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Original Article

The hepatic veins: Anatomy and classification on single slice spiral CT in North Indian population

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ARTICLE INFO

Article history:
Received 30 October 2013
Accepted 3 December 2013

Keywords:
Hepatic veins
Inferior vena cava
Liver

ABSTRACT

Aims: To find out the normal pattern of hepatic veins in the North Indian population and to categorize them.
Methods: The present study was conducted on 100 patients whose spiral CT abdomen was performed for various medical conditions in the department of radiodiagnosis.
Results: Four categories were recognized. **Category-1**, when right hepatic vein drains independently into the inferior vena cava whereas middle and left hepatic veins join together to form a common trunk before draining into the inferior vena cava. It was observed in 74% patients. **Category-2** was observed in 2% patients, where right & middle hepatic veins join to form a common trunk and left hepatic vein drain independently into the inferior vena cava. **Category-3** was observed in 21% patients, where all the three major hepatic veins drain independently into the inferior vena cava. **Category-4** was observed in 3% patients, where all the three major hepatic veins join together to form a common trunk before draining into the inferior vena cava.
Conclusions: Category-1 is the most common pattern of major hepatic vein drainage found in the North Indian population. The present study also concluded that single right, middle and left hepatic vein is the most common pattern of hepatic veins present in the North Indian population. Caudate lobe is drained by more than one vein in majority of North Indians. Also superomedial vein, right accessory vein and inferior right hepatic vein are the most common accessory veins present in the North Indian population.

1. Introduction

The surgical anatomy of the liver is based on detailed knowledge of its natural divisions including congenital variants, and comprises morphological and functional aspects.[1] The study of functional anatomy of the liver permits the description of a hepatic segmentation based upon the distribution of the portal pedicles and the location of the hepatic veins.[2] The precise visualization of intrahepatic venous and portal structures has potential surgical importance, as it increases the confidence with which hepatic tumours can be localized to specific subsegments.[3,4] Preoperative tumour localization greatly affects the surgical decision making, as it

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0003-2778/$ – see front matter
http://dx.doi.org/10.1016/j.jasi.2013.12.001

may dictate the type of resection and allow preoperative prediction of the postoperative liver volume.[5,6] The variations in intrahepatic venous anatomy also influence the surgical approach. For example, knowledge of the presence of supernumerary right hepatic veins or an inferior right hepatic vein may facilitate extrahepatic or intrahepatic venous ligation during resection of the right hemiliver.[7] Knowledge of the venous anatomy also facilitates recipient hepatectomy with preservation of the retrohepatic portion of the inferior vena cava for orthotopic liver transplantation.

On axial CT images, hepatic veins are situated between adjacent segmental portal vein branches and demarcate the interlobar and intersegmental planes of the liver. The main right hepatic vein lies in the plane between the anterior and posterior segments of the right lobe, where it drains the entire posterior segment as well as the posterior aspect of the anterior segment. The main middle hepatic vein lies in the plane between the right and left lobes, where it drains most of the anterior segment of the right lobe and the entire medial segment of the left lobe. The main left hepatic vein drains the lateral segment of the left lobe. High in the subdiaphragmatic portion of the liver, the three major hepatic veins turn, and course in a nearly axial plane to enter the IVC.[8]

Because of severe shortage of cadaveric livers, transplantation surgeons are now performing living donor liver transplantation. Living adult right lobe liver transplantation is therefore performed, and removal of the right lobe of the liver must be accomplished without endangering the vascular supply or metabolic function of the remaining left lobe. The main goal of presurgical imaging is to provide a vascular arterial and venous "road map", which is critical for surgical guidance.[9]

2. Material & method

The present study was conducted in 100 North Indian patients (from Himachal Pradesh) who were requested spiral CT abdomen for various medical conditions in the department of radiodiagnosis. The most common medical condition for which CT was requested was carcinoma cervix in females and carcinoma lung in case of males. Out of these 100 patients 37 were male and 63 were female. The age of the patients ranged from 18 to 80 years with the mean age of 51.46 years. Maximum numbers of patients were in their 4th decade of life.

2.1. *Exclusion criteria*

1. Patients with known or suspected hypersensitivity to iodinated contrast media.
2. Pregnant or lactating women.
3. Patients with known severe renal impairment or serum creatinine level greater than 2.5 mg/dl.
4. Patients with known history of asthma, pheochromocytoma, sickle cell disease.
5. Patients with severe hypertension (diastolic BP > 120 mmHG) or congestive heart failure
6. Patients with hepatic mass, cirrhosis, portal hypertension distorting the architecture of the veins.

The study was conducted by using single slice spiral CT machine of GE (Sytec-SRI). Single slice spiral CT of the liver was performed through the liver after the ingestion of 750 ml of water as a negative contrast agent starting one & a half hours before the scan and intravenous injection of 100 ml of non-ionic contrast material (iohexol) followed by 50 ml of saline. Rate of injection of contrast material was 4–5 ml/s, with delay of 55 s for venous phase from the beginning of injection of contrast. The pattern of drainage of hepatic veins on single slice spiral CT was studied.

2.2. *Scan parameters*

- Scanning collimation – 10 mm with interval of 10 mm.
- kVp – 100.
- mA – 100.
- Scan time – 1.5 s.
- Pitch – 1.
- Retrorecon interval – 5 mm for the venous phase.

3. Observations

On spiral CT, the three major hepatic veins were seen in all the 100 patients and based upon the pattern of their drainage into the inferior vena cava they were categorized into four types. In 74 patients (74% cases) forming Category-1, the right hepatic vein drains independently into the inferior vena cava whereas middle and left hepatic veins join together to form a common trunk and then drain into the inferior vena cava (Fig. 1). In Category-2, the right and middle hepatic veins join to form a common trunk and then drain into the inferior vena cava whereas left hepatic vein drain into the inferior vena cava independently. It was observed in only 2 patients (2%), out of whom one was male and the other female (Fig. 2). In Category-3, the right, middle and left hepatic veins drain independently into

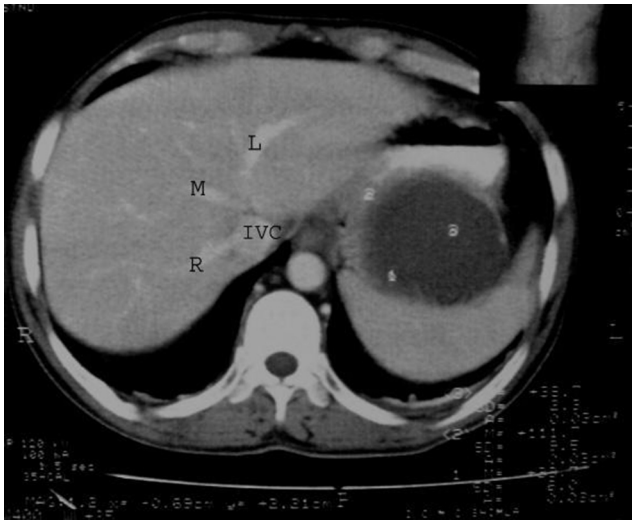

Fig. 1 – Showing right hepatic vein draining independently into the IVC whereas middle & left hepatic veins join to form a common trunk before draining into the IVC. R – Right hepatic vein; M – Middle hepatic vein; L – Left hepatic vein; IVC – Inferior vena cava.

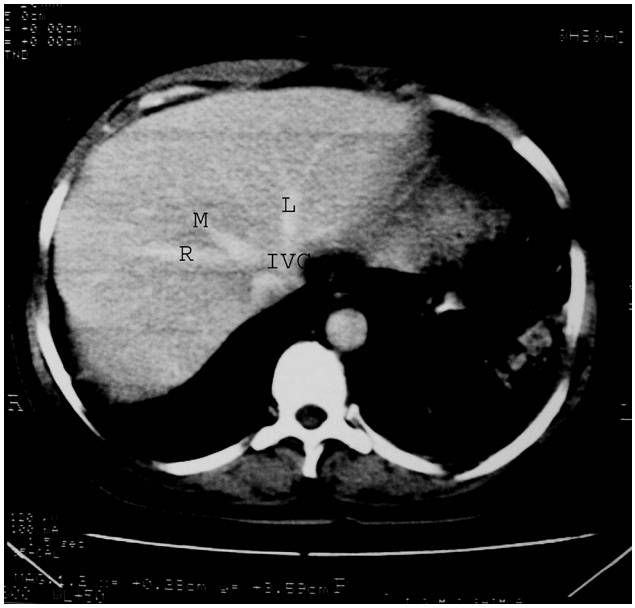

Fig. 2 – Showing right and middle hepatic veins join to form a common trunk before draining into IVC whereas left hepatic vein drains independently. R – Right hepatic vein; M – Middle hepatic vein; L – Left hepatic vein; IVC – Inferior vena cava.

the inferior vena cava. It was observed in 21 patients (21%), out of whom 6 were male and 15 were female (Fig. 3). In Category-4, the right, middle and left hepatic veins join to form a common trunk and then drain into the inferior vena cava. It was observed in 3 patients (3%), out of whom 2 were male and 1 female (Fig. 4). Pattern of drainage of individual hepatic veins were also

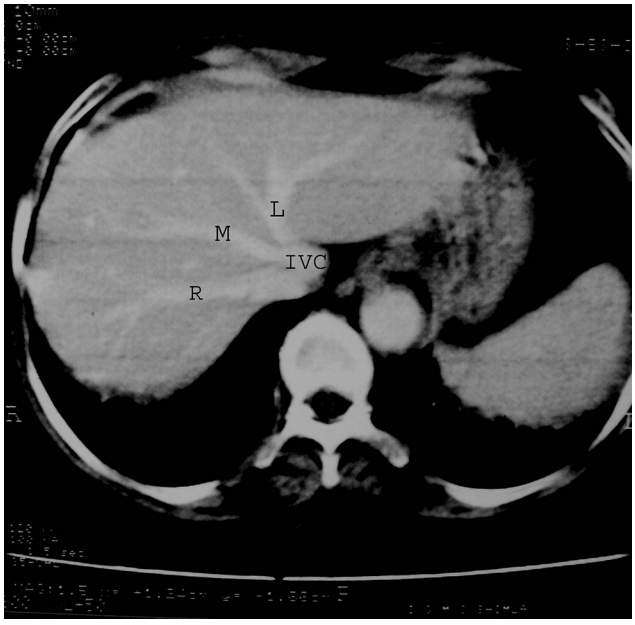

Fig. 3 – Showing all the three hepatic veins draining independently into the IVC. R – Right hepatic vein; M – Middle hepatic vein; L – Left hepatic vein; IVC – Inferior vena cava.

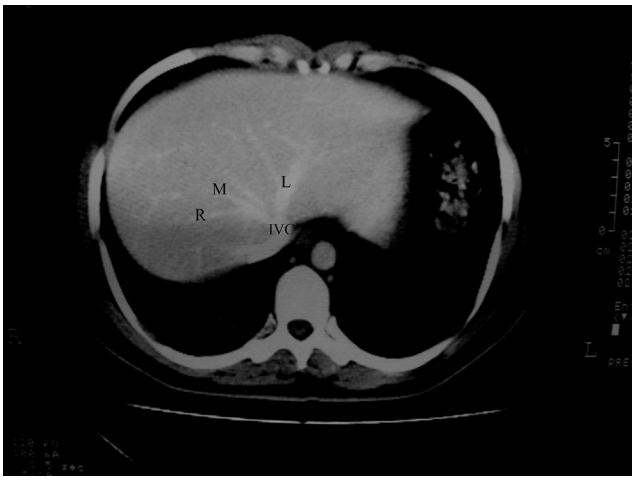

Fig. 4 – Showing all the three major hepatic veins join to form a common trunk before draining into the IVC. R – Right hepatic vein; M – Middle hepatic vein; L – Left hepatic vein; IVC – Inferior vena cava.

observed. In 91% patients, there was a single right hepatic vein, in 6% patients there was a right accessory hepatic vein which joins with the right hepatic vein to form a single trunk before draining into the inferior vena cava, in 1% patients there were two right accessory hepatic veins which join with the right hepatic vein to form a single trunk before draining into the inferior vena cava and in 2% patients there was a right accessory hepatic vein draining independently into the inferior vena cava. In 90% patients a single middle hepatic vein was observed, in 9% patients a middle accessory hepatic vein was observed which join with the middle hepatic vein to form a common trunk and in 1% patients two middle accessory hepatic veins were observed which join with the middle hepatic vein to form a single trunk. In 78% patients a single left hepatic vein was observed, in 17% patients a left accessory hepatic vein joining with the left hepatic vein to form a common trunk was observed and in 5% patients two left accessory hepatic veins joining with the left hepatic vein to form a common trunk were observed. Caudate lobe was drained by a single hepatic vein in 9.5% patients and by more than one hepatic veins in 90.5% patients. Various accessory hepatic veins were also observed. Superomedial accessory hepatic vein was found lying between middle and left hepatic vein in 47 (47%) patients, out of which in 14 (29.8%) patients it drained into middle hepatic vein (Fig. 5a) and in 33 (70.2%) patients it drained into left hepatic vein (Fig. 5b). Right anterosuperior vein was observed between right and middle hepatic vein in 13 (13%) patients and was draining middle hepatic vein (Fig. 6). Inferior right hepatic vein was observed draining the posteroinferior segment of right lobe of liver and drains directly into the inferior vena cava in 31 (31%) patients (Fig. 7).

4. Discussion

In the present study, the main pattern of the drainage of the three major hepatic veins is Category-1, where the right hepatic vein drains independently and middle & left hepatic

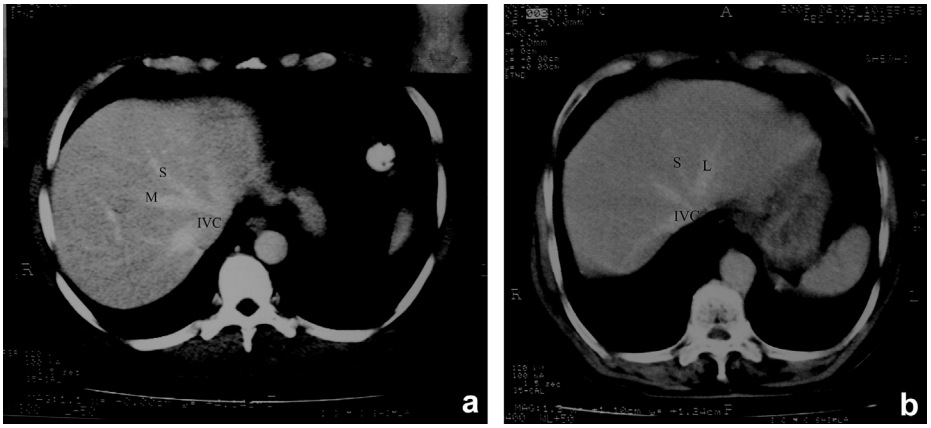

Fig. 5 – (a). Showing the superomedial hepatic vein draining into middle hepatic vein S – Superomedial hepatic vein; M – Middle hepatic vein; IVC – Inferior vena cava. (b). Showing the superomedial hepatic vein draining into the left hepatic vein. S – Superomedial hepatic vein; L – Left hepatic vein; IVC – Inferior vena cava.

veins join to form a common trunk before draining into the inferior vena cava. The frequency of 74% of this pattern observed vary from, 50% by Banner & Brasfield[10] in New York, USA to 95% as observed by Soyer et al[11] in Baltimore, USA. Lafortune et al[12] in Montreal, Canada found similar pattern of three hepatic veins forming a 'W' with its base on the inferior vena cava in 70% of their subjects, and they considered this to be the normal anatomy of the hepatic veins. In the present study, the same distribution was found with similar frequency (74%). Gupta & Gupta[13] from India observed this pattern in 63% livers obtained at autopsy in medical college at Agra. The Category-2, where right & middle hepatic veins join to form a common trunk and left hepatic vein drain independently into the inferior vena cava, was observed by Gupta & Gupta[13] in 3.15% cases. In present study this was observed in 2% patients, which is comparable to the study done by Gupta & Gupta.[13] The Category-3, where all the three major hepatic veins drain independently into the inferior vena cava, has incidence varying from 5% as observed by Soyer et al[11] to 35% as observed by Banner & Brasfield.[10] The frequency of similar pattern observed by Baird & Britton[14] is 9%, by Hardy[15] & Chang et al[16] is 10%, by Gupta & Gupta[13] is 10.5%, by Camargo et al[17] is 13.7%, and by Nakamura & Tsuzuki[18] is 15.7%. The difference in the frequency may be due to the regional or racial differences. Present study found this category in 21% cases. The Category-4, where all the three major hepatic veins combine to form a common trunk before draining into the inferior vena cava, was observed in 3% patients in the present

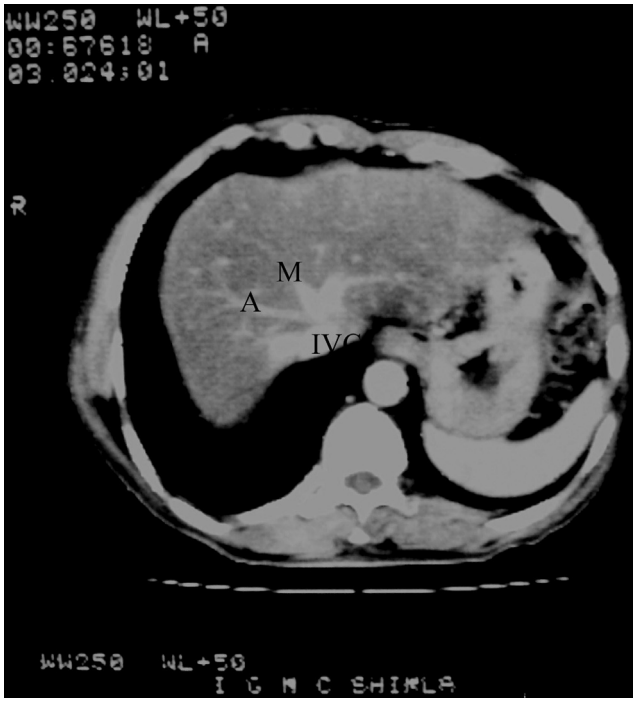

Fig. 6 – Showing right anterosuperior hepatic vein draining into middle hepatic vein. A – Anterosuperior hepatic vein; M – Middle hepatic vein; IVC – Inferior vena cava.

Fig. 7 – Showing inferior right hepatic vein draining directly into the inferior vena cava. I – Inferior right hepatic vein; IVC – Inferior vena cava.

study. Other authors also observed this pattern of drainage of major hepatic veins where its frequency vary from 1.7% as observed by Chang et al,[16] 4% by Gupta & Gupta[13] to 15% as observed by Banner and Brasfield.[10] Various authors observed different accessory hepatic veins and mentioned their incidence in their population of study. Superomedial accessory hepatic veins draining into middle hepatic vein were observed in 5.26% cases and those draining into left hepatic vein in 16.84% cases by Gupta & Gupta[13] whereas it was observed in 47% cases in the present study. Right anterosuperior hepatic vein was observed in 13.25% cases by Nakamura & Tsuzuki[18] and in 13% cases in the present study. The accessory vein draining the segment VII was named as 'inferior right hepatic vein' by Makuuchi.[19] He observed this vein in 10% cases. In the present study this vein was observed in 31% cases. Other authors also observed this vein where its incidence vary from 24% as observed by Nakamura & Tsuzuki,[18] 18% as observed by Cheng et al,[20] 28% as observed by Cecchis et al[21] to 19% as observed by Sahani et al.[22]

5. Conclusion

After examining the spiral CT abdomen of 100 patients, the hepatic veins were mainly divided into four categories based upon the pattern of three major hepatic veins drainage. The most common category found in the North Indian Population is Category-1 in which, right hepatic vein drains independently into the inferior vena cava whereas middle and left hepatic veins join together to form a common trunk before draining into the inferior vena cava and the least common is Category-2 where the right and middle hepatic veins join together to form a common trunk before draining into the inferior vena cava whereas left hepatic vein drains independently.

The present study also concluded that single right, middle and left hepatic vein is the most common pattern present in the North Indian population and Caudate lobe is drained by more than one vein in majority of North Indians.

The present study further concluded that superomedial veins, right anterosuperior veins and inferior right hepatic veins are the most common accessory veins present in the North Indian population.

Conflicts of interest

All authors have none to declare.

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