

# Investigation of right lobe hepatic vein variations of donor using 64-detector computed tomography before living donor liver transplantation

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## ABSTRACT

**Background/Aims:** To investigate the anatomy and variations of right lobe accessory veins and segment 5-8 veins draining into middle hepatic vein with 64 slice multidetector computed tomography (CT).

**Materials and Methods:** 100 consecutive living donor candidates underwent 64 slice CT angiography. Image interpretation was performed based on source axial images, multiplanar reformats, and three-dimensional post-processing images by the same radiologist.

**Results:** Segment 5 and 8 veins with larger diameters were frequently found to be the proximal ones. Accessory hepatic veins were present in the great majority of cases (83%). Most of them were the inferior right hepatic veins (55%). All cases were classified according to the number of segment 5-8 veins and the presence or absence of a right accessory hepatic vein. Most of the donors had more than one segment 5-8 vein and right lobe accessory veins (57%).

**Conclusion:** Multidetector CT is a valuable technique for investigating the venous anatomy of the liver in living donor candidates. Anatomy and variations of the hepatic veins can easily be evaluated by using multiplanar images.

**Keywords:** Liver transplantation, multidetector CT, hepatic vein variation

## INTRODUCTION

Liver transplantation has become the standard therapy for end-stage chronic liver disease and acute hepatic failure since 1963. The shortage of cadaveric donor organs has led to the development of living donor liver transplantation (LDLT). Careful evaluation and selection of donors before transplantation result in good patient and graft survival rates. However, LDLT poses some risks to the donor. The greatest risk is donor death, whose ratio is estimated between 0.1% and 0.5% (1,2). Variations in hepatic venous anatomy may predict the risk of hepatic venous complications (2,3). Thus it is important to preoperatively evaluate the hepatic venous anatomy in order to minimize surgical complications (4,5). To perform right lobe LDLT successfully, the anatomic variations of the middle hepatic vein (MHV) and the inferior right hepatic vein (IRHV) must be considered. Multidetector computed tomography (MDCT) allows non-

invasive preoperative examination of the hepatic veins by using three-dimensional images (6,7). The purpose of this study is to evaluate the capability and reliability of 64 slice multidetector CT in evaluation of the anatomy and variations of right lobe accessory veins and segment 5-8 veins before LDLT. We also aim to create a new classification system for the hepatic veins.

## MATERIALS AND METHODS

### Donor candidates

100 consecutive living donor candidates (67 men: median age, 32 years; age range, 19-56; and 33 women: median age, 36 years; age range, 18-59) were analysed in this retrospective study. The number and diameters of segment 5-8 veins and accessory hepatic veins draining into the middle hepatic vein (MHV) and inferior vena cava (IVC) were determined.

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The study was approved by the institutional Ethics Committee and detailed consent forms were signed by all patients.

### MDCT imaging technique

MDCT angiography images were obtained with intravenous injection of 81.65g iomeprol, equivalent to 40g iodine in 100 mL (Iomeron 400, Bracco s.p.a. Milano, Italy) through the right antecubital vein, using an automatic injector (Missouri, Ulrich Medical, Hollanda) at 3-3.5 mL/s flow rate. A 64 detector CT scanner was used (Aquilion 64 TSX-101A; Toshiba Medical Systems, Japan). The bolus tracking method was used, in which a region of interest is placed on the transverse image of the abdominal aorta during the injection of contrast material. Hepatic venograms were obtained 70 seconds after the initial injection. The parameters used for scanning were as follows: slice thickness: 5 mm, pitch: 0.8, kVp: 120, mAs: 31, reconstruction interval: 5 mm.

The MDCT images were then transferred to a postprocessing unit and were reconstructed by using the Aquilion VB. 10ER004 software program. Maximum-intensity projection (MIP), multiplanar reformation and volume rendering techniques were used to display the hepatic vein images in sagittal, coronal and oblique planes. Hepatic vein diameters were measured on thin MIP images, to avoid the superposition of the veins in thick MIP images. Thus, possible confusion between portal vein branches and hepatic vein branches was avoided. The volume rendering technique enabled us to differentiate structures with different densities by rendering them in different colours. The presence and number of accessory hepatic veins was determined. The diameters of both the accessory hepatic veins and the segment 5-8 veins were measured at 1cm from IVC and MHV re-

spectively. In particular, we marked large accessory veins ( $\geq 5$  mm) crossing the dissection line, which might require separate anastomosis in the recipient. The postprocessing time for each case was approximately 30 minutes.

### Hepatic venous anatomy

The names of the hepatic veins and their branches were based on Couinaud's segmentation (8). The vein draining segment 5 (the inferior part of the anterior sector) was named V5. The vein draining segment 8 (the superior part of the anterior sector) was named V8. The MHV was divided into tributaries in the right and left lobes.

The accessory hepatic veins were divided into superior, medial and inferior groups, and were separately named the superior right hepatic vein (SRHV), middle right hepatic veins (MRHV) and inferior right hepatic vein (IRHV) according to the position at which the accessory veins enter the IVC. The SRHV is the 'major' right hepatic vein at the dome of the liver. The MRHV are those hepatic veins that drain into the vena cava at a level cranial to the right posterior pedicle (hence, veins that drain primarily segment 7). The IRHV are those hepatic veins that drain into the vena cava at a level caudal to the right posterior pedicle (hence, veins that drain primarily segment 6).

### Proposed hepatic venous classification system

The cases were classified into four groups according to the number of segment 5-8 veins and presence of accessory hepatic veins. The features of the groups are summarized in Table 1 and 2 and Figure 1.

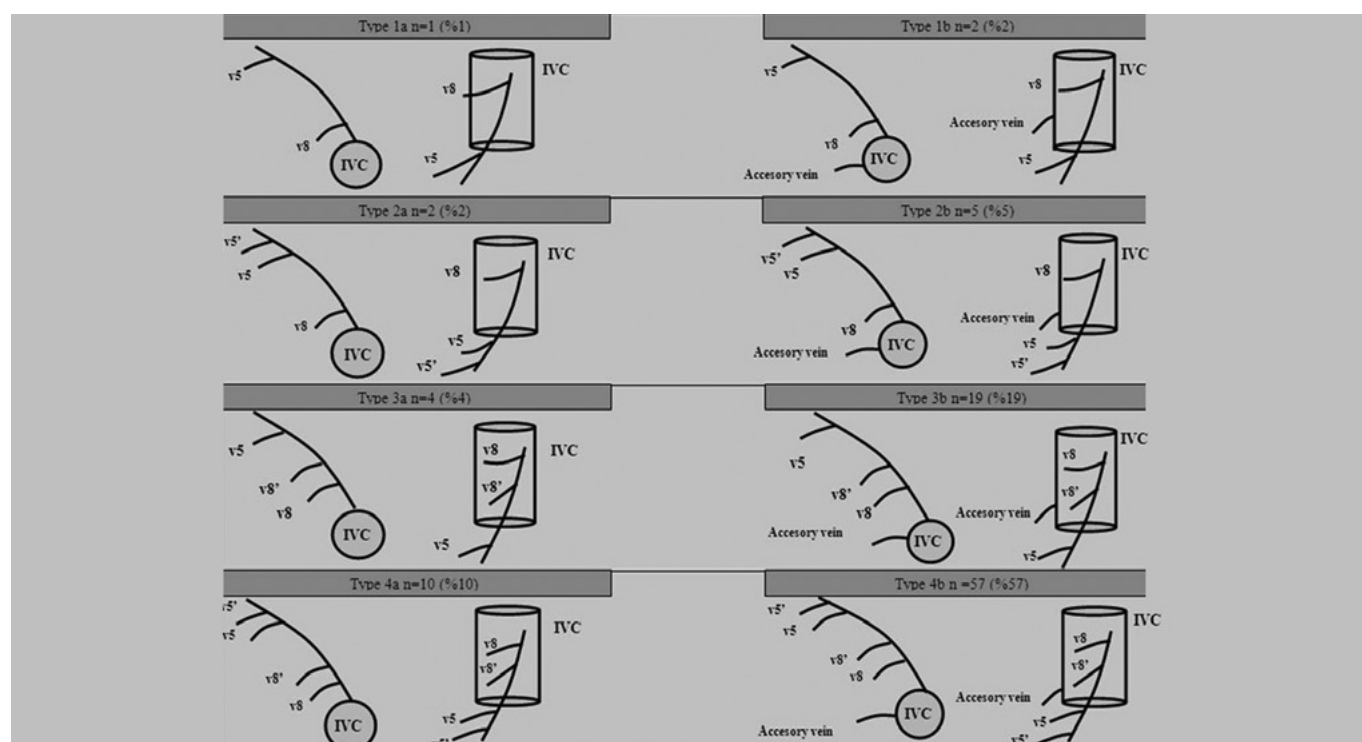


Figure 1. Proposed hepatic venous classification.

**Table 1.** Proposed hepatic venous classification, related to number of segment 5 to 8 veins, and presence or absence of accessory veins.

Type 1	One V5 and one V8	1a accessory hepatic vein is absent. 1b accessory hepatic vein is present.
Type 2	One V8, more V5	2a accessory hepatic vein is absent. 2b accessory hepatic vein is present.
Type 3	One V5, more V8	3a accessory hepatic vein is absent. 3b accessory hepatic vein is present.
Type 4	More than one V5 and V8	4a accessory hepatic vein is absent. 4b accessory hepatic vein is present.

V8: branch of middle hepatic vein draining segment 8 V5: branch of middle hepatic vein draining segment 5

**Table 2.** Number of cases in each group, based on proposed classification system in Table 1.

Group	Number	%
1a	1	1.0
1b	2	2.0
2a	2	2.0
2b	5	5.0
3a	4	4.0
3b	19	19.0
4a	10	10.0
4b	57	57.0
Total	100	100.0

### Statistical analysis

Data were analysed using SPSS software (Statistical Package for the Social Sciences, version 13.0, SPSS Inc., Chicago, Illinois, USA). Measurable data were presented in mean form, while categorized data were given in percentages. Pearson's correlations coefficient and unpaired t-test scores were used in statistical evaluations. P values less than 0.05 were considered statistically significant.

## RESULTS

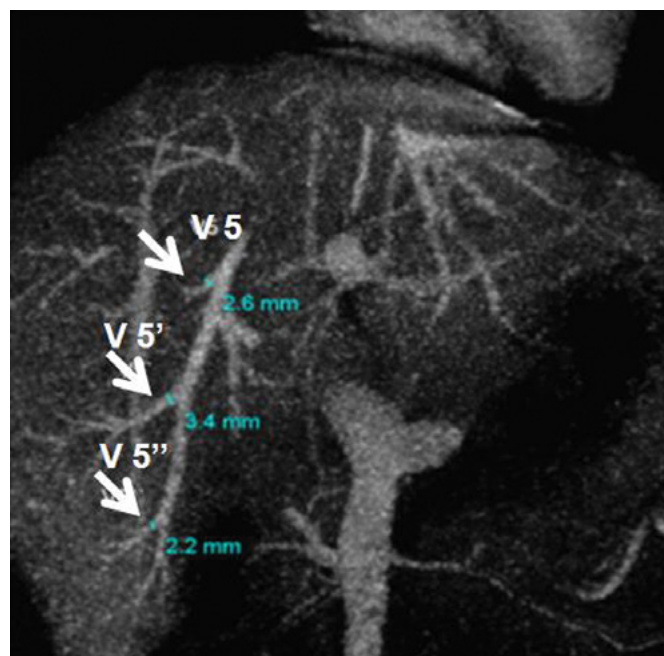
### Patients

33 out of 100 donors (median age, 34 years; age range, 18-55 years) for living adult-to-adult right lobe liver transplantation underwent surgery. This included 19 men with an average age of 30 years, and 14 women with an average age of 38 years. Graft rejection occurred in one out of 33 liver transplantations. No major complications developed in the other 32 cases.

### Major hepatic veins

Each branch depicted by MDCT was more than 1 mm in diameter.

In 20 cases hepatic veins drained into the IVC by means of a common trunk (Group A). In 70 cases, only middle and left

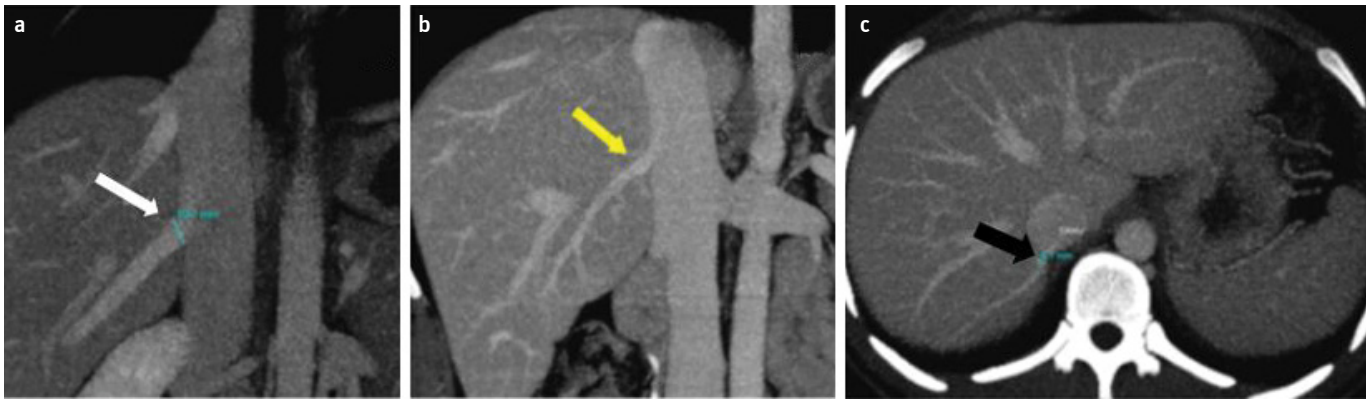
**Figure 2.** CT image of liver on axial plane using MIP technique. Hepatic vein variation of group B, based on how large hepatic veins drain into IVC, and middle and left hepatic veins drain into IVC with common trunks.**Figure 3.** CT image of liver coronal planes using MIP technique. Demonstrating common hepatic venous variations of segment 5 branches draining to middle hepatic vein. MHV has more than one segment 5 branch, named as V5, V5' and V5''.

hepatic veins formed a common trunk (Group B) (Figure 2). In the remaining 10 cases, each hepatic vein drained into the IVC separately (Group C).

### Segment 5 and 8 veins

Most donors either had more than one of either V5 or V8 veins (67%) or at least one accessory vein (83%). These cases also had a large MHV.

The number of veins draining segment 5 were: one in 10 cases, two in 20 cases, three in 36 cases (Figure 3) and four in 34 cases. The number of veins draining segment 8 were: one in 26 cases, two in 48 cases, three in 21 cases and four in 5 cases.



**Figure 4.** CT images of liver on coronal (a, b) and axial (c) plane using MIP and MPR technique. Right lobe accessory hepatic veins draining segment 6 (a), segment 5 (b) and segment 7 (c).

### Accessory hepatic veins

Accessory hepatic veins were detected in 83 cases. 58 cases had IRHV (Figures 4a, b). There was a single IRHV in 48 cases and two branches in 10 cases. 36 cases had one or more MRHVs, with a single one in 33 cases and two branches in 3 cases. 44 cases had one or more SRHVs (Figure 4c), with a single one in 38 cases and two branches in 6 cases.

### Comparison of the results

The comparison between the total number of accessory hepatic veins and numbers of MRHV and IRHV using Pearson's correlation revealed a positive significant correlation ( $p=0.0001$ ,  $p=0.026$ ). No significant correlation was observed between the accessory hepatic vein numbers and diameters ( $p>0.05$ ). There was a positive correlation between MHV diameters and total accessory vein numbers ( $p=0.031$ ). Those donors who had large MHVs also had large IRHVs (55%) ( $p=0.026$ ). There was a negative correlation between the diameters of the superior branch of segment 5 veins and IRHVs ( $p=0.048$ ). Also, a negative correlation was found between the numbers of V8 and the calibrations of V5 and V8 ( $p=0.029$ ,  $p=0.0001$ ).

### DISCUSSION

The critical issue of liver transplantation from living donors is the risk to the donors, who were healthy until the transplantation; this risk is now estimated to be 0.5% mortality and 21% postoperative morbidity (9, 10). For successful surgery, it is necessary to analyse the hepatic venous anatomy in detail prior to the operation. Post-contrast CT and CT angiography are used to evaluate the vascular and nonvascular anatomy of the liver (3). Because thin images are routinely used with MDCT, it is possible to obtain artefact-free high quality two- or three-dimensional high speed volumetric scanning. However, the preferred choice at the moment is MDCT, due to its superiority in displaying the intrahepatic bile ducts, arteries and veins, its easy accessibility, and its shorter examination time (9). This method has proved to be successful in determining the transplantation potential of livers. As anatomy can be imaged in any desired plane and angle, MDCT angiography can be used to easily detect hepatic vascular variations. Hepatic venous anat-

omy and variations can be evaluated best at axial planes using the MIP technique (11).

One important variation hepatic venous system that must be known before transplantation is the existence of right accessory hepatic veins, not to be mistaken for the caudate lobe veins, which drain the dorsal sector of the liver and empty directly into the retrohepatic IVC on its right (12). This common variation was detected by Kamel et al. in 68% of subjects (13,14). In the study of Nakamura et al. (15), 30% of right lobe grafts showed larger accessory hepatic veins, 13.9% of which were multiple. Marcos et al. (16) reported a 40% incidence of accessory right hepatic veins in their series of 40 living liver donors. In our study, 83 of the 100 patients were found to have accessory hepatic veins. Also, most of them (58%) also had IRHV, draining the inferior dorsal part of the liver (segment 6). Orguc et al. (17) reported a 47% incidence of accessory right hepatic veins, and in 22 of them accessory veins were significant ( $\geq 5\text{mm}$ ). In our study, 35 of the 100 donors had significant accessory veins ( $\geq 5\text{mm}$ ) that required surgical anastomoses. During hepatectomy, accessory hepatic veins of 5mm or larger have importance and are maintained for reconstruction (18). Failure to recognize a significant accessory vein before surgery may cause excessive bleeding and compromise the venous drainage of the graft. The key to a successful hepatectomy is to obtain a graft that shows a balance between blood supply and venous drainage. Accessory hepatic veins should be left intact or reconstructed as much as possible since venous congestion, even in a limited region, may damage the implanted graft (17).

Previously, the morphology of each hepatic vein pattern has been classified individually as surgical anatomy for hepatectomy. Marcos et al. (19) and Neumann et al. (20) classified the MHV, and Radtke et al. (21) classified the IRHV. Recently, Uchida et al. (7) classified the hepatic veins on the basis of the anatomical presentation of the IRHV. Varotti et al. (22) published a classification of hepatic vein variations based on the presence or absence of significant segment 5 and 8 accessory hepatic veins (S5 and S8) and one or more accessory short hepatic veins (SHV).



When we grouped our cases according to the classification of Varotti et al. (22), we noted no cases consistent with type 1, 2 or 3. Since all of our cases had one or more segment 5 and 8 veins, the classification of Varotti et al. was not suitable for grouping our cases effectively. So we prepared a new classification of V5-V8 and accessory veins crossing the dissection line in right lobe transplantation. Our classification was made according to the number of V5-V8 and presence or absence of accessory veins. We found that most donors (67%) had more than one segment 5 and 8 vein, and 57 of these donors also had at least one accessory vein, with type 4 vein pattern. Therefore, donors with type 4b pattern may need multiple anastomosis, leading to an increase in operative time. For these donors, special attention must be given to large accessory veins draining to the IVC, or large branches of the middle hepatic vein crossing the dissection line. These veins may cause unexpected bleeding during retrieval and should be preserved when they are of significant size ( $\geq 5$  mm in diameter).

We also compared the numbers and diameters of hepatic veins and found that a positive correlation between MHV calibration and the total number of accessory veins. Those donors who had large MHVs also had large IRHVs (55%) and at least one accessory vein. These donors needed more reconstructions during the surgery. There was a negative correlation between the diameters of the superior branch of segment 5 and IRHVs. This finding may be a result of the closeness of those veins (V5 and IRHV). The negative correlation between the numbers of V8 and the diameters of V5 and V8 implies that donors who have multiple segment 8 branches will not have large V5 and V8s which may need additional reconstruction.

In conclusion, different variations of the middle hepatic veins must be known in order to manage a careful parenchymal transaction by preserving the veins draining the graft liver and remnant liver (23). The preoperative evaluation of the numbers, diameters and variations of the middle hepatic veins, segment 5-8 branches and the presence of accessory veins along the hepatectomy line is required for successful surgery.

The present study has some limitations. It is a retrospective study and this is our first experience of hepatic venous variations in liver donor candidates before LDLT without surgical correlation. Further studies with larger series and using surgical correlation of hepatic veins are needed. Our new hepatic vein classification may help radiologists and surgeons in the evaluation of living donor candidates in terms of hepatic venous anatomy and variations.

**Conflicts of Interest:** No conflict of interest was declared by the authors.

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