EVALUATION OF VARIATIONS OF PORTAL VEIN BRANCHING BY MULTIDETECTOR COMPUTED TOMOGRAPHY

Vijay Kumar K. R[1], Jagruthi Sundar[2]

[1]Professor, Department of Radio-diagnosis, Bangalore Medical College and Research Institute, Bengaluru, Karnataka.
[2]Final Year Postgraduate, Department of Radio-diagnosis, Bangalore Medical College and Research Institute, Bengaluru, Karnataka.

ABSTRACT

BACKGROUND

Variations of the main portal vein (MPV) and right portal vein (RPV) branching at the hepatic hilum are quite frequent. Identification and reporting of such variations are necessary prior to interventions such as liver transplantation, as some are relative contraindications to living donor lobectomy or they at least require different techniques of anastomosis.

MATERIALS AND METHODS

This was a prospective study conducted on 100 patients at Department of Radiodiagnosis, Victoria Hospital, Bangalore Medical College and Research Institute. The study was conducted from May 2018 to November 2018. Multidetector Computed Tomography (MDCT) scan was performed with Philips Ingenuity 128 Slice CT machine. Portal venous phase images were acquired in an axial plane. Images were transferred to a Philips workstation; maximum intensity projection (MIP) and 3D volume-rendering images were reconstructed and the branching patterns of MPV and RPV were analysed.

RESULTS

Type 1 anatomy was the most common type, seen in 68 patients, that is, conventional portal venous anatomy. Type 3 anatomy was the most common type of variation in our study. Three patients had miscellaneous variations. Most patients had conventional MPV branching had conventional RPV branching. Ten out of 68 patients with conventional main portal vein branching had variant right portal vein branching. Most patients with conventional MPV branching had conventional RPV branching. Other variations observed were RPV quadrification and proximal origin of segment VII vein from RPV.

CONCLUSION

Main portal vein branching variations are quite frequent. Common RAPV-LPV trunk is more common than trifurcation of MPV. Variations in right portal vein branching are less frequent. MDCT plays an important role in accurate assessment of variations.

KEYWORDS

Portal Vein, Multidetector Computed Tomography, Hepatectomy, Liver Transplantation, Variant Anatomy, Transjugular Intrahepatic Portosystemic Shunt, Embolization.

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BACKGROUND

Variations of the main portal vein (MPV) and right portal vein (RPV) branching at the hepatic hilum are quite frequent. Identification and reporting of such variations are necessary prior to interventions such as liver transplantation, as some are contraindications to living donor lobectomy or they at least require different techniques of anastomosis.

Types of main portal vein branching include:[1]

1. Type 1: Main portal vein (MPV) bifurcating into the Right portal vein (RPV) and Left portal vein (LPV), the RPV then dividing into the Right anterior portal vein (RAPV) and Right posterior portal vein (RPPV).
2. Type 2: Trifurcation of the MPV into the LPV, RAPV and RPPV.
3. Type 3: Common trunk for LPV-RAPV and a separate origin of the RPPV.

Conventionally RPV divides into RAPV and RPPV, further giving off branches that supply segments V and VIII and segments VI and VII, respectively. Deviations from conventional pattern were studied.

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Corresponding Author:
Dr. Jagruthi Sundar,
No. 281/2A, 4th Main,
9th Cross, Srinivasanagar,
Banashankari 1st Stage,
Bangalore- 560050, Karnataka.
E-mail: jagruthi912@gmail.com
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Aim of the Study

The aim of this study is to evaluate and estimate the prevalence of variations of main portal vein and right portal vein branching by Multi detector computed tomography (MDCT) in South Indian population.

MATERIALS AND METHODS

This was a prospective study conducted on Patients referred to the Department of Radio-diagnosis, Victoria hospital,

Bangalore medical college and research institute, for contrast enhanced CT of abdomen. The study was conducted from May 2018 to November 2018. A total of 100 cases were studied.

Methods

Intravenous injection of 100 mL of nonionic 350 mg/mL contrast medium (Iohexol, Maxview), was given at the rate of 3 mL/s. CT scan was performed with Philips ingenuity 128 slice CT machine. Scan parameters includes, 8 × 2.5 mm collimation, 35 mm/s table feed, 2.5 mm section thickness, 1.25 mm reconstruction interval, 120 kV, 350 mA, and 0.5 seconds rotation time.

Images were obtained after a delay of 70 seconds for portal venous phase images. Axial images were transferred to a Philips workstation and analyzed. Axial images were assessed. Then maximum intensity projection (MIP) and 3D volume-rendering images were reconstructed in the workstation and the branching patterns of MPV and RPV were analyzed.

Type 1	MPV dividing into LPV and RPV, RPV dividing into RAPV and RPPV
Type 2	MPV trifurcating into LPV, RAPV and RPPV
Type 3	MPV dividing into RPPV and a common RAPV-LPV trunk

Table 1. Main Portal Vein Branching Patterns

Inclusion Criteria

1. Adult patients aged above 18 years
2. Patients undergoing Contrast enhanced CT abdomen for indications other than Suspected liver pathology.

Exclusion Criteria

1. Patients with hepatic lesions as it can distort the intrahepatic portal venous anatomy.
2. Patients with history major abdominal surgery.
3. Cases with insufficient portal venous opacification.
4. Cases with motion artifacts resulting in poor quality images.
5. Patients with allergy to contrast media.

RESULTS

Types	Number of Patients
Type 1	68
Type 2	11
Type 3	18
Miscellaneous	3

Table 2. Frequencies of Main Portal Vein Branching Patterns

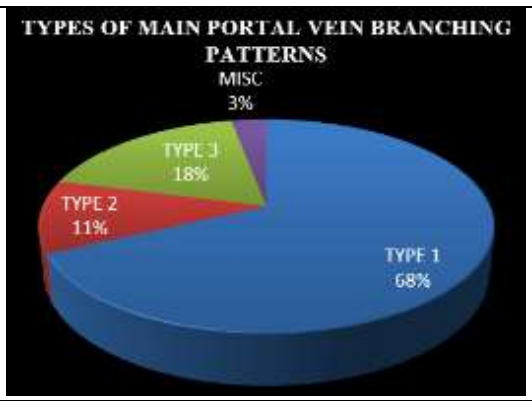

Chart 1. Pie Chart Depicting Frequencies of Main Portal Vein Branching Patterns

Type	No. of Patients	(%)
Conventional	58	85.2
Trifurcation	6	8.8
Proximal Origin of Segment VII Vein	3	4.4
Quadrification	1	1.4

Table 3. Frequencies of Right Portal Vein Branching Patterns

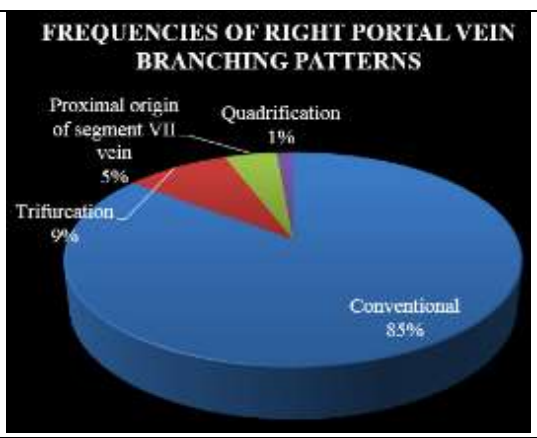

Chart 2. Pie Chart Depicting Frequencies of Right Portal Vein Branching Patterns

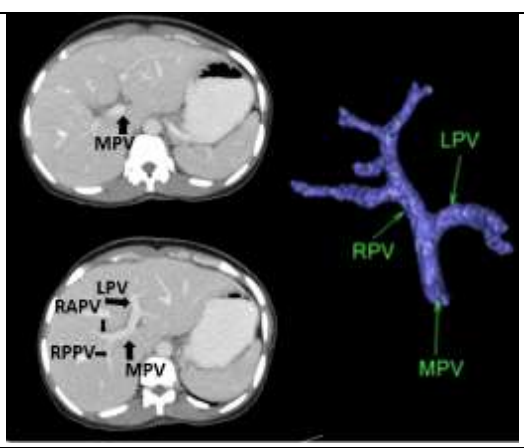

Figure 1. Type 1 Main Portal Vein (MPV) Anatomy. Axial MIP and Volume Rendered Images Show MPV Bifurcating into Left Portal Vein (LPV) and Right Portal Vein (RPV). Right Portal Vein Divides into RAPV and RPPV

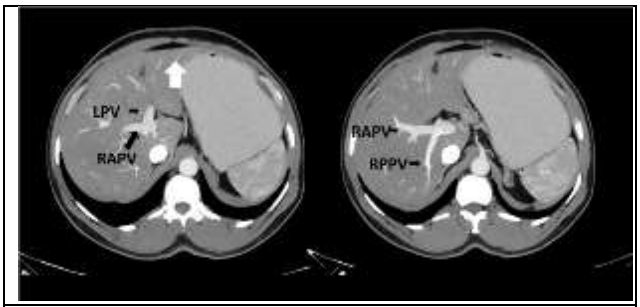

Figure 2. Type 2 Main Portal Vein (MPV) Anatomy. Axial MIP Images show MPV Trifurcating into Left Portal Vein (LPV), Right Anterior Portal Vein (RAPV), and Right Posterior Portal Vein (RPPV)

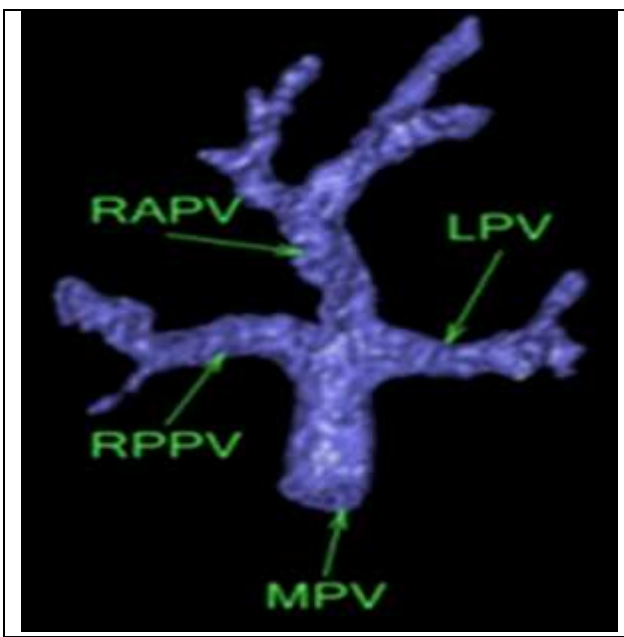

Figure 3. Volume Rendered Image showing MPV Dividing into Left Portal Vein (LPV), Right Anterior Portal Vein (RAPV), and Right Posterior Portal Vein (RPPV)

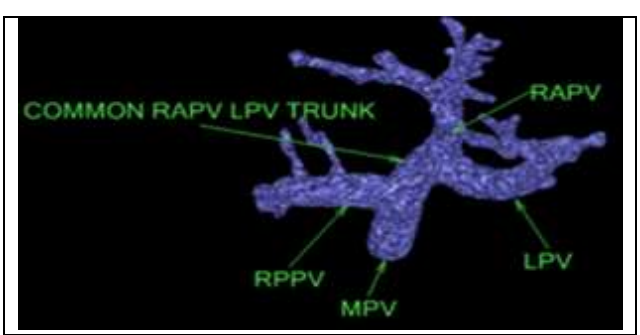

Figure 4. Type 3 Main Portal Vein (MPV) Anatomy. Volume-Rendered Image Shows MPV Bifurcating into Right Posterior Portal Vein (RPPV) and Common Trunk (RAPV–LPV) that Gives Rise to Left Portal Vein (LPV) and Right Anterior Portal Vein (RAPV)

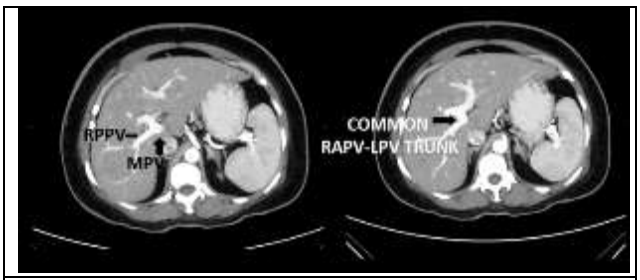

Figure 5. Type 3 Main Portal Vein (MPV) Anatomy. Axial MIP Images Show MPV Bifurcating into Right Posterior Portal Vein (RPPV) and Common Trunk (RAPV–LPV) that Gives Rise to Left Portal Vein (LPV) and Right Anterior Portal Vein (RAPV).

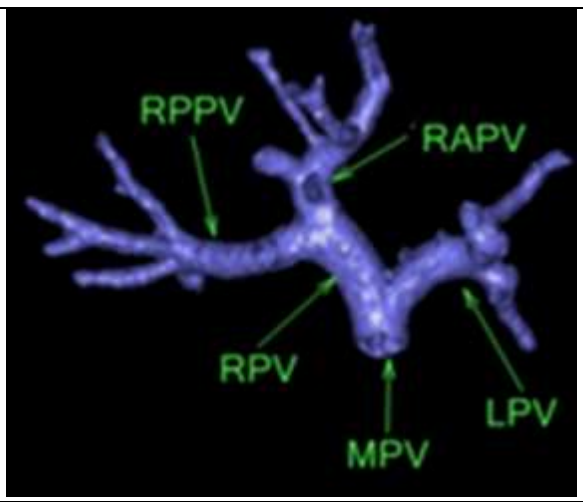

Figure 6. Volume Rendered Image Showing Conventional RPV Branching into RAPV and RPPV

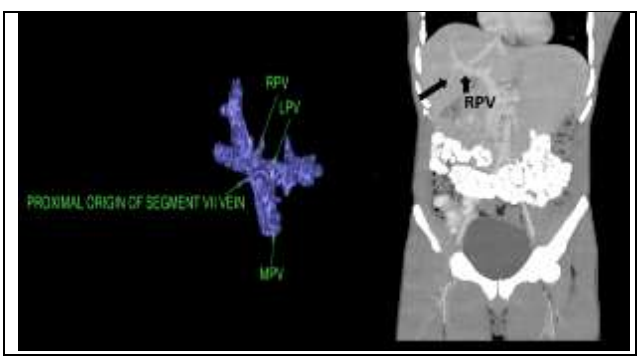

Figure 7. Volume Rendered Image and Coronal MIP Image Showing Proximal Origin of Segment VII Vein from RPV

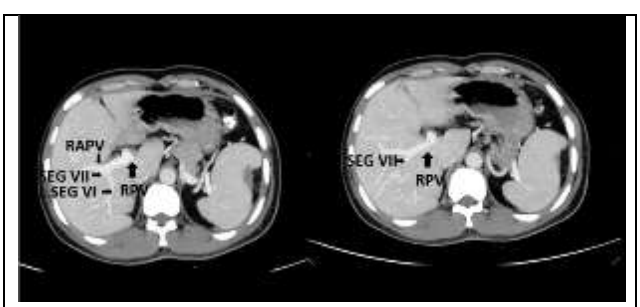

Figure 8. Axial MIP Images Showing Trifurcation of RPV into RAPV, Segment VI and Segment VII Veins

Table 2 and Chart 1depict the frequency distributions of main portal vein branching patterns. Type 1 anatomy was the most common type, seen in 68 (68%) patients, that is, conventional portal venous anatomy. Type 2 anatomy was observed in 11 (11%) patients. Type 3 anatomy was observed in 18(18%) patients.

Three patients had miscellaneous variations. Two patients had an LPV arising from the RAPV. In the third patient the left lobe had a co-dominant portal supply, one vein from the LPV and the other from the RAPV.

Table 3 and Chart 2 depict the frequencies of variations in right portal vein branching patterns. Fifty-eight (85.2%) out of 68 patients with conventional MPV branching had conventional RPV branching. Ten (14.7%) out of 68 patients with conventional main portal vein branching had variant right portal vein branching. Six (8.8%) of the patients had RPV trifurcation. In five of these patients the RPV trifurcated into the RAPV and segment VI and segment VII and in another patient, into the RAPV and RPPV and a separate segment VI vein. One (1.4%) of the patients had RPV quadrification into the RAPV, segment V vein, segment VI vein, and segment VII vein. In three (4.4%) of the patients, a segment VII vein originated proximal to the division of the RPV, which later bifurcated into the RAPV and segment VI vein and in two patients and into the RAPV and a common vein that supplied branches to segments V and VI in one patient.

In type 2 anatomy, the gap between the vessels is triangular in shape whereas in type 3 anatomy, the gap is rectangular.[2]

In our study, most common MPV branching variant was a common RAPV–LPV trunk followed by trifurcation. There were several types of variations of RPV branching, but the most common was trifurcation, which most frequently involved separate origins of segment VI and VII veins from the RPV. In three patients the segment VII vein arose from the RPV proximal to its bifurcation. In two patients segment V and segment VI veins ramified from a common trunk. The latter variation can hinder identification of the anterior border of segment VI.[3]

This is similar in comparison to a study conducted by Atasoy C et al, in which, common RAPV-LPV trunk was the most common variation in MPV and trifurcation of RPV was the most common type of variation in RPV.[1]

However, this is in disagreement with the study conducted by Kamel IR et al, trifurcation was found to be the most common type of variation.[4]

DISCUSSION

Embryological Development of Portal Vein

The Portal Vein is formed from the right and left vitelline veins. The vitelline veins in turn, arise from ramifications on the yolk sac. The terminal parts of the two vitelline veins are joined by three transverse communications. The upper two parts may be recognised in the portal vein of the adult as-

1) Part which lies behind the pancreas and duodenum.
2) Part in the gastro-hepatic omentum and transverse fissure of the liver.

Anatomy[5]

Main portal vein is formed by the convergence of the superior mesenteric and splenic veins posterior to the neck of pancreas at the level of L2 vertebra. Conventionally, the Main Portal Vein divides into the Right Portal Vein and Left Portal Vein. The RPV then divides into right anterior portal vein (RAPV) and Right Posterior Portal Vein which further subdivides into superior and inferior segmental branches. RAPV supplies Segments V and VIII. RPPV supplies Segments VI and VII. The left PV (LPV) initially has a horizontal course to the left and then it turns medially towards the ligamentum teres giving branches to supply Segments II, III and IV and the caudate lobe.

The LPV trunk gives off branches to liver Segments II, III and IV.

Types of Branching Patterns of Main Portal Vein[1]

1. Type 1- Main Portal Vein divides into the Right Portal Vein and Left Portal Vein.
2. Type 2-Trifurcation of main portal vein-MPV divides into three branches—RAPV, RPPV and LPV
3. Type 3-Common RAPV-LPV trunk- Right posterior portal vein as a first branch of main portal vein. The first branch of MPV is RPPV, which continues to the right for a short distance, and then divides into RAPV and LPV.

In our study, most common MPV branching variant was a common RAPV–LPV trunk followed by trifurcation. There were several types of variations of RPV branching, but the most common was trifurcation, which most frequently involved separate origins of segment VI and VII veins from the RPV. In three patients the segment VII vein arose from the RPV proximal to its bifurcation. In two patients segment V and segment VI veins ramified from a common trunk.

Knowledge of normal anatomical variants in branching patterns are necessary pre-operatively for portal vein embolization, liver transplantation, hepatic tumor resection, and placement of trans jugular intrahepatic portosystemic shunts and for accurate tumor localization.[6]

Association with Biliary Tree Variants

The intrahepatic bile ducts develop from progenitor cells which are in contact with the mesenchyme of the PV and thus form the "ductal plates". Thus, anatomic variations in intrahepatic branching pattern of PV are usually associated with variant biliary anatomy since embryological development of the hepatic duct occurs later than development of the primary divisions of the PV.[7] Hence during pre-operative evaluation, one must meticulously search for biliary tree variations when portal vein variations are encountered.

Portal Vein Embolization

Portal vein embolization is a procedure performed prior to major hepatic resections to increase the size of the residual liver that will be left behind. It consists of embolizing the branches of the liver that will be ultimately resected few weeks before surgery. The procedure can be performed

from a contralateral or from an ipsilateral approach. Some anatomic variations increase the complexity of the procedure from a contralateral approach. In patients with main portal vein trifurcation in which no right portal vein exists, the right anterior and posterior portal veins must be embolized individually, with at least a 1-cm proximal portion remaining patent. In patients with a segmental branch arising from the right portal vein, this branch usually needs to be embolized separately, especially when the branch arises from the proximal 1-cm portion of the right portal vein.[8,9]

Precise knowledge of intrahepatic segmental anatomy is of considerable importance when an atypical PVE is planned.

Liver Resections

A hepatectomy needs complete occlusion of the portal branches that will be resected during hepatic dissection. If a portal branch remains unoccluded during parenchymal resection, the risk of bleeding is significantly increased. In type 3 pattern, if only right anterior branch is ligated and right posterior branch is left behind; it may lead to active bleeding.[10]

Liver Transplantation

Precise knowledge of all vascular and biliary anatomical variants is mandatory prior to liver transplantation. The most suitable portal vein anatomy for right lobe living donor liver transplantation is the presence of conventional MPV branching, in which the right anterior portal vein (RAPV) and right posterior portal vein (RPPV) originate from the right portal vein (RPV) only one portal vein anastomosis is made between the recipient's MPV and donor's RPV. Type II anatomy significantly increases the complexity of surgical procedures, making the portal vein clamping more difficult. A type 3 portal vein variant requires two portal vein anastomoses have to be done on two separate veins in the recipient. This is because the branch supplying the segment IV is originating from the right portal branch, a single anastomosis would render the segment IV devascularised after right hepatic lobe harvesting. In both these variations, two portal vein anastomoses are needed, increasing the risk of postoperative portal vein thrombosis.

If these duplicated portal branches are close to each other, reconstruction with the bifurcation of the recipient's portal vein can be performed easily. When, however, the RAPV branches from the LPV more distally or within the parenchyma, an interposed vein graft is needed for reconstruction, making transplantation a challenging task.[11] An extension-type graft may be needed for reconstruction. This can result in delayed reperfusion of a segment of the graft. However, Y-graft reconstruction will allow simultaneous reperfusion through both donor portal branches.[12]

Differentiation of type 3 from type 2 anatomy has several advantages: In most donors with type 2 anatomy, despite the absence of an RPV, a single portal lumen can be obtained from the RAPV and RPPV owing to their close approximation. Type 3 anatomy, however, makes surgery more complicated, because two transections of the RAPV and RPPV are needed, resulting in two portal lumens in the right lobe graft.

Unlike in right lobe transplantation, in right posterior segment procurement the presence of type 3 anatomy is more desirable in donor selection.[4]

Transjugular Intrahepatic Portosystemic Shunt (TIPS)

Conventionally transjugular intrahepatic portosystemic shunt is created between the right hepatic vein and right portal vein. In Type II and Type III variations, the main large right trunk may be available and thus the target may be smaller in calibre.[7]

Preoperative awareness of variant RPV branching may be beneficial in right posterior segment harvesting and in segmental resection involving the right lobe. The RPV also seems to have a considerable rate of variant branching with several different patterns, some of which may influence decision making regarding right lobe surgery.

CONCLUSION

Main portal vein branching variations are quite frequent. Common RAPV-LPV trunk is more common than trifurcation of MPV. Variations in right portal vein branching are less frequent. MDCT plays an important role in accurate assessment of variations. Axial-oblique images with MPR and MIP reformations are particularly important in identifying these variations. Knowledge of anatomic variants is valuable in preoperative planning, particularly in donor candidates for adult-to-adult liver transplantation, wherein typically the right lobe of the donor is transplanted to the recipient. Although anomalous anatomy is not always a contraindication for liver donation, knowledge of variant anatomy is critical to ensuring the safety of the donors and aids in selection of suitable candidates.

REFERENCES

[1] Atasoy C, Ozyurek E. Prevalence and types of main and right portal vein branching variations on MDCT. Am J Roentgenol 2006;187(3):676-681.

[2] Hwang S, Lee SG, Lee YJ, et al. Donor selection for procurement of right posterior segment graft in living donor liver transplantation. Liver Transpl 2004;10(9):1150-1155.

[3] Hata F, Hirata K, Murakami G, et al. Identification of segments VI and VII of the liver based on the ramification patterns of the intrahepatic portal and hepatic veins. Clin Anat 1999;12(4):229-244.

[4] Kamel IR, Kruskal JB, Pomfret EA, et al. Impact of Multidetector CT on donor selection and surgical planning before living adult right lobe liver transplantation. Am J Roentgenol 2001;176(1):193-200.

[5] Atri M, Bret PM, Fraser-Hill MA. Intrahepatic portal venous variations: prevalence with US. Radiology 1992;184(1):157-158.

[6] Varotti G, Gondolesi GE, Goldman J, et al. Anatomic variations in right liver living donors. J Am Coll Surg 2004;198(4):577-582.
[7] Sureka B, Patidar Y, Bansal K, et al. Portal vein variations in 1000 patients: surgical and radiological importance. Br J Radiol 2015;88(1055):20150326.
[8] de Baere T, Roche A, Vavasseur D, et al. Portal vein embolization: utility for inducing left hepatic lobe hypertrophy before surgery. Radiology 1993;188(1):73-77.
[9] Orcutt S, Kobayashi K, Sultenfuss M, et al. Portal Vein embolization as an oncosurgical strategy prior to major hepatic resection: anatomic, surgical, and technical considerations. Front Surg 2016;3:14.
[10] Schmidt S, Demartines N, Soler L, et al. Portal vein normal anatomy and variants: implication for liver surgery and portal vein embolization. Semin Intervent Radiol 2008;25(2):86-91.
[11] Nakamura TN, Tanaka K, Kiuchi T, et al. Anatomical variations and surgical strategies in right lobe living donor liver transplantation: lessons from 120 cases. Transplantation 2002;73(12):1896-1903.
[12] Marcos A, Orloff M, Mieles L, et al. Reconstruction of double hepatic arterial and portal venous branches for right-lobe living donor liver transplantation. Liver Transpl 2001;7(8):673-679.