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Inferior right hepatic vein on routine contrast-enhanced CT of the abdomen: prevalence and correlation with right hepatic vein size

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AIM: To determine the prevalence of the inferior right hepatic vein (IRHV) in patients undergoing routine contrast-enhanced computed tomography (CECT) of the abdomen and to compare it with the size of the right hepatic vein (RHV).

MATERIALS AND METHODS: Two hundred and twenty-four consecutive patients who underwent routine CECT abdomen, with adequate venous opacification, were included in the study. The number and diameter of IRHVs and the diameter of the RHV was noted in each case.

RESULTS: A total of 214 IRHVs were detected in 126 cases (56.2%) with a mean diameter of 4.15±1.44 mm. The number of IRHVs ranged from one to four (more than one IRHV was present in 39.7% [50/126] of cases). In approximately one-third of cases (46/126), an IRHV ≥5 mm was found. A weak negative correlation was found between size of the RHV and IRHV (Pearson's correlation coefficient −0.222; p=0.01). The RHV was smaller in size in patients with an IRHV (7.34±1.88 mm) than in patients without an IRHV (8.47±1.99 mm) on CECT abdomen. A larger IRHV was associated with a smaller RHV (6.91±2.05 mm).

CONCLUSION: The presence of IRHV on routine CECT abdomen is frequent, and it is not uncommon to encounter more than one IRHV. The diameter of the IRHV has a weak negative correlation with the diameter of the RHV, and a smaller RHV is found in patients with an IRHV.

Introduction

With advent of multidetector row computed tomography (CT), and advances in processing and display technology, accurate hepatic vascular anatomy can be defined.[1] Continuous evolution of non-invasive imaging techniques have led to increased detection of variant vascular anatomy in routine practice. As hepatic veins define the segmental anatomy of the liver along with the portal vein, any variation in them is important for adequate preoperative planning.[2]

An accessory inferior right hepatic vein (IRHV) is most common hepatic venous variant[3] with a reported prevalence of 6–67% in various previous studies.[2,4–10] The presence of an IRHV has implications for various surgical procedures, such as partial hepatectomy and living-donor liver transplantation.[11] Preoperative knowledge about the presence, size, and location of IRHVs helps in adequate preoperative planning allowing a wider margin of operative safety. Recent technical advances have also led to an

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increased number of complex hepatobiliary intervention procedures such as transjugular intrahepatic portosystemic shunt (TIPS). Inadvertent cannulation of a large IRHV in TIPS can increase the complexity of procedure.

Despite playing an important role in planning of complex hepatobiliary surgical and interventional procedures, the presence of an IRHV is frequently underreported on routine abdominal CT. In addition, it has been seen that the presence of a thick IRHV is associated with a smaller right hepatic vein (RHV); however, no study has been undertaken to determine the statistical correlation between the two. The aim of the present study was to determine the prevalence of IRHVs on routine contrast-enhanced CT (CECT) of the abdomen and to determine statistical correlation between the size of the main RHV and IRHV. A secondary objective was to determine if any differences existed in the diameter of the RHV in patients with and without an IRHV and also in patients with smaller and larger ($\geq$5 mm) IRHVs.

Materials and methods

This was an observational cross-sectional study, undertaken in a tertiary-care hospital in North India. The study was approved by the institutional ethical committee. Informed written consent was taken from all patients. All adult patients ($\geq$18 years) who underwent routine abdominal CECT were included in the study. Patients with a history of previous hepatic surgery or chronic liver disease were excluded from the study. In addition, images with inadequate venous opacification, imaging features of chronic liver disease, or the presence of a large hepatic or abdominal mass (which interfered with visualisation of normal venous structures) were excluded from the study.

Image acquisition

All CT examinations were acquired on a 16 section MDCT system (Brilliance CT, Philips, Netherlands). Bowel opacification was achieved using a mixture of 1,000 ml water and 20 ml contrast material (urografin 76%). Images were acquired in portal venous phase after a fixed scan delay of 65 seconds after intravenous administration of 100 ml non-ionic contrast material (iohexol, 300 mg iodine/ml) at a rate of 3.5 ml/s via a 18 or 20 G intravenous cannula.

Acquisition parameters were 16$\times$0.75 mm detector collimation, 1.5 helical pitch, 0.75 seconds rotation time, 120 kVp tube voltage, 250 mA tube current, 10 mm section thickness, and reconstruction at 2 mm.

Image analysis and interpretation

All CT images of each patient were analysed at a dedicated workstation using post-processing. Post-processing techniques such as maximum intensity projection (MIP), multiplanar reformation (MPR), and volume rendering (VR) were used in most of the cases. MPR and MIP imaging were the most frequently used techniques. Thickness of MIP images was adjusted according to the vein examined. In each case, all the images were analysed separately at different times by two radiologists (having 3 and 5 years of experience in abdominal radiology, respectively). This was followed by a combined reading session in which both the radiologists discussed the imaging findings and a consensus was reached. In some doubtful cases, when consensus could not be reached, opinion of a senior radiologist was obtained for final decision.

In each case, the diameter of main RHV draining into inferior vena cava (IVC) at the level of diaphragm was recorded. In cases in which more than one RHV was present, the diameter of the largest RHV was recorded. Although some authors have classified accessory RHVs into middle and inferior groups, there is ambiguity regarding the distinction between these two groups. Due to non-uniformity of criteria, all the accessory veins draining segments VI and VII of liver, below the level of the diaphragm were classified as IRHVs. The number of IRHVs in each case and their diameter was noted. The diameters of both the RHV and IRHV were measured on axial images. MIP images were not used for measurement of diameter as it can lead to overestimation.

Statistical analysis

Statistical analysis was performed using SPSS trial version (IBM, Armonk, NY, USA). Mean and standard deviation were calculated for all numerical variables. The chi-squared test was used to determine the association between gender and the presence of an IRHV. Pearson's correlation coefficient was used to measure the correlation between size of the RHVs and IRHVs. Student's *t*-test was used to compare the diameter of the RHVs in patients with and without an IRHV and patients with smaller and larger IRHVs ($\geq$5 mm in size). One-way analysis of variance (ANOVA) was used to compare the size of the RHV with the number of IRHVs. A p-value <0.05 was considered significant.

Results

The CECT images of 300 patients were reviewed, out of which 76 cases were excluded due to poor venous opacification, the presence of underlying chronic liver disease, or the presence of a large hepatic or abdominal mass causing compression of hepatic veins. A total of 224 patients (72 male and 152 female) were included in the study with a mean age of 50$\pm$15.95 years (18–89 years). The mean diameter of the RHV was 7.84$\pm$2.01mm (3.9–14.5 mm).

Table 1
The number of inferior right hepatic veins (IRHVs) in each case.

No. of IRHV	No. of cases (n=126)	Diameter of right hepatic vein (in mm)
1	76 (60.3%)	7.65$\pm$1.68
2	33 (26.2%)	6.94$\pm$2.14
3	14 (11.1%)	6.85$\pm$1.99
4	3 (2.4%)	6.27$\pm$2.54

Figure 1 Axial MIP CECT image in a patient showing a single IRHV draining segment VII, opening into the IVC below the level of the diaphragm (arrow).

A total of 214 IRHVs were detected in 126 patients (56.25%; 35 male and 91 female). The number of IRHVs ranged from one to four (Table 1). A single IRHV was most common and was seen in 76 patients, draining into the IVC inferior to the diaphragm (Fig 1). Thirty-three patients had two IRHVs (Fig 2) and 14 patients had three IRHVs (Fig 3). The presence of four IRHVs was least common and was seen in only three cases (Fig 4). None of the patients had more than four IRHVs. The mean diameter of the IRHVs was 4.15±1.44mm (1.8–8.3mm). In 46 patients, the diameter of at least one IRHV was ≥5 mm. No association was seen between gender and presence of an IRHV (chi-squared test, p=0.113).

The mean diameter of the RHV was significantly less in patients with an IRHV than in patients without an IRHV (Table 2). The diameter of the RHV was smaller in patients having an IRHV ≥5 mm as compared to patients having an IRHV that was <5 mm. In 126 cases with the presence of an IRHV, correlation was made between the diameter of the RHV (largest RHV if more than one RHV was present) and diameter of the IRHV (largest IRHV if more than one IRHV was present). There was a negative correlation with a Pearson's correlation coefficient of −0.222 (p=0.01). Although the diameter of the RHV decreased with increasing number of IRHVs (Table 1); however, the association was not statistically significant (p=0.458; one-way ANOVA).

Discussion

It is not uncommon to encounter variant vascular anatomy of hepatic veins in routine practice. Venous drainage of

Figure 2 CECT MIP images showing (a) a medium-sized RHV (arrow) with (b) two IRHVs on inferior sections (arrows). (c) Coronal MIP image showing the RHV (curved arrow) and larger IRHV (straight arrow) opening into the IVC.

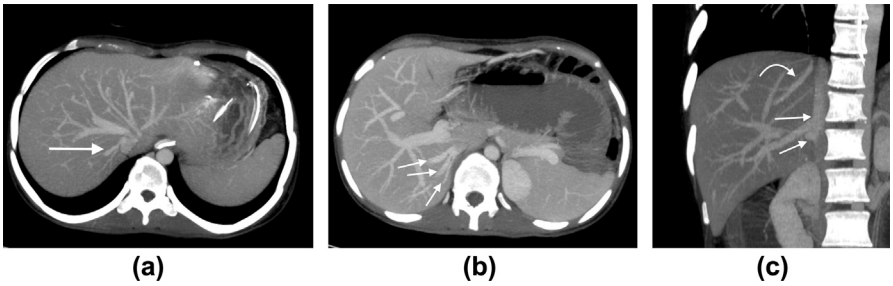

Figure 3 CECT abdomen, axial MIP images showing (a) a small RHV (arrow), with three IRHVs (arrows). (c) Coronal MIP image showing two larger IRHVs draining into the IVC at different levels (straight arrows). Also note the main RHV draining superiorly into the IVC (curved arrow).

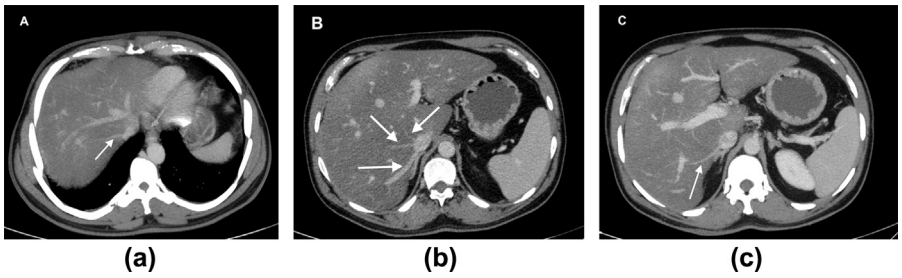

Figure 4 Axial MIP images showing (a) a small RHV (arrow) with (b) three variable-sized IRHVs opening into the IVC at the same level (arrows). (c) More inferiorly, another IRHV was seen draining into the IVC (arrow).

the liver is through three main hepatic veins: right, left, and middle hepatic veins, which open into the IVC at the level of the diaphragm; however, besides these veins, there are smaller inferior veins draining posteromedial portion of liver.[2] These veins vary in size and number, lie posteroinferior to the RHV complementing it,[6] and open into the IVC at a variable distance from the diaphragm. These veins have been termed as IFHVs. Although few authors have further divided these veins into middle and inferior groups depending upon their drainage into the IVC,[2,5] others have included all the inferior veins into one group.[4,6]

Although asymptomatic, clinical implications of the presence of an IRHV cannot be understated. Firstly, the presence of an IRHV may alter the expected course of disease and knowledge about this variant can help in better understanding of disease processes. In case of IVC obstruction by a large right lobe lesion, collateral pathways may develop between the IRHV and middle and left hepatic veins, and IVC obstruction may remain asymptomatic.[2,12] Similarly, in primary Budd–Chiari syndrome, an IRHV becomes the main drainage of the right lobe of the liver.[5] In cases of hepatocellular carcinoma (HCC), thrombus can extend into an IRHV and further into the IVC.[5] Secondly, presence of an IRHV may alter the surgical management of the patient. In partial hepatectomy, the extent of liver resection can be limited in the presence of a large IRHV, and posteroinferior segments of the liver can be preserved.[2,5,9] In living-donor liver transplantation, if the donor IRHV is ≥5 mm in size, it should be anastomosed separately to the recipient's IVC to reduce graft malfunction[13]; however, few surgeons preserve any donor IRHV >3 mm in size.[3] In addition, while performing TIPS, if preprocedure knowledge of the IRHV is not present, it can confuse the interventional radiologist during cannulation of the RHV.

The prevalence of IRHV on CT in various previous studies ranges from 8.6–67.5% and has been summarised in Table 3. Most of these studies have been undertaken on liver donors[13–19] while few others have been undertaken using routine CECT abdomen images[1,2,20] and in patients with liver tumours.[8,21] A prevalence of 56.25% was found in the present study. Soyer *et al.*[8] reported a prevalence of 8.6% on CT arterial portography. The acquisition was undertaken at 8 mm collimation with a reconstruction interval of 4 mm. The study was interpreted in the axial plane only and multiplanar reformations were not used. These factors could have resulted in underreporting of smaller IRHV, resulting in a lower prevalence. Kamel *et al.*[10] reported the presence of IRHVs in 67.5% of cases, with a single IRHV in 21 cases and two or more IRHVs in six cases. Sahani *et al.*[21] reported the presence of IRHVs in 19% of cases with liver

Table 2
Comparison in diameter of right hepatic vein (RHV) in patients with and without inferior right hepatic veins (IRHVs), and patients with smaller and larger IRHV (≥5 mm).

	Diameter of RHV (in mm)	*p*-Value[a]
Cases without IRHV (98/224)	8.47±1.99	<0.01
Cases with IRHV (126/224)	7.34±1.88	
Cases with IRHV <5 mm (80/126)	7.59±1.74	0.049
Cases with IRHV ≥5 mm (46/126)	6.91±2.05	

[a] Student's *t* test.

Table 3
Prevalence of inferior right hepatic veins (IRHVs) in previous studies.

Study	Prevalence of IRHV	Study population
Soyer *et al.* (1995)[8]	6/69 (8.6%)	Patients with small hepatic tumours
Kamel et at (2001)[10]	27/40 (67.5%)	Liver donors
Sahani *et al.* (2002)[21]	8/42 (19%)	Patients with malignant liver tumours
Erbay *et al.* (2003)[13]	33/107 (30.8%)	Liver donors and recipients
Guiney *et al.* (2003)[14]	40/100 (40%)	Liver donors
Akgul *et al.* (2004)[2]	65/308 (21%)	Patients undergoing routine CECT abdomen
Orguc *et al.* (2004)[15]	47/100 (47%)	Liver donors
Saylisoy *et al.* (2005)[16]	25/52 (48.1%)	Liver donors
Schroeder *et al.* (2006)[17]	108/250 (43.2%)	Liver donors
Koc *et al.* (2007)[1]	356/1261 (28.2%)	Patients undergoing routine CECT abdomen
Fang *et al.* (2012)[20]	42/200 (21%)	Patients undergoing routine CECT abdomen
Kalaycı *et al.* (2014)[18]	58/100 (58%)	Liver donors
Ahmed *et al.* (2017)[19]	25/42 (59.5%)	Liver donors
The present study	126/224 (56.25%)	Patients undergoing routine CECT abdomen

CECT, contrast-enhanced computed tomography.

tumours, which were scheduled for surgery. The presence of liver lesions in these patients could have interfered with visualisation of smaller veins. Hepatic veins were involved by the tumour in 23.8% of cases. Erbay *et al.*[13] found the accessory IRHV to be the most common variant in liver donors and recipients with a prevalence of 30.8%; however, most cases had a single IRHV and two IRHVs were seen in only four patients (3.74%). Guiney *et al.*[14] detected accessory hepatic veins draining right lobe into the IVC in 40 cases with a mean diameter of 5.3 mm; 45% of these veins were >6 mm. Akgul *et al.*[2] reported the presence of IRHVs in 65 cases (21%). In only 8% of these patients was the diameter of the IRHV >5 mm. Most of the patients had only one IRHV with two IRHVs detected in 11% cases. More than two IRHVs were not seen in any case. The mean diameter of the IRHV was not reported. Orguc *et al.*[15] reported an IRHV in 47 out of 100 liver donors out of which, 22 had a calibre of ≥5 mm. Saylisoy[16] reported an IRHV >3 mm in 48% of cases. Schroeder *et al.*[17] reported a thick IRHV associated with small or medium-sized RHVs in 43.2% cases; however, the exact diameters of the RHVs and IRHVs were not reported. Koc *et al.*[1] reported 446 IRHVs in 356 patients with a prevalence of 28.2%. In approximately 50% of these patients, the diameter of the IRHV was ≥5 mm; however, more than two IRHVs were detected in only seven cases (0.6%). Only one patient had four IRHVs. Fang *et al.* reported an IRHV in 21% of cases, which was accompanied by a small RHV; however, there was no mention about size of the RHVs or IRHVs.

In the present study, 214 IRHVs were detected in 126 cases, and a significant number of these cases had more than one IRHV (39.7%; 50/126). Koc *et al.*[1] reported more than one IRHV in 23% of cases (82/356), Kamel *et al.*[10] in 22.2% (6/27), Akgul *et al.*[2] in 17% (11/65), and Erbay *et al.*[13] in 3.74% (4/33) of cases. Only few of these studies mentioned the mean diameter of the IRHV. Koc *et al.*[1] reported a mean diameter of 4.9 mm, while Guiney *et al.*[15] reported mean diameter of 5.3 mm. In the present study, the mean diameter of the IRHVs was 4.15+1.44 mm and 36.5% (46/126) of cases had at least one IRHV measuring ≥5 mm in diameter. An IRHV measuring ≥5 mm requires separate anastomosis during living-donor liver transplantation to prevent graft congestion.

Although previous studies have mentioned that a small RHV is associated with a thick IRHV, the correlation between RHV and IRHV has not been measured in previous studies. Kim *et al.*[22] compared MHV/RHV diameter ratio in patients with and without an accessory hepatic vein and found that the MHV/RHV ratio was significantly higher in the group with accessory hepatic veins. The probability of an accessory hepatic vein was significantly higher when the RHV was smaller than the MHV.[22] A negative correlation between size of the RHV and IRHV was found in the present study. There was also a significant difference in size of the RHV in patients with (7.34+1.88) and without (8.47+1.99 mm) an IRHV.

The present study had limitations. First, it was a small study with limited sample size. Secondly, the distance of the IRHV from the RHV–IVC confluence was not calculated, which is important from a surgical point of view. A small RHV has an association with a large IRHV as well as a large MHV; however, the diameters of the MHVs were not recorded in the present study. To conclude, an IRHV is a frequently encountered variant on routine CECT abdomen, and it is not uncommon to encounter more than one IRHV. An IRHV is frequently associated with a relatively smaller RHV.

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Conflict of interest

None.

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