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Blood flow reconstruction in portal vein anatomical variations in right lobe living donor liver transplantation[1]

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Abstract

Background. *Adequate restoration of blood flow through the portal vein in the graft is only possible with a clear understanding of its anatomy in the donor.*

Aim*. To describe new and extend current data on the portal vein anatomy in a donor of the right liver lobe, to describe variants and formulate principles of portal reconstruction in right lobe living donor liver transplantation.*

Material and methods. *306 living donor liver transplantations were performed from 2009 to 2021 in the State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency. The vascular anatomy of 518 potential donors was analyzed. Portal vein variants of the anatomy of right lobe graft were assessed.*

Results. *Nine types and 3 subtypes of portal vein branching were evaluated. A, B, C, D, E types match the types described earlier in Nakamura classification. Subtypes B1, B2 u D1 are specifications of types B and D. Types F, G, H, I have been described additionally. The incidence of types and subtypes where reconstruction was made: type A (82%), B (4.6%), B1 (3.9%), B2 (1.3%), C (3.9%), D (3.9%). The incidence of E, G, H, I types among 518 potential donors was 0.4%, 0.6%, 0.2%, 0.4%, respectively. The recipient portal vein complications were detected in 12 cases (3.9%), where 3(25%) were Class 3b according to Clavien-Dindo and 9(75%) of Clavien-Dindo Class 2. There were no correlations between portal vein complications and the method of portal vein reconstruction. (p<0.05). No complications occurred with portal vein in donors.*

Conclusion. *The existing classification of right liver graft portal vein has been updated and detailed. A certain way of reconstruction has been proposed for each portal vein type. Anatomical types in which donation and transplantation are contraindicated have been specified.*

Keywords: living donor liver transplantation, anatomy, portal vein, reconstruction, classification

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ASPV, anterior sectoral portal vein
LLPV, left lobar portal vein
MSCT, multislice spiral computed tomography
PSPV, posterior sectoral portal vein

PV, portal vein
RLPV, right lobar portal vein

Introduction

Living-related donor liver transplantation from in adults is an important method of definitive treatment of patients with end-stage liver diseases, especially in regions with a low number of transplants from postmortem donors. The number of transplants is 3 per 1 million population of the country, which is certainly not enough, given the increasing number of the diagnosed liver diseases that potentially require surgical treatment [1]. In this regard, lifetime donation of liver fragments is an important aspect of the treatment of end-stage liver diseases. It is also important to expand the use of lifetime donors by obtaining a graft from donors with an atypical anatomy of vascular structures and biliary tree. It has been shown that the venous anatomy of the liver right lobe, its efferent and afferent components, is more variable in right lobe liver donations, whereas left lobe liver grafts have higher rates of complex arterial reconstruction [2]. Important aspects of the use of donor organs with variable vascular anatomy are: a detailed preoperative examination to identify specific features and anomalies of the vascular anatomy, and a special surgical technique that makes it possible to obtain the graft safely for the donor and perform full reconstruction in the recipient's body. At the moment, the classifications of T. Nakamura and Y.F. Cheng are most often used to assess the anatomy of the portal vein of the liver right lobe [3, 4].

Contrast computed tomography makes it possible at the preoperative stage to identify all the variants of portal vein branching in a donor described in these classifications, as well as to clarify the presence of other features important for the operation, such as thrombosis or

fibrosis of the portal vein in the recipient. However, the proposed classifications do not take into account a number of important anatomical variations, since when performing portal reconstruction for types D and E, they can be potentially dangerous for the donor [5]. In this regard, defining the criteria for safe donation, based on knowledge of the portal vein anatomy, is extremely important for the successful completion of living related donor liver transplantation.

Material and methods

We have analyzed the experience of *the State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency* in performing 306 living related donor transplantations of the liver right lobe in adults in the period from 2009 to 2021. Five hundred eighteen subjects were examined as potential donors. The anatomical structure of the donor portal vein was made assessed in the preoperative period using multislice spiral computed tomography (MSCT) with intravenous contrast. When donor hemihepatectomy was performed after cholecystectomy, the elements of the hepatoduodenal ligament were mobilized. Meantime, devascularization of the common bile duct was avoided throughout its length. The hepatic artery was isolated only in a short section directly at the porta hepatis, where it had to be crossed. The method of portal vein mobilization with regard to the previously identified anatomical features. The single trunk of the right lobar portal vein was mobilized circularly extrahepatically. In the presence of two closely spaced sectoral trunks of the portal vein, both trunks were mobilized. Due to the fact that the parenchyma was usually transsected using the “liver hanging manouver” [6], the tape was passed anterior to the previously mobilized portal veins. If there were two trunks of the portal vein, one of which was located deep in the porta hepatis, the

mobilization of the distant branch occurred while working with the Glissonian pedicle of the right lobe. The intersection of the lobar or sectoral branches of the portal vein took place taking into account the principle of maximum donor safety. In this regard, a restriction of blood flow along the portal vein trunk had never been used, except in situations where blood flow through the portal vein and hepatic artery was briefly limited in order to visualize the line of demarcation and determine the trajectory of parenchymal transsection. Vascular clamps were applied strictly in a vertical plane to the right lobar portal vein and sectoral veins so that the resulting stump(s) of the portal vein during its suturing did not lead to the formation of sharp angles and possible stenosis of the portal vein in the donor. Thus, if preserving a single entry of the portal vein, for example, during its trifurcation in the recipient, was possible only in case of a risk of complex reconstruction and(or) stenosis of the donor's portal vein, the sectoral branches were intersected only with separate trunks in order to save the length of the portal vein stump in the donor and preventing its stenosis. Suturing the portal vein stump was performed over the applied clamp with a 5-6/0 polypropylene suture. Mobilization of the hepatic veins was described in detail previously [7]. Typically, after completing the transsection, the right hepatic artery was transsected, then the right lobar portal vein or its sectoral branches, after which the hepatic veins were transsected. After the explantation, the liver preservation was performed in Custodiol solution (cooled to 4°C.) At a "back-table" stage, the options for future reconstruction of the hepatic veins, bile ducts, portal vein and hepatic artery were determined. We should note that in all cases of surgery on the recipient, a high mobilization of the porta hepatis was performed, exposing the bifurcation of the portal vein, lobar hepatic arteries and bile ducts with the possibility of their high intersection if necessary. Control ultrasound examinations to

assess the blood flow rate in the graft were performed daily during the first week and then as necessary.

Results

Nine types and three subtypes of portal vein branching were identified. The anatomical types of the portal vein structure of the donor liver right lobe, their definitions, their case rate, and the possibility of reconstruction are presented in Table. 1. Types A, B, C, D, E correspond to the types described previously in the Nakamura Classification. Subtypes B1, B2, D1, F, G, H, I were described additionally. Organs with types A, B, C, D, F of portal vein branching were considered suitable for transplantation, while the possibility of transplantation was not considered for types E, G, H, I. Moreover, in a series of 518 potential donors, type E was found in 2 cases type (0.4%), G in 3 (0.6%), H in 1 (0.2%), and I in 2 (0.4%). The number of complications of the portal vein was 12 cases (3.9%), and all of them were portal vein thrombosis. Of those, 3 (25%) were of Class 3b, as assessed by Clavien-Dindo classification of complications, and required thrombectomy; 9 (75%) cases were non-occlusive thrombosis of Clavien-Dindo Class 2 and were treated conservatively. The median period of thrombotic complications to develop in the portal vein was 17 days. Pre-existing thrombosis of the portal and/or superior mesenteric veins was identified in 37 recipients (12%). The presence of pre-existing thrombosis did not increase the risk of thrombotic complications ($p<0.05$). The incidence of portal vein complications was not related to the type of portal vein reconstruction ($p<0.05$).

No complications related to a liver donor portal vein were reported in the study.

Table 1. Anatomical types of the portal vein structure in a donor of the right liver lobe: definitions, case rate, possibility of transplantation

Anatomical types and subtypes of the portal vein		Definition	n=306*, n (%)	Possibility of transplantation
Type	**Subtype**			
A		There is a bifurcation of the main trunk of the portal vein into the right and left lobar veins	251 (82)	+
B (middle)		Trifurcation of the portal vein, in which the portal vein trunk is divided into the anterior, posterior right sectoral veins and the left lobar vein, while the ostia of the posterior sectoral and left lobar branches are located at the same level	14 (4.6)	+
	B 1 (right)	The ostium of the posterior sectoral branch is located distal to the ostium of the left lobar branch	12 (3.9)	+
	B 2 (left)	The ostium of the posterior sectoral branch is located proximal to the ostium of the left lobar branch	4 (1.3)	+
C		Bifurcation of the portal vein main trunk into the anterior sectoral and left lobar branches, while the posterior sectoral branch arises directly from the main trunk of the portal vein	12 (3.9)	+
D		Bifurcation of the main trunk of the portal vein into the posterior sectoral and left lobar branches, with one anterior sectoral branch arising from the left lobar portal vein	12 (3.9)	+
	D1	Bifurcation of the main trunk of the portal vein into the posterior sectoral and left lobar branches, while two right anterior segmental veins depart from the left lobar	0	+
E		Division of the portal vein trunk into the right posterior, anterior sectoral and left lobar veins, in which the blood supply to segments 4, 5 and 8 is made by separate branches of the anterior sectoral vein	0	-

F		Quadrifurcation of the portal vein main trunk into the left lobar vein and three branches to the right lobe of the liver	1 (0.3)	+
G		Variants of the portal vein branching, in which a significant, but unsuitable for reconstruction branch departs from the left lobar branch to the anterior or posterior segments/sector of the liver right lobe, passing through the liver transsection area	0	-
H		Variants of the portal vein branching, in which a significant branch departs from the right lobar branch to the segment/sector of the liver left lobe passing through the liver transsection area	0	-
I		Agenesis of the right lobar portal vein. The right lobar portal vein is absent, and the blood supply to the right lobe of the liver is provided from small vessels arising from the portal vein main trunk, which passes into the left lobar portal vein	0	-

Notes: “+” means "transplantation is possible; “-” means "transplantation is not considered"
*= case rates in operated donors are given, case rates case rates for subtypes and types D1, E, G, H, O, I in 518 potential donors are given in the text

The method of restoring blood flow through the portal vein in the recipient depended on its anatomical type (Table 2).

Table 2. Portal vein reconstruction options for different anatomical types

Type of reconstruction	Anatomical portal vein type of the graft
Portoportal anastomosis	A, B, B1
Bisectoral portal anastomosis (after forming the common ostium of the sectoral veins)	B, B1, B2
Bisegmental sectoral portal anastomosis (after forming the common ostium of two segmental and one sectoral veins)	F
Use of Y-shape autovenous graft	C, D, D1

Discussion

Peculiarities of the donor and the recipient structures of the mesenteric-portal system must be taken into account at the stage of

planning the intervention, when MSCT is widely used, which makes it possible to determine both anatomical variations and the presence of venous thrombosis in the recipient [8, 9]. The Nakamura classification is basic for preoperative planning of a donor operation, however, as shown above, it does not fully satisfy the needs of transplant surgeons, despite the fact that the variants of portal vein branching described in it are observed in a predominant number of cases. Cetin Atasoy et al. and G. Varotti offer a different classification of the types of the liver right lobe portal vein (Tables 3, 4) [10, 11].

Table 3. Anatomical types of the portal vein according to Çetin Atasoy

Anatomical type of portal vein	Description
1	The portal vein gives rise to the left and right lobar veins, the right lobar vein gives rise to the right anterior and right posterior sectoral portal veins
2	Trifurcation of the portal vein into the left lobar portal vein, right anterior and posterior sectoral veins
3	The main trunk of the portal vein is divided into the right posterior sectoral portal vein and the common trunk of the right anterior sectoral portal vein and the left lobar vein

Table 4. Anatomical types of the portal vein according to G. Varotti

Anatomical type of portal vein	Description
1 (normal type)	The right lobar portal vein arises from the common trunk and gives rise to the right anterior and posterior branches within the right lobe of the liver
2 (trifurcation)	The right lobar vein is absent, and the right anterior and posterior portal veins arise directly from the common trunk
3 (left type)	The right lobar vein is absent, and the right anterior branch arises from the left lobar vein

These classifications largely reflect the experience of the authors who presented them and do not take into account, for example, the differences between types C and D in the Nakamura classification, nor do they highlight options in which obtaining the graft may be associated with the development of additional risks for both the donor, and the

recipient. The MSCT image should certainly be subjected to a rational assessment in order to prevent an attempt at donation in the presence of the types of portal vein branching that are not subject to transplantation, and to plan the safest surgical method for obtaining the graft, as well as to select the most optimal technique for portal reconstruction.

Type A (Fig. 1) of the classification we have developed represents bifurcation of the portal vein into the left and right lobar veins corresponds to the Nakamura classification. Our proposed type B and subtypes B1, B2 (Fig. 2–4) are a more detailed pattern of portal vein trifurcation in the Nakamura classification. These options are defined above. In type B, obtaining a graft with one portal vein entry is possible in approximately half of the cases by maintaining a bridge between the ostia of the sectoral veins. With subtype B1, it is always possible to preserve the bridge between the vessels; and with subtype B2, the graft will always contain two ostia, which require merging into one at the "back table" stage. Types C (Fig. 5) and D (Fig. 6), according to Nakamura, require reconstruction using a Y-shape conduit or some other surgical techniques [12]. In our understanding, the main and significant difference between type C and D is that that in type C, the anterior sectoral portal vein arises outside the Glissonian sheath and can be isolated separately from the rest elements of the pedicle, whereas in type D it is included in the triad Walaeus sheath, and thus arises intraparenchymally from the left lobar portal vein. Type D1 (Fig. 7) is a subtype of type D, in which there are two segmental branches to the anterior sector of the right lobe, arising from the left lobar portal vein. In our study, the bifurcation of the portal vein of the recipient's liver was used for portal vein transposition for the purpose of reconstruction. This approach is considered as a priority, since it does not require additional manipulations to obtain other grafts. Type E (Fig. 8), for which

Nakamura et al. described a possible method of reconstruction that consisted of abandoning the restoration of the branch to S8 and reconstructing the branch to S5 through a venous graft is a contraindication to donation, in our opinion, since there is a significant risk of a graft loss. Moreover, the presence of a branch to S4, extending in the transsection plane, creates an unjustified additional risk for the donor's liver. The variant F we identified (Fig. 9) is a quadrifurcation of the portal vein. The graft contains 3 portal vein ostia, and the reconstruction is performed by joining them together.

The main difference of type G (Fig. 10) is the deep intrahepatic arising of the anterior right subsegmental or segmental branch to S8 of the liver from the left lobar portal vein. The mouth of the vessel in this case is shifted to the left from the Rex-Cantlie line along the left lobar vein. This option may create additional and unpredictable risks of ischemia of part of the graft and, as a consequence, its loss. For this reason, patients with similar anatomy were not considered as donors. In type H (Fig. 11), as a rule, there is a branch arising from the right lobar portal vein to liver S4 and this branch ligation will create the segment ischemia in the donor's liver, which is an unacceptable event. We described earlier the portal blood supply to the left lobe of the liver from the right portal vein, which has been observed with an incidence of 1.5% to 7% [13, 14]. In most cases, these options are regarded as not subject to donation. The presence of small venous vessels crossing the interlobar border from right to left, as a rule, is not a contraindication to donation, while option H presupposes the presence of a well-defined trunk supplying blood to liver S4, and therefore requires allocating into a separate group.

Agenesis of the lobar portal vein, type I (Fig. 12), which has also been described by a number of authors, may be accompanied by

hypotrophy of the liver right lobe, and therefore an organ with similar anatomy cannot be considered as a potential graft [15]. In alternate cases, the blood supply to the liver is ensured by many separate segmental, subsegmental, and sectoral vessels that are not subject to reconstruction.

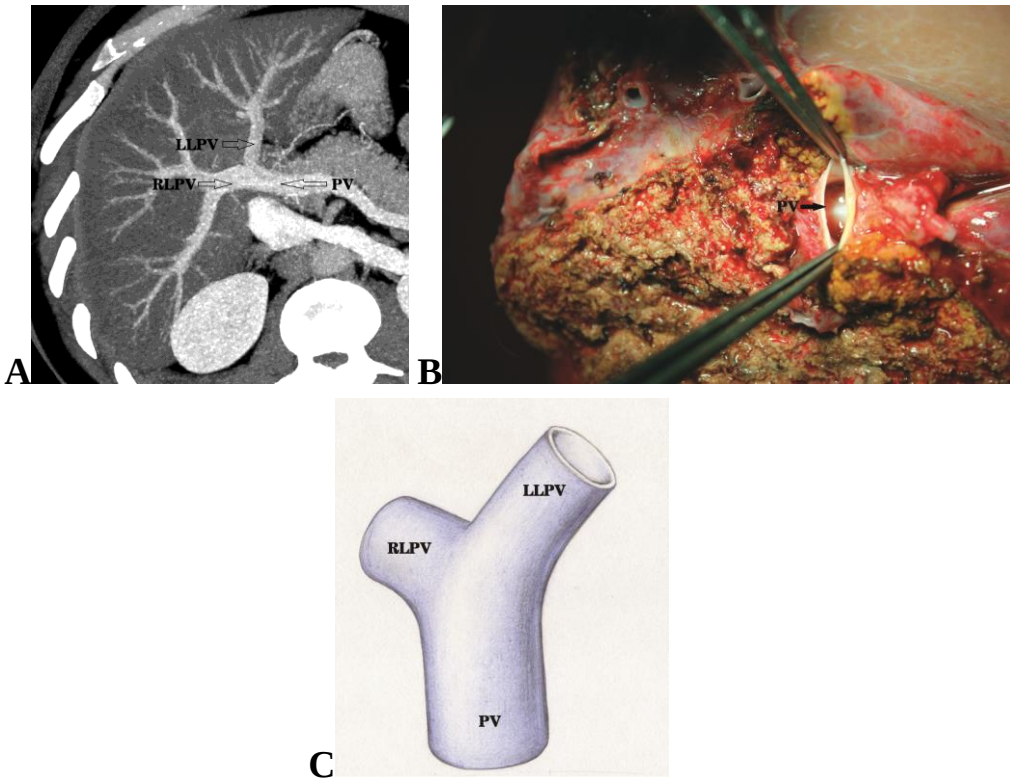

Fig. 1. Anatomical type A: A. (CT image); B. (Photo); C. (Diagram).
PV, portal vein; LLPV, left lobar portal vein; RLPV, right lobar portal vein

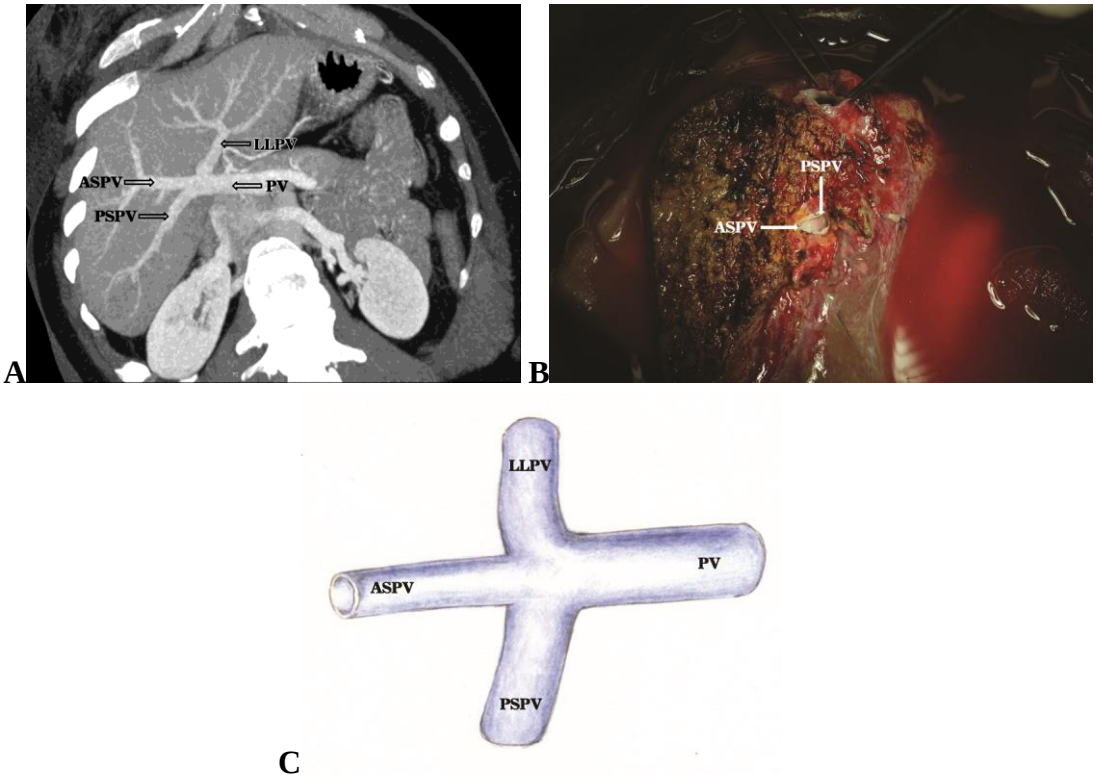

Fig. 2. Anatomical type B: A. (CT image); B. (Photo); C. (Diagram).
PV, portal vein; LLPV, left lobar portal vein; ASPV, anterior sectoral portal vein, PSPV, posterior sectoral portal vein

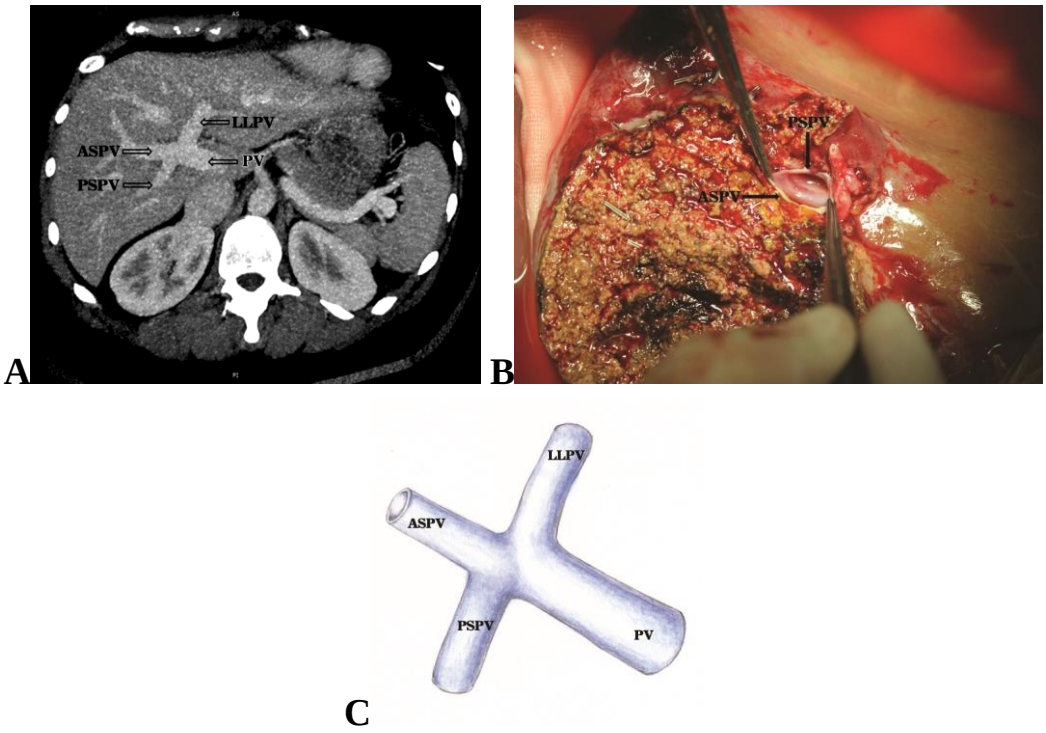

Fig. 3. Anatomical subtype B1: A. (CT image); B. (Photo); C. (Diagram). PV, portal vein; LLPV, left lobar portal vein; ASPV, anterior sectoral portal vein; PSPV, posterior sectoral portal vein

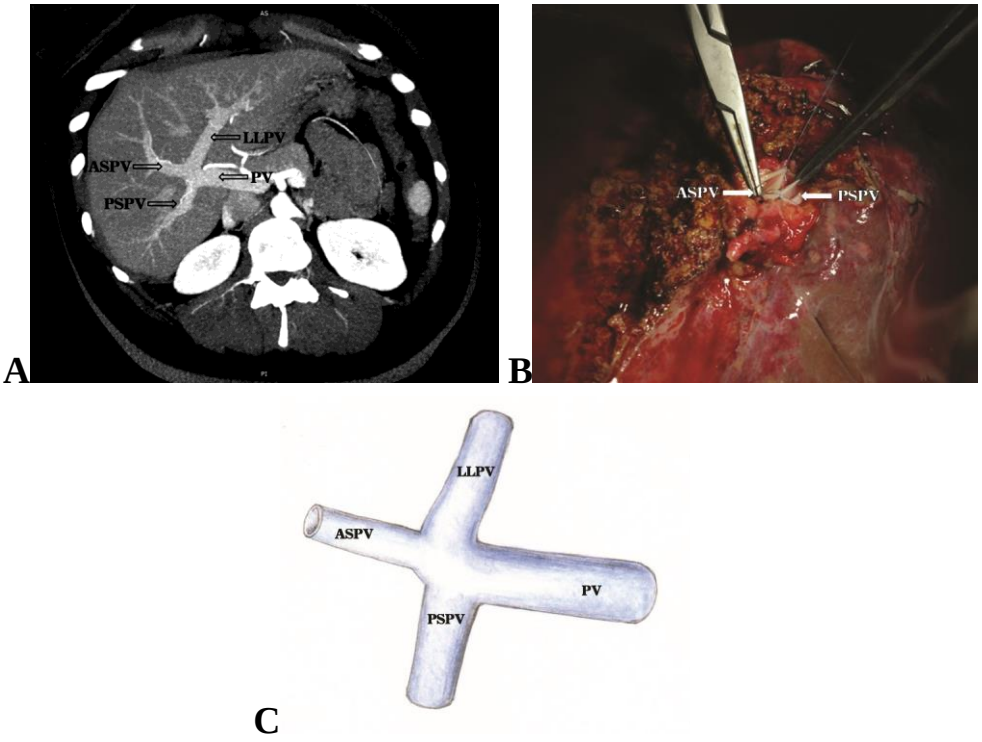

Fig. 4. Anatomical subtype B2: A. (CT image); B. (Photo); C. (Diagram). PV, portal vein; LLPV, left lobar portal vein; ASPV, anterior sectoral portal vein; PSPV, posterior sectoral portal vein

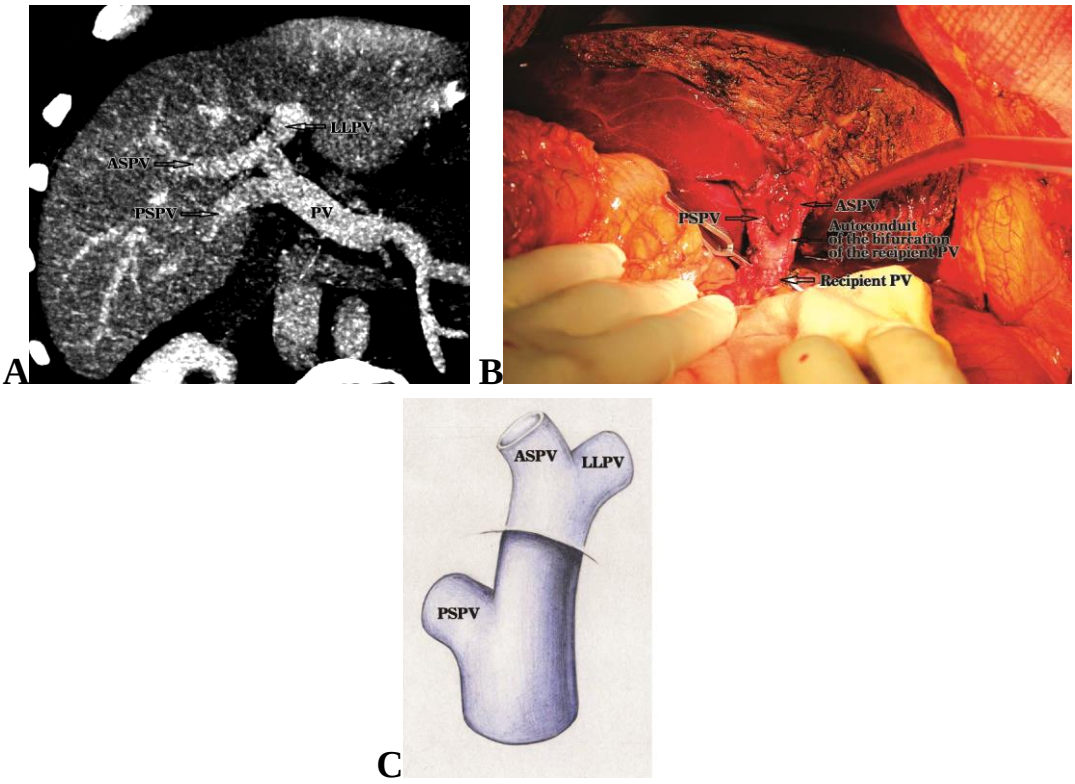

Fig. 5. Anatomical type C: A. (CT image); B. (Photo); C. (Diagram). PV, portal vein; LLPV, left lobar portal vein; ASPV, anterior sectoral portal vein; PSPV, posterior sectoral portal vein

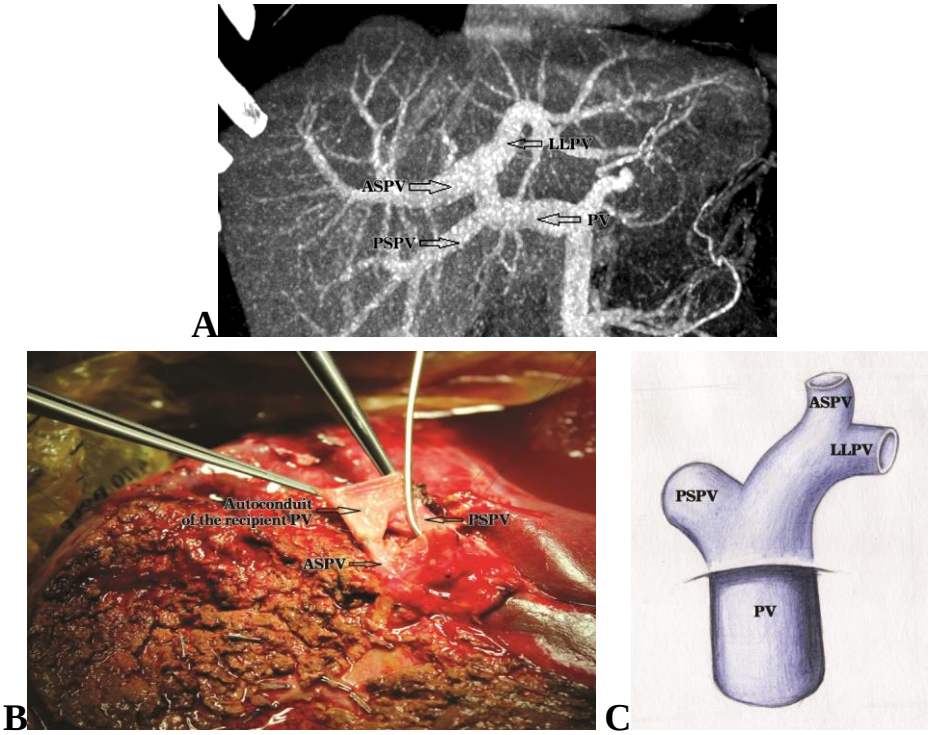

Fig. 6. Anatomical type D: A. (CT image); B. (Photo); C. (Diagram).
PV, portal vein; LLPV, left lobar portal vein; ASPV, anterior sectoral portal vein; PSPV, posterior sectoral portal vein

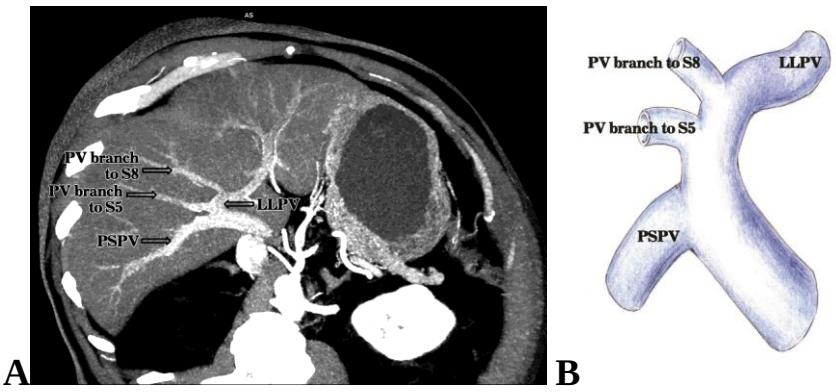

Fig. 7. Anatomical subtype D1: A. (CT image); B. (Diagram).
LLPV, left lobar portal vein; PSPV, posterior sectoral portal vein; PV, portal vein

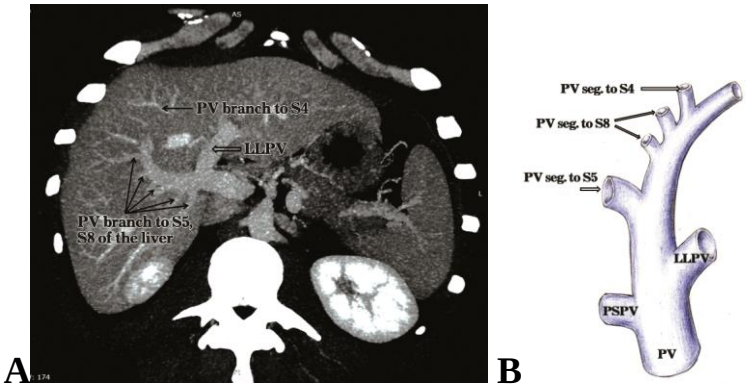

Fig. 8. Anatomical type E: A. (CT image); B. (Diagram). PV, portal vein, LLPV, left lobar portal vein, PSPV, posterior sectoral portal vein; PV seg.S5, portal vein segmental branch to S5 of the liver; PV seg. to S8, portal vein segmental branch to S8 of the liver; PV seg. to S4, portal vein segmental branch to S4 of the liver

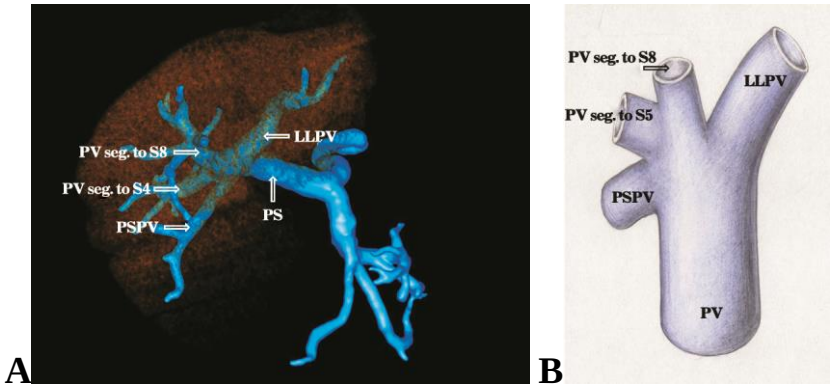

Fig. 9. Anatomical type F: A. (CT reconstruction); B. (Diagram). PV, portal vein; LLVP, left lobar portal vein; PSPV, posterior sectoral portal vein; PV seg to S5, portal vein segmental branch to S5 of the liver; PV seg. to S8, portal vein segmental branch to S8 of the liver

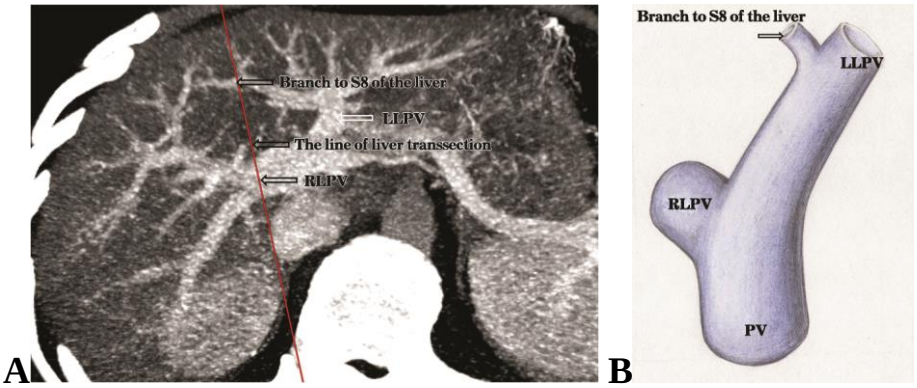

Fig. 10. Anatomical type G: A. (CT image); B. (Diagram). PV, portal vein; LLPV, left lobar portal vein; RLPV, right lobar portal vein

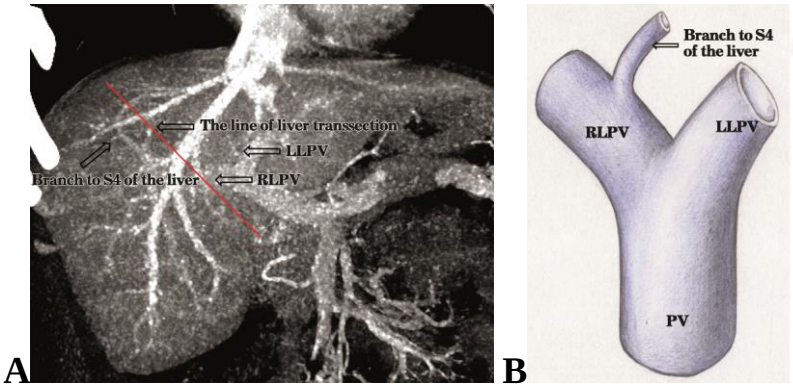

Fig. 11. Anatomical type H: A. (CT image): B. (Diagram). PV, portal vein; LLPV, left lobar portal vein; RLPV, right lobar portal vein

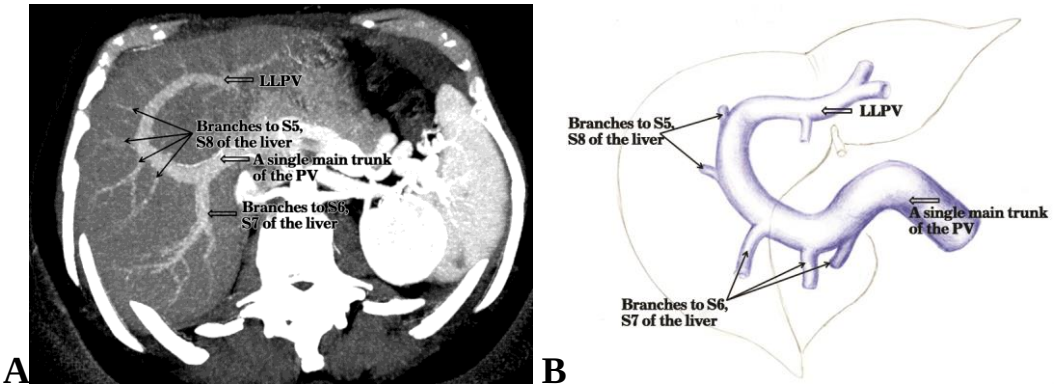

Fig. 12. Anatomical type I: A. (CT image); B. (Diagram). LLPV, left lobar portal vein; PV, portal vein

The presented results, illustrating the presence of the portal vein branching types in right half liver donors, which are not included in the Nakamura classification, indicate the need to supplement it. Obviously, to improve preoperative planning and prevent the development of portal vein thrombosis in the recipient, the knowledge of possible variations in the anatomy of the portal vein is necessary. The donor safety plays a key role in live-related donor liver transplantation; therefore, we consider unacceptable the situations of taking an autovenous graft from a donor, as described by Nakamura, in case of reconstruction of the portal blood flow with branching type E or D. Although the complication rates from part of the donor portal system have been reported relatively low, up to 0.5% [16, 17], we believe that the portal vein should be transsected in the most

safe manner for the donor in order to avoid the development of complications.

With gaining the experience in performing live-related donor liver transplantation, such classifications of portal anatomy as those developed by Nakamura, Cheng, and others require detailing and supplementing; definitions of existing types have been given, and additional 7 types and subtypes of the portal vein anatomical variations were introduced.

The anatomical types of the donor portal vein structure, in which donation is contraindicated, have been clarified.

Methods for reconstructing blood flow through the portal vein in a graft of the liver right lobe have been described for 10 types and subtypes.

Conclusions

1. Expanding Nakamura classification of portal vein structure variations by identifying subtypes B1 and B2 in type B, identifying subtype D1 in type D, and identifying types F, G, H, and I has an important applied significance in surgery and liver transplantation for planning an adequate method of portal revascularization

2. Planning of portal reconstructions: portoportal anastomosis, bisectoral-portal anastomosis (after the formation of the common ostium of the sectoral veins), bisegmental sectoral portal anastomosis (after the formation of the common ostium of two segmental and one sectoral veins), reconstruction using Y-shape autologous vein graft, is advisable to undertake in the preoperative period, based on the obtained anatomical data.

References

1. Bogomolov PO, Matsievich MV, Bueverov AO, Kokina KY, Voronkova NV, Beznosenko VD. Liver cirrhosis in the Moscow Region:

figures and facts. *Almanac of Clinical Medicine.* 2018;46(1):59–67. https://doi.org/10.18786/2072-0505-2018-46-1-59-67

2. Yagi S, Singhal A, Jung DH, Hashimoto K. Living-donor liver transplantation: right versus left. *Int J Surg.* 2020;82S:128–133. PMID: 32619620 http://doi.org/10.1016/j.ijsu.2020.06.022

3. Nakamura T, Tanaka K, Kiuchi T, Kasahara M, Oike F, Ueda M, et al. Anatomical variations and surgical strategies in right lobe living donor liver transplantation: lessons from 120 cases. *Transplantation.* 2002;73(12):1896–1903. PMID: 12131684 http://doi.org/10.1097/00007890-200206270-00008

4. Cheng YF, Huang TL, Lee TY, Chen TY, Chen CL. Variation of the intrahepatic portal vein; angiographic demonstration and application in living-related hepatic transplantation. *Transplant Proc.* 1996;28(3):1667–1668. PMID: 8658830

5. Thorat A, Jeng LB, Hsu S, Li P, Yeh CC, Chen T, et al. Reconstruction of the portal vein with expanded polytetrafluoroethylene jump graft in living donor liver transplantation recipients with complete portal vein thrombosis: a feasible and safe alternative. *Surgery, Gastroenterology and Oncology.* 2018;23(1):1–16. http://doi.org/10.21614/sgo-23-1-16

6. Belghiti J, Guevara OA, Noun R, Saldinger PF, Kianmanesh R. Liver hanging maneuver: a safe approach to right hepatectomy without liver mobilization. *J Am Coll Surg.* 2001;193(1):109–111. PMID: 11442247 http://doi.org/10.1016/S1072-7515(01)00909-7

7. Voskanyan SE, Kolyshev IYu, Bashkov AN, Artemiev AI, Rudakov VS, Shabalin MV, et al. Efferent blood supply to the right hepatic lobe regarding its transplantation from a living donor: variant anatomy, classification. Part 1. *Annaly khirurgicheskoy gepatologii* =

Annals of HPB Surgery. 2023;28(1):10–24. (In Russ.). https://doi.org/10.16931/1995-5464.2023-1-10-24

8. Rzaev RT, Kamalov IuR, Tatarkina MA, Kryzhanovskaia EIu, Kim EF, Filin AV, et al. The possibilities of non-invasive visualization methods for the detection of anatomic variants of vena cava division and renal veins syntopy before the allied orthotopic liver transplantation. *Pirogov Russian Journal of Surgery = Khirurgiya. Zurnal im. N.I. Pirogova*. 2012;(10):70–76. (In Russ.).

9. Kolsanov AV, Manukyan AA, Zelter PM, Chaplygin SS, Zvonareva ZN. Variant anatomy of the portal vein according to computed tomography. *Journal of Anatomy and Histopathology*. 2017;6(4):31–36. (In Russ.). https://doi.org/10.18499/2225-7357-2017-6-4-31-36

10. Atasoy C, Ozyürek E. Prevalence and types of main and right portal vein branching variations on MDCT. *AJR Am J Roentgenol*. 2006;187(3):676–681. PMID: 16928929 http://doi.org/10.2214/AJR.05.0847

11. Varotti G, Gondolesi GE, Goldman J, Wayne M, Florman SS, Schwartz ME, et al. Anatomic variations in right liver living donors. *J Am Coll Surg*. 2004;198(4):577–582. PMID: 15051012 https://doi.org/10.2214/AJR.05.0847

12. Yilmaz S, Kayaalp C, Isik B, Ersan V, Otan E, Akbulut S, et al. Reconstruction of anomalous portal venous branching in right lobe living donor liver transplantation: Malatya approach. *Liver Transpl*. 2017;23(6):751–761. PMID: 28240812 https://doi.org/10.1002/lt.24753

13. Schroeder T, Nadalin S, Stattaus J, Debatin JF, Malagó M, Ruehm SG. Potential living liver donors: evaluation with an all-in-one protocol with multi-detector row CT. *Radiology*. 2002;224(2):586–591. PMID: 12147860 http://doi.org/10.1148/radiol.2242011340

14. Guiney MJ, Kruskal JB, Sosna J, Hanto DW, Goldberg SN, Raptopoulos V. Multi-detector row CT of relevant vascular anatomy of the

surgical plane in split-liver transplantation. *Radiology.* 2003;229(2):401–407. PMID: 14595144 http://doi.org/10.1148/radiol.2292021437

15. Gallego C, Velasco M, Marcuello P, Tejedor D, De Campo L, Friera A. Congenital and acquired anomalies of the portal venous system. *Radiographics.* 2002;22(1):141–159. PMID: 1179690 http://doi.org/10.1148/radiographics.22.1.g02ja08141

16. Ghobrial RM, Freise CE, Trotter JF, Tong L, Ojo AO, Fair JH, et al. A2ALL Study Group. Donor morbidity after living donation for liver transplantation. *Gastroenterology.* 2008;135(2):468–476. PMID: 18505689 https://doi.org/10.1053/j.gastro.2008.04.018

17. Piardi T, Lhuaire M, Bruno O, Memeo R, Pessaux P, Kianmanesh R, et al. Vascular complications following liver transplantation: a literature review of advances in 2015. *World J Hepatol.* 2016;8(1):36–57. PMID: 26783420 http://doi.org/10.4254/wjh.v8.i1.36

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