Relationship of the Presence of the Inferior Right Hepatic Vein with the Right Hepatic Vein Diameter and CT Liver Volumetry

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Abstract

Background Right hepatic venous anatomy, right lobe volume, and percentage of remnant liver are issues to be considered in preoperative planning especially transplantation.

Objectives The aim of this study was to investigate the relationship of the presence of the inferior right hepatic vein (IRHV) with the right hepatic vein (RHV) diameter, right lobe volume, and percentage of remnant liver.

Materials and Methods In this cross-sectional study, the computed tomography (CT) images of 90 patients who underwent triphasic CT for being living liver donation were evaluated retrospectively. The number and diameter of IRHVs and the diameter of main RHV were recorded. For the liver volume analysis, a deep learning-based automatic liver segmentation (Hepatic VCAR) program was used. A virtual hepatectomy plane was drawn, where the right and left liver volumes were found and the percentage of the left lobe to the total liver volume was calculated. Pearson’s correlation analysis was used for correlation analysis and Student’s t-test was used to compare parameters.

Results A total of 74 IRHVs were detected in 53 (58.88%) of 90 patients. There were no differences in the percentage of remnant left lobe volume, right lobe volume, and RHV diameter between the IRHV (+) and (−) groups. The RHV diameter had a weak negative correlation with the IRHV diameter, and a weak positive correlation with the right lobe volume.

Conclusions The percentage of remnant left lobe volume, right lobe volume, and RHV diameter did not differ in liver donors with and without an IRHV. The RHV diameter had a weak negative correlation with the IRHV diameter and a weak positive correlation with the right lobe volume.

Introduction

Hepatic veins are the main veins that provide the connection between the systemic and portal systems and perform venous drainage of the liver. The left, middle, and right hepatic veins (RHVs) are the main veins draining the liver (►Fig. 1). In addition, there are many small veins called accessory or short hepatic veins.1 The numerical and
Positional variations in venous structures are very important in complex hepatobiliary surgical procedures, especially in liver transplantation from living donors.\(^2,3\) Prevention of acute complications, e.g., necrosis and hepatic failure, and chronic complications, such as atrophy, is only possible with the complete venous drainage of each segment of the liver.\(^4\)

The morphological and functional anatomy of the liver differs. Morphologically, it is divided into the right and left lobes by the falciform ligament. The concept of functional anatomy was introduced in 1957 by the French surgeon Couinaud,\(^5\) who suggested that the liver consisted of independent functional segments with their own vascular and biliary drainage. According to this concept of functional anatomy, the liver is divided into eight segments. This classification is used by surgeons because each segment can be surgically resected separately. Although new classifications of functional anatomy have been developed by various researchers, the Federative Committee on Anatomical Terminology still recommends the use of the Couinaud classification for a common terminology.\(^6\)

For adult patients, donor right hepatectomy is performed in right lobe transplantation from a living donor.\(^7\) In the hemihepatectomy plane, the relatively avascular Cantlie line (Fig. 2), which passes approximately 1 cm to the right of the middle hepatic vein and runs in the direction of the gallbladder bed and the inferior vena cava, is preferred.\(^8\) Right hepatic venous anatomy, right lobe volume, and percentage of remnant liver are issues to be considered in preoperative planning.\(^3,7\) Right lobe venous drainage is mainly provided by RHV. The accessory inferior right hepatic vein (IRHV) is the most common venous variation observed at a rate of 6 to 67%, mainly playing a role in the drainage of segment 6.\(^1,9\)

The presence and diameter of IRHVs are important for the decision of venous reconstruction. Reconstruction is not required for IRHVs with a diameter of less than 5 mm, while there is a need for surgical reconstruction in those with a diameter of 5 mm or above.\(^9\) It has been reported that there is a negative correlation between the presence of IRHV and the RHV diameter,\(^1,4\) which is even more important considering the possibility of a diameter mismatch in RHV anastomosis.

Although there are a limited number of radiological studies evaluating the relationship between the presence and diameter of IRHV and the diameter of RHV, to our knowledge, no research has investigated the relationship between the presence and diameter of IRHV and the right lobe volume and percentage of remnant liver. Therefore, this study aimed to investigate the relationship between the presence of IRHV and the RHV diameter, right lobe volume, and percentage of remnant liver.

**Materials and Methods**

The study was undertaken in a tertiary-care hospital. It was approved by the Ethics Committee of the Faculty of Medicine.
A total of 74 IRHVs were detected in 53 (58.88%) patients (two in 15 patients and three in three patients) (Fig. 3). The mean IRHV diameter was 6.16 ± 4.20 (2–14) mm. There was no difference in age or gender between the IRHV (+) and (−) groups (p = 0.49 and p = 0.37, respectively).

No significant difference was found between the IRHV (+) and (−) groups in terms of the percentage of remnant left lobe volume and the right lobe volume (p = 0.592 and p = 0.433, respectively). Among the IRHV (+) patients, the RHV was of finer calibration, but this difference was not statistically significant (p = 0.19). The findings are summarized in Table 1.

The IRHV diameter was more than or equal to 5 mm in 20 (22.22%) patients. There were no significant differences in the remnant left lobe volume percentage, right lobe volume, and RHV diameter between the more than or equal to 5 mm IRHV (+) and (−) groups (p = 0.432, p = 0.599, and p = 0.10, respectively). The findings are summarized in Table 2.
There was a weak negative correlation between the RHV diameter and the IRHV diameter in IRHV (+) group (correlation coefficient: -0.358, \( p = 0.01 \)). A weak positive correlation was observed between the RHV diameter and the right lobe volume (correlation coefficient: 0.250, \( p = 0.05 \)).

The ROC curve analysis was performed to evaluate the diagnostic efficacy of the RHV diameter in predicting the presence of IRHV (Fig. 4). When the cutoff value was taken as 9.36 mm for the RHV diameter, there was no IRHV in the presence of an RHV with a greater diameter, and the sensitivity and specificity were calculated as 54 and 71.2%, respectively (AUC: 0.593).

### Discussion

IRHV was found in 53 (58.88%) of the 90 patients included in our study, and it was more than or equal to 5 mm in 20 (22.22%) of these patients. There were no significant differences in the remnant left lobe volume percentage, right lobe volume, and RHV diameter between the IRHV (+) and (-) groups or between the more than or equal to 5 mm IRHV (+) and (-) groups. A weak negative correlation was found between the RHV diameter and the IRHV diameter in the IRHV (+) patients. There was also a weak positive correlation between the RHV diameter and the right lobe volume. The cutoff value for the RHV diameter was 9.36 mm in predicting the presence of IRHV.

The prevalence of IRHV has been reported as 6 to 67% in previous studies. One of the main reasons why prevalence rates vary is due to technical parameters. Makuuchi et al evaluated the presence of IRHV with ultrasonography (USG) and reported the prevalence of IRHV to be 10%. This low rate can be explained by USG being operator-dependent, affected by gas artifacts, and unable to adequately evaluate especially posterior body regions in obese patients. In addition, the authors conducted that study back in 1983, and

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**Table 1** Comparison of the right hepatic vein diameter, right lobe volume, and percentage of remnant left lobe volume between the IRHV (+) and (-) groups

<table>
<thead>
<tr>
<th></th>
<th>IRHV (+) group (n = 53)</th>
<th>IRHV (-) group (n = 37)</th>
<th>( p )-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right hepatic vein diameter (mm)</td>
<td>8.59 ± 2.73</td>
<td>9.28 ± 1.98</td>
<td>0.19</td>
</tr>
<tr>
<td>Right lobe volume (cm³)</td>
<td>1,037.38 ± 254.49</td>
<td>996.57 ± 241.53</td>
<td>0.433</td>
</tr>
<tr>
<td>Percentage of left lobe volume (%)</td>
<td>33.41 ± 6.25</td>
<td>34.13 ± 6.30</td>
<td>0.592</td>
</tr>
</tbody>
</table>

Abbreviation: IRHV, inferior right hepatic vein.

**Table 2** Comparison of the right hepatic vein diameter, right lobe volume, and percentage of remnant left lobe volume between the more than or equal to 5 mm IRHV (+) and (-) groups

<table>
<thead>
<tr>
<th></th>
<th>≥5 mm IRHV (+) group (n = 20)</th>
<th>≥5 mm IRHV (-) group (n = 70)</th>
<th>( p )-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right hepatic vein diameter (mm)</td>
<td>8.04 ± 2.57</td>
<td>9.11 ± 2.40</td>
<td>0.10</td>
</tr>
<tr>
<td>Right lobe volume (cm³)</td>
<td>1,043.90 ± 210.91</td>
<td>1,013.94 ± 259.46</td>
<td>0.599</td>
</tr>
<tr>
<td>Percentage of left lobe volume (%)</td>
<td>32.91 ± 4.58</td>
<td>33.93 ± 6.66</td>
<td>0.432</td>
</tr>
</tbody>
</table>

Abbreviation: IRHV, inferior right hepatic vein.

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Fig. 3 Axial and coronal plane computed tomography images showing the inferior right hepatic vein.

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since then technological developments have increased USG image resolution. Another study reporting a low prevalence rate was Soyer et al. In that study, the prevalence of IRHV was determined as 8.6% based on CT. The authors performed CT examinations with 8 mm collimation, 8 mm per second table speed, and 4 mm reconstruction interval and obtained images only in the axial plane, and the CT device was of the helical type. These factors can result in small IRHVs not being visualized. Therefore, their low prevalence value is considered to be due to technical reasons. In other studies with a relatively low prevalence, there was a bias due to patient selection. The prevalence of IRHV was reported as 21% by Fang et al, who evaluated patients with chronic hepatitis of a certain age range and 19% by Sahani et al, who evaluated patients with hepatic tumors scheduled for surgery. In contrast, in studies conducted with liver donor candidates in the literature, higher prevalence rates, such as 40 to 67.5%, have been reported. In this study, we found the prevalence of IRHV to be 58.88% in hepatic donor candidates, which is similar to the literature. Performing a multiphasic examination that includes hepatic and portal phases separately in liver donor candidates can increase the detectability of IRHV. Especially small IRHVs can be overlooked in routine portal phase imaging; therefore, we consider that higher rates are reported in donor candidates who undergo a multiphasic examination. IRHVs of 5 mm and larger require separate anastomosis to prevent venous congestion at the graft. In the literature, the prevalence of IRHVs greater than 5 mm has been reported to vary between 6 and 56.7%. Consistent with the literature, we found the prevalence of more than or equal to 5 mm IRHV as 22.22%.

In this study, we found the volume percentage and the right lobe volume. In light of this information, it can be predicted that the right lobe volume will be greater in donors with greater RHV diameters. To our knowledge, there is no study on this subject in the literature, and thus we consider that our results make a valuable contribution to the literature and should be supported by further studies involving more patients.

The RHV diameter is important for donor-recipient diameter compatibility. Since both RHV and IRHV drain the same liver lobe and there are intersections between drainage areas, we tested whether the RHV diameter would be smaller in the presence of IRHV and in thick IRHVs. In both the IRHV (−) and more than or equal to 5 mm IRHV (+) groups, the RHV was of finer calibration, but the differences were not statistically significant compared with the remaining patients. Nevertheless, we did find a weak negative correlation between the RHV diameter and the right lobe volume. According to the results of our study, although there is no significant relationship between the presence of IRHV and remnant left lobe volume percentage, right lobe volume, and RHV diameter, it may be necessary to be more sensitive in the evaluation of volumetric measurements in this patient group, since the remnant left lobe volume percentage decreases in the presence of IRHV. In the current donor evaluation, there are different methods for hepatic volume (manual, semiautomatic, automatic liver segmentation), especially in radiology departments with limited experience in transplantation, their combined use can be thought. Internal validation can be achieved by looking at the intraobserver and interobserver correlations in patients with IRHV.
The main limitation of our study is the small number of patients. Our results need to be supported by further studies involving a larger number of patients. In addition, CT examinations being evaluated by a single radiologist can be seen as a limitation, but we consider that the evaluator’s experience in transplantation radiology invalidates this limitation.

**Conclusion**

The remnant left lobe volume percentage, right lobe volume, and RHV diameter did not differ in liver donors with and without an IRHV. There was a weak negative correlation between the RHV diameter and the IRHV diameter and a weak positive correlation between the RHV diameter and the right lobe volume. A thin RHV diameter should alert clinicians to the presence of IRHV. It can be predicted that the right lobe volume will be greater in patients with a thick RHV.

Funding

None.

Conflict of Interest

None declared.

**References**