Investigation of Right Lobe Hepatic Vein Variations of Donors Using 64-Detector Computed Tomography before Living Donor Liver Transplantation

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Aims and objectives

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 results 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.

Methods and materials

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.

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 (lomeron 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: 5mm, 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 respectively. In particular, we marked large accessory veins (#5mm) 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.

**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.

Images for this section:

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

<table>
<thead>
<tr>
<th>Type 1</th>
<th>One V5 and one V8</th>
<th>1a accessory hepatic vein is absent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1b accessory hepatic vein is present.</td>
</tr>
<tr>
<td>Type 2</td>
<td>One V8, more V5</td>
<td>2a accessory hepatic vein is absent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2b accessory hepatic vein is present.</td>
</tr>
<tr>
<td>Type 3</td>
<td>One V5, more V8</td>
<td>3a accessory hepatic vein is absent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3b accessory hepatic vein is present.</td>
</tr>
<tr>
<td>Type 4</td>
<td>More than one V5 and V8</td>
<td>4a accessory hepatic vein is absent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4b accessory hepatic vein is present.</td>
</tr>
</tbody>
</table>

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

Table 1

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>1</td>
<td>1,0</td>
</tr>
<tr>
<td>1b</td>
<td>2</td>
<td>2,0</td>
</tr>
<tr>
<td>2a</td>
<td>2</td>
<td>2,0</td>
</tr>
<tr>
<td>2b</td>
<td>5</td>
<td>5,0</td>
</tr>
<tr>
<td>3a</td>
<td>4</td>
<td>4,0</td>
</tr>
<tr>
<td>3b</td>
<td>19</td>
<td>19,0</td>
</tr>
<tr>
<td>4a</td>
<td>10</td>
<td>10,0</td>
</tr>
<tr>
<td>4b</td>
<td>57</td>
<td>57,0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100,0</td>
</tr>
</tbody>
</table>

Table 2
Fig. 1: Fig. 1. Proposed hepatic venous classification.
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 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.

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).

Images for this section:

**Fig. 2:** Fig. 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.
**Fig. 3:** Fig. 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''.
**Fig. 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).
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 [9]. 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.

Personal information

References


