience. In September 2019, they published a paper suggesting that vascular reconstruction should not be performed at the pre-transplantation stage. During multi-organ harvesting, surgeons transected the common hepatic artery after splitting the celiac trunk, allowing them to leave the splenic and superior mesenteric arteries with the celiac trunk in the same location as the aortic site (Fig. 6). This harvesting technique made it possible to perform donor organ revascularization, forming one arterial anastomosis, without prior formation of a Y-graft. The authors believe that this modification can theoretically reduce the incidence of vascular complications caused by thrombosis, bleeding and prolonged cold ischemia, since instead of three (in the classical version), one arterial anastomosis is formed, which reduces the number of risk zones and the time for pre-transplant preparation of the pancreatoduodenal complex. Of the 12 recipients who underwent pancreatic transplantation using this technique, no vascular complications were identified in any case. Graft function in all 12 cases was found to be satisfactory [19].

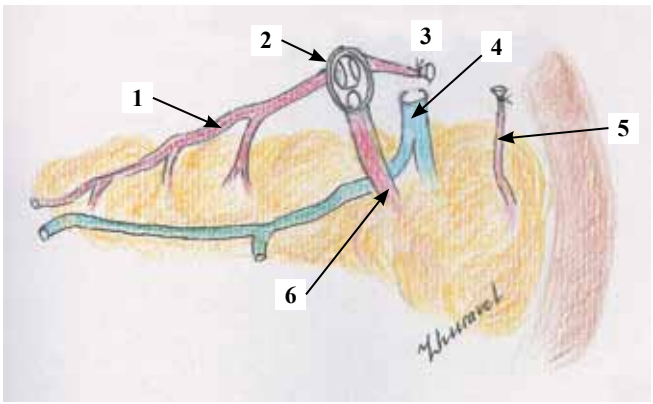

Fig. 6. Graft revascularization using the Carrel patch: 1 – Splenic artery; 2 – Carrel patch; 3 – Common hepatic artery; 4 – Portal vein; 5 – Gastroduodenal artery; 6 – Superior mesenteric artery

Earlier, a similar technique was described by J. Paulino et al. In their work, they focused on the "transverse pancreas" transplantation technique. But no less important is the graft revascularization technique applied by the authors. In 64 surgical interventions, they formed an anastomosis between the common area of the donor's aorta, with the celiac trunk and superior mesenteric artery, and the recipient's common iliac artery. Pancreas graft loss was 7.1%, and the main cause was venous thrombosis. That notwithstanding, there were no complications from arterial anastomosis [20].

ISOLATED BLOOD SUPPLY TO THE PANCREATICODUODENAL COMPLEX VIA THE SPLENIC ARTERY

In some cases, after harvesting the liver graft, the superior mesenteric artery supplying the pancreas remains too short for typical arterial reconstruction, since the orifice of the inferior pancreaticoduodenal artery is inevitably compromised during vascular anastomosis. Previously, in such cases, the pancreas was considered unsuitable for transplantation. At the same time, MSCT of recipients with a successfully functioning pancreaticoduodenal complex usually reveals a well-developed network of vascular collaterals between the basins of the splenic and superior mesenteric arteries. Due to the high occurrence of such vascular architectonics, a technique for isolated revascularization of the pancreaticoduodenal complex through the splenic artery was suggested and tested in practice. A special test was proposed to determine whether there is sufficient number of collaterals; if it gives a positive result, the graft can be successfully transplanted with restoration of arterial blood supply only through the splenic artery. From 2012 to 2018, out of 21 recipients who underwent SPK transplantation, surgery was performed using this technique in 6 cases. The control group of recipients underwent revascularization using the classical arterial reconstruction technique. No

vascular complications were detected in recipients of both groups. There were no statistically significant differences in the volume blood flow characteristics revealed by control MSCT of the pancreaticoduodenal graft in the control and comparison groups [21].

COMPLETE RECONSTRUCTION OF THE MAIN ARTERIES SUPPLYING BLOOD TO THE PANCREAS

In some transplantation centers, surgeons during pancreatic transplantation consider it reasonable to restore blood supply to the graft through all the three main arteries supplying blood to the pancreas – gastroduodenal, splenic and inferior pancreaticoduodenal (i.e. superior mesenteric) arteries. One of the practical ways to implement this reasonable aspiration is to insert a Y-graft between the gastroduodenal and splenic arteries, followed by formation of a common site with the superior mesenteric artery (Fig. 7). This technique makes it possible to transplant even the organs with iatrogenic arterial injuries without ischemia injury to the graft due to insufficiency of intraorganic circulation [22]. C. Socci *et al.* assessed the treatment outcomes of 199 patients who underwent pancreatic transplantation. In 60% of cases, blood supply to the graft was restored through the gastroduodenal artery using Y-graft. In other cases, the classical vascular reconstruction technique was used. Among the complications that developed in the postoperative period, the authors describe the occurrence of gastrointestinal bleeding, while, in 85% of cases of their development, revascularization of the pancreas was done using the classical technique [23].

DISCUSSION

Three main arteries are involved in supplying blood to the pancreas. When using the classical revascularization technique, blood supply to the pancreas is restored through two of the arteries – the inferior pancreaticoduodenal (first branch of the superior mesenteric artery) and the splenic. In this case, blood supply to the graft parenchyma goes through the inferior anterior and posterior pancreaticoduodenal arteries, the dorsal pancreatic artery, the pancreas tail artery, and the greater pancreatic artery. In this respect, due to insufficient revascularization of the gastroduodenal artery, blood supply through the superior anterior and posterior pancreaticoduodenal arteries and, in some cases, the superior duodenal artery, is carried out retrogradely, from intraorgan vascular collaterals. Theoretically, this can lead to circulatory insufficiency in the region of the pancreas head and donor duodenal stump. Given the presence of anastomoses between the superior and inferior pancreaticoduodenal arteries, the Y-graft method is recognized by most experts as sufficient and the most optimal. Having said that, formation of three arterial anastomoses can increase the risk

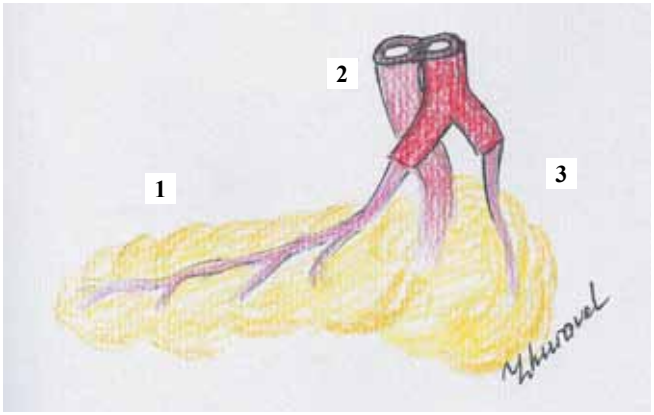

Fig. 7. Graft revascularization via 3 main arteries: 1 – Splenic artery; 2 – Superior mesenteric artery; 3 – Gastroduodenal artery

of vascular complications, such as stenosis, thrombosis, and anastomotic aneurysm. The technique for forming an anastomosis between the aortic site (carrel patch) of the graft and the recipient's iliac artery reduces the risk of developing vascular complications and reduces the warm ischemia time. However, in multi-organ harvesting, the portion of the aorta required for the arterial site is used in most cases during liver transplantation.

Gastroduodenal artery repair can improve blood supply to the pancreas head and duodenum, preventing ischemia. However, this method increases the number of anastomoses, which increases the ischemia time and number of potentially dangerous, "weak" sites for occurrence of vascular complications. The technique involving restoration of isolated blood supply to the graft along the splenic artery has also proved to be effective in cases where the length of the superior mesenteric artery does not allow forming an anastomosis using any other technique. However, this technique can be safely used only with intensive development of arterial collaterals in the graft parenchyma.

During organ harvesting and pre-transplant preparation, one should also not forget about the importance of the dorsal pancreatic artery, which can extend not only from the splenic artery, but also from the common hepatic artery, and even the celiac trunk. When it is damaged, blood supply to the organ is disturbed so significantly that it can lead to ischemia of a large part of the parenchyma with corresponding severe complications and consequences [24]. Besides, in a number of cases, there is a variant anatomy of the pancreas, including, in addition to the dorsal artery, a doubling of the splenic artery. In this case, for sufficient graft revascularization, a modification of the Y-graft technique can be used, in which two splenic arteries are connected side-to-side to form a single arterial orifice, which is then anastomosed with the internal iliac artery Y-graft. The dorsal artery can also be attached to the Y-graft end-to-side (Fig. 8) [25].

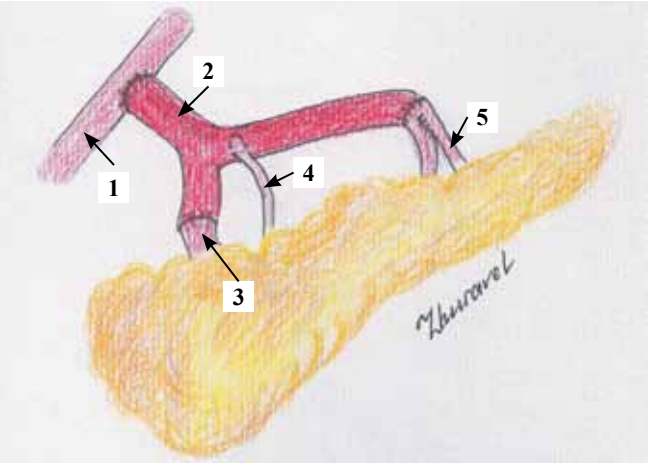

Fig. 8. Additional revascularization of the dorsal pancreatic artery and accessory splenic artery: 1 – Native external iliac artery; 2 – Common iliac artery; 3 – Superior mesenteric artery; 4 – Dorsal pancreatic artery; 5 – Syndactylized splenic arteries

CONCLUSION

At present, quite a lot of variants have been proposed for donor pancreas revascularization during transplantation. Each technique has its own advantages and disadvantages; even the classical technique comes with rather many complications from arterial anastomoses. This has made surgeons around the world to develop and implement new graft revascularization modifications and variants. The final choice of a particular technique depends on the anatomical features of the graft, the specific surgical situation, and the preferences of the surgeons performing the pancreas transplantation.

The authors declare no conflict of interest.

REFERENCES

1. *Shestakova MV, Vikulova OK, Zheleznyakova AV, Isakov MA, Dedov II*. Diabetes epidemiology in Russia: what has changed over the decade? *Terapevticheskii arkhiv*. 2019; 91 (10): 4–13. (in Russ, English abstract). https://doi.org/10.26442/00403660.2019.10.000364.
2. Global observatory on donation and transplantation – 2018 [Internet] [updated 2020 August 11]. Available from: http://www.transplant-observatory.org/summary/.
3. *Starzl T, Thai N, Shapiro R.* The history of pancreas transplantation. In: Corry RJ (ed.) *Pancreatic transplantation*. New York: Springer; 2006: 21–31.
4. *Kelly WD, Lillehei RC, Merkel FK, Idezuki Y, Goetz FC.* Allotransplantation of the pancreas and duodenum along with the kidney in diabetic nephropathy. *Surgery*. 1967; 61 (6): 827–837. PMID: 5338113.
5. *Gruessner RWG, Sutherland DER*. (eds.) Transplantation of the Pancreas. New York: Springer; 2004.
6. *Sutherland DE, Gruessner RW, Dunn DL, Matas AJ, Humar A, Kandaswamy R et al*. Lessons learned from more than 1,000 pancreas transplants at a single institution. *Ann Surg*. 2001; 233 (4): 463–501. PMID: 11303130. https://doi.org/10.1097/00000658-200104000-00003.
7. *Yadav K, Young S, Finger EB, Kandaswamy R, Sutherland DER, Golzarian J, Dunn TB.* Significant arterial complications after pancreas transplantation – A single-center experience and review of literature. *Clin Transplant*. 2017; 31 (10). PMID: 28787529. https://doi.org/10.1111/ctr.13070.
8. *Surowiecka-Pastewka A, Matejak-Górska M, Frączek M, Sklinda K, Walecki J, Durlik M*. Endovascular Interventions in Vascular Complications After Simultaneous Pancreas and Kidney Transplantations: A Single-Center Experience. *Ann Transplant*. 2019; 24: 199–207. PMID: 30975974. https://doi.org/10.12659/AOT.912005.
9. *Grabowska-Derlatkaa L, Grochowiecki T, Pacho R, Rowiński O, Szmidt J.* Role of 16-Multidetector Computerized Tomography in Evaluation of Graft Failure Risk in Patients with Pancreatic Graft Thrombosis After Simultaneous Pancreas and Kidney Transplantation. *Transplant Proc*. 2014; 46 (8): 2822–2824. PMID: 25380927. https://doi.org/10.1016/j.transproceed.2014.09.073.
10. *Tondolo V, Manunza R, Pellegrino RA, Zamboni F*. Pancreas Transplantation: Small-Center Experience in Type 1 Diabetes Mellitus in a High-Incidence Region. *Transplant Proc*. 2015; 47 (7): 2169–2172. PMID: 26361670. https://doi.org/10.1016/j.transproceed.2014.11.070.
11. *Troppmann C, Gruessner AC, Benedetti E, Papalois BE, Dunn DL, Najarian JS et al*. Vascular graft thrombosis after pancreatic transplantation: univariate and multivariate operative and nonoperative risk factor analysis. *J Am Coll Surg*. 1996; 182 (4): 285–316. PMID: 8605554.
12. *Tso PL, Cash MP, Pearson TC, Larsen CP, Newell KA*. Simultaneous Pancreas-Kidney Transplantation Utilizing a Common Arterial Conduit: Early Experience and Potential Applications. *Am J Transplant*. 2003 Nov; 3 (11): 1440–1443. PMID: 14525607. https://doi.org/10.1046/j.1600-6135.2003.00236.x.
13. *Mercer DF, Rigley T, Stevens RB*. Extended donor iliac arterial patch for vascular reconstruction during pancreas transplantation. *Am J Transplant*. 2004; 4 (5): 834–837. PMID: 15084183. https://doi.org/10.1111/j.1600-6143.2004.00422.x.
14. *Ciancio G, Olson L, Burke GW*. The use of the brachiocephalic trunk for arterial reconstruction of the whole pancreas allograft for transplantation. *J Am Coll Surg*. 1995; 181 (1): 79–80. PMID: 7599778.
15. *De Miranda MP, Genzini T, Gil AO, Tacconi M, Gama-Rodrigues J*. Use of a donor aortic cross for arterial reconstruction of the pancreaticoduodenal allograft. *Clin Transplant*. 1998; 12 (3): 165–167. PMID: 9642505.
16. *Mizrahi S, Boudreaux JP, Hayes DH, Hussey JL*. Modified vascular reconstruction for pancreaticoduodenal allograft. *Surg Gynecol Obstet*. 1993; 177 (1): 89–90. PMID: 8322161.
17. *Troppmann C, Gruessner AC, Benedetti E, Papalois BE, Dunn DL, Najarian JS et al*. Vascular graft thrombosis after pancreatic transplantation: univariate and multivariate operative and nonoperative risk factor analysis. *J Am Coll Surg*. 1996; 182 (4): 285–316. PMID: 8605554.

18. *Bigam DL, Hemming AW, Sanabria JR, Cattral MS.* Innominate artery interposition graft simplifies the portal venous drainage method of pancreas transplantation. *Transplantation*. 1999; 68 (2): 314–315. PMID: 10440410. https://doi.org/10.1097/00007890-199907270-00029.
19. *Liao W-W, Ling X-C, Zhang C, Liu F-R, Zhu X-F, He X-S, Hu A-B.* Novel surgical technique and efficacy analysis of donor pancreas preparation without vascular reconstruction in pancreas transplantation. *J Int Med Res*. 2019; 47 (12): 6182–6191. PMID: 31500486. https://doi.org/10.1177/0300060519870894.
20. *Paulino J, Martins A, Vigia E, Marcelino P, Nobre AM, Bicho L et al.* Simultaneous Kidney-Pancreas Transplantation With an Original "Transverse Pancreas" Technique: Initial 9 Years' Experience With 56 Cases. *Transplant Proc*. 2017; 49 (8): 1879–1882. PMID: 28923641. https://doi.org/10.1016/j.transproceed.2017.04.015.
21. *Pinchuk AV, Dmitriev IV, Anisimov YA, Storozhev RV, Balkarov AG, Kondrashkin AS et al.* Pancreas transplantation with isolated splenic artery blood supply – Single center experience. *Asian J Surg*. 2020; 43 (1): 315–321. PMID: 31301933. https://doi.org/10.1016/j.asjsur.2019.06.011.
22. *Miyagi S, Shimizu K, Miyazawa K, Nakanishi W, Hara Y, Tokodai K et al.* A Case of Successful Simultaneous Pancreas-Kidney Transplantation Using the Injured Pancreas Graft. *Transplant Proc*. 2017; 49 (10): 2315–2317. PMID: 29198668. https://doi.org/10.1016/j.transproceed.2017.10.017.
23. *Socci C, Orsenigo E, Zuber V, Caldara R, Castoldi R, Parolini D et al.* Triple arterial reconstruction improves vascularization of whole pancreas for transplantation. *Transplant Proc*. 2006; 38 (4): 1158–1159. PMID: 16757294. https://doi.org/10.1016/j.transproceed.2006.02.020.
24. *Baranski AG, Lam HD, Braat AE, Schaapherder AF*. The dorsal pancreatic artery in pancreas procurement and transplantation: anatomical considerations and potential implications. *Clin Transplant*. 2016; 30 (10): 1360–1364. PMID: 27555344. https://doi.org/10.1111/ctr.12814.
25. *Adamson D, Holzner ML, Wadhera V, Shapiro R*. Reconstruction of a Pancreatic Allograft With Variant Arterial Anatomy for Transplantation. *Transplant Direct*. 2019; 5 (2): e425. PMID: 30882029. https://doi.org/10.1097/TXD.0000000000000863.

The article was submitted to the journal on 13.08.2020