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"Evaluation of Anatomic Variations of Hepatic Veins on Contrast Enhanced Computed Tomography Scans"

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I. Introduction

Liver has complex system of blood flow. It receives blood from two sources, which are the hepatic artery and portal vein. Hepatic artery forms only about 25% of the inflow, rest 75% is formed by the portal vein. Venous outflow of the liver is via three hepatic veins into the inferior vena cava.

Liver is one such organ in the human body which is frequently affected by trauma, various tumours, or failure which may require surgery for resection of segments or part of liver.

Previously cadaveric liver transplant was the only option available for transplant recipients. Now a days the live donor liver transplant [LDLT] has emerged as a latest surgery. The resection of segments in the living donor requires detailed study of the hepatic vascular anatomy for successful resection, donor safety as well as successful recipient outcomes.(1)

Knowledge of anatomy of hepatic veins and portal vein is essential for classification of liver segments according to Couinaud's segmentation system.(2)

Although hepatic artery is most studied for its anatomic variations, hepatic and portal venous system also shows anatomic variations(3), and keeping this variations in mind helps to not only avoid unexpected complications in resection surgery which includes catastrophes of massive bleeding or air embolism due to laceration of major veins but also to maintain adequate blood flow to liver after surgery and thus help in speedy recovery of the patient. It is also essential for R0 resection of liver tumors.

The precise visualization of portal structures is potentially important in surgery.

Determining the location of a tumor preoperatively greatly affects surgical decision making, since it may help to decide the type of resection and allow preoperative assessment and calculation of the postoperative liver volume. Also, variations of intrahepatic venous anatomy may influence the surgical approach. Knowledge of the hepatic vascular anatomy is of importance in safely creating TIPS.(4)(5).

With advent of Computed tomography scans it has been possible to depict the vascular anatomy of the body with the help of contrast study. Both, MRI and multiphasic computed tomography scans are useful in pre-operative donor and recipient workup prior to LDLT.(6)

CT scan is the most widely used modality due to its easy availability and low cost. 3D CT scan has made the depiction and anatomical understanding easier for surgeons, so that the resection can be planned before the operation by visualizing the exact anatomy of the vessels supplying the liver- portal vein and hepatic artery and vessels draining the liver- hepatic veins.

II. Aims And Objectives:

1: To look for anatomic variations in hepatic veins.
2: To classify each hepatic veins according to its branching pattern.

III. Material And Methods

Study design: Non-interventional cross sectional observational study.
Period of study: 12 months.
Setting: Department of radiology, Tertiary care teaching hospital.
Number of subjects: 200 cases were studied over a period of twelve months.
Patients undergoing contrast enhanced CT scan of abdomen daily in department of Radiology in our Hospital, number of patients that can fulfill inclusion- exclusion criteria of study among these patients and were adequate enough to give representative values of parameters of study. The necessary changes were made in study protocol.

Inclusion criteria for cases:
Any adult patient who were undergoing contrast enhanced CT scan as advised by the respective physician/surgeon and willing to participate into the study fulfilling the below mentioned criteria:

- Any sex, male or female.
- Age more than 18 years.
- Patients having normal serum creatinine value (0.3-1.4 mg/dl).
- Patients non-allergic to contrast.
- Patient having registration at this institute.
- Patients who were advised contrast enhanced CT scans by their physicians.
- The patients with small hepatic tumours that are not distorting the hepatic and portal venous anatomy are included.

Exclusion criteria:

- Any patient not willing for the study.
- Any patient having increased serum creatinine levels (>1.4 mg/dl)
- Any patient having history of contrast allergy reaction.
- Any patient having large tumor or mass in liver causing distortion of hepatic and portal venous anatomy.
- Any patient having thrombosis of portal or hepatic venous system

STUDY PROCEDURE:

Proper informed consent was taken from patient after explaining to them about the risks and benefits of examination. Essential clinical history was obtained mainly regarding previous surgery or interventional procedure. All the study related data was collected at the time of undergoing CT scan. Patient did not have the inconvenience of performing additional visits solely for the purpose of this study.
The serum creatinine value of patient was checked.
All studies will be performed on Toshibha 16slice Computed tomography scanner.

Field of view	350mm
Thickness	2 mm
Pitch	1 mm
Filter standard	B
Window width	60
Window length	360
Matrix	512x 512

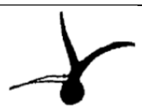
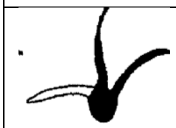
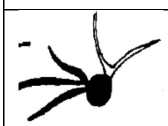
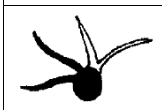
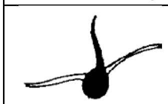
All studies were performed on a Toshibha 16slice Computed Tomography unit. CT data was obtained with above parameters:
Standard contrast enhanced abdomen scanning protocol includes plain phase, arterial phase portal phase and venous phase.
Plain scan will include from lung bases to pelvis.
Followed by 1.5 ml/kg non-ionic iodinated contrast material was injected at the rate of 3ml/sec using pressure injector.
Arterial phase scan included lower thoracic aorta to abdominal aortic bifurcation.
Portal phase scan included lower thoracic aorta till bifurcation of aorta.
Venous phase scan included from lung bases to pelvis.
All the image data was sent electronically to a workstation for analysis.
Data for study was mainly obtained from plain scan and portal and venous phase of contrast scan.

Scans would be assessed for presence of any variations in all 3 hepatic veins and recorded as described by Soyer et al.

Statistical Methods:
All the data was recorded in a case record form and analyzed using descriptive statistics.

IV. Results

Hepatic veins:
Hepatic veins were identified at their junction with IVC (hepatocaval junction as follows:
Right hepatic vein was identified in 200 (100%) of 200 patients; middle and left in 200 (100%) of 200 patients.
Small hepatic veins draining the caudate lobe (i.e. segment 1) and joining the anterior wall of IVC were depicted in 40 patients (20%).
Classical anatomy of hepatic veins i.e all 3 hepatic veins visualized with middle and left hepatic vein forming an common trunk near its confluence with the IVC was found in 150 (75%) patients.
Rest of the 50 patients (25%) showed all 3 hepatic veins with separate confluence of the hepatic veins with IVC.
Supernumerary hepatic veins were found in 92(46%) patients, including the accessory right hepatic veins.
The individual hepatic vein branching variation were classified according the Soyer et al schematic diagram.Of these, the patients in which the right hepatic vein was visible, 59(29%) had one main right hepatic vein with small branches. 128(60%) had two main right hepatic veins forming a common trunk before joining the IVC. 21(3%) had three hepatic veins forming a common trunk and 2(1%) had two separate right hepatic veins opening separately at the same level.
In all the patients the middle hepatic vein was visible. Of these patients 56(28%) had one main middle hepatic vein with small branches.
128(60%) had two main middle hepatic veins forming a common trunk just before the confluence with IVC.
23(11%) had three main hepatic veins forming a confluence.
2(1%) had two separate middle hepatic veins with separate opening into the IVC.

Type	Description	Number of patients (Percentage) N=200
Main pattern		
	MHV and LHV as confluence	150(75%)
	All 3 HV's drain separately into IVC	50(25%)
RHV branching variation		
	Single RHV	59(29%)
	2 RHV's forming confluence before draining into IVC	128(60%)
	3 RHV's draining into IVC	21(10%)
	2 RHV's draining separately into IVC	2(1%)
MHV branching variation		
	Single MHV	56(28%)

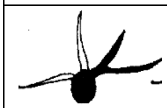
	2 MHV's draining into IVC as a confluence	121(60%)
	3 MHV's draining as a confluence	23(11%)
	2 MHV's draining separately into IVC	2(1%)
LHV branching variation		
	Single LHV	55(27%)
	2 LHV's draining separately into IVC	8(4%)
	2 LHV's draining into IVC as a confluence	87(43%)
	2 LHV's draining into IVC separately or as a confluence.	47(26%)

Table 1: hepatic vein variation in our study of 200 patients

In all the patients in whom the left hepatic vein was visible, 50 (25%) of the patients left hepatic vein formed a common confluence with middle hepatic vein before joining the IVC.
Of these 55(27%) had one main left hepatic vein with small branches.
8(4%)had two separate left hepatic veins with separate opening into the IVC.
87(43%) had two left hepatic vein forming a confluence just before joining the IVC.
47(26%) had three separate left hepatic veins individually opening into the IVC.
An inferior right hepatic vein was identified in 46% of the patients; of these the inferior RHV of diameter greater then 5mm was considered significant. 44(22%) patients had inferior RHV of diameter greater then 5mm. 48(24%) had an inferior RHV of < 5 mm diameter. Rest of the 107 (54%) patients did not have any accessory inferior RHV.

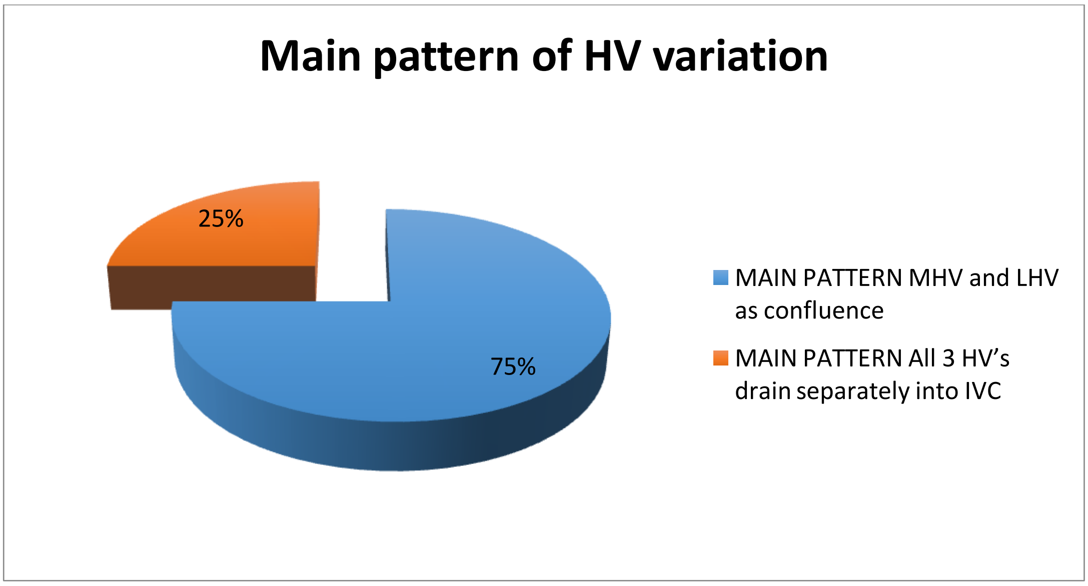


Fig 1: Pie chart showing main pattern of hepatic vein variation.

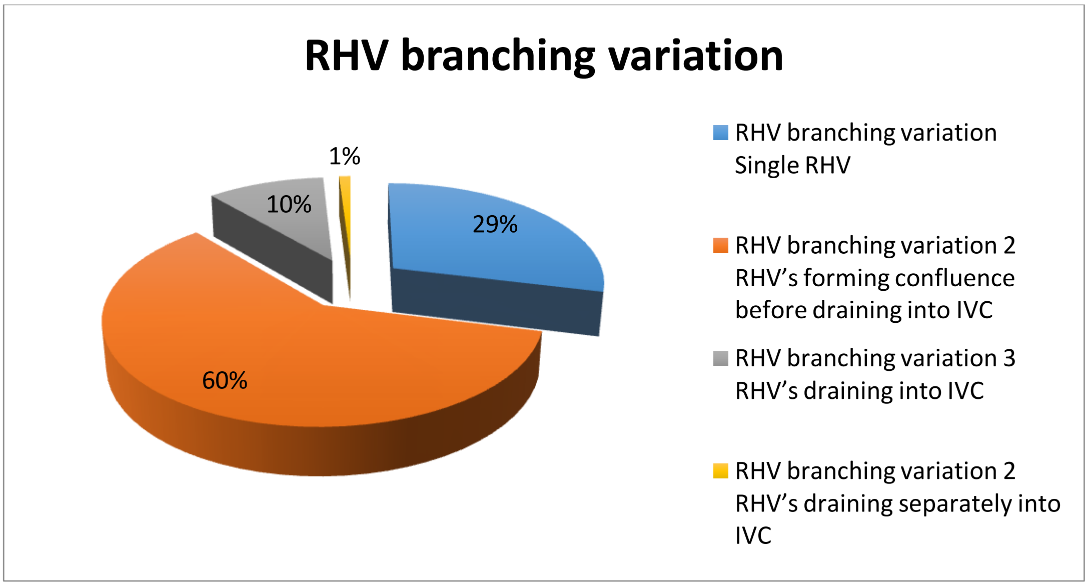


Fig 2: Pie chart showing RHV branching variation

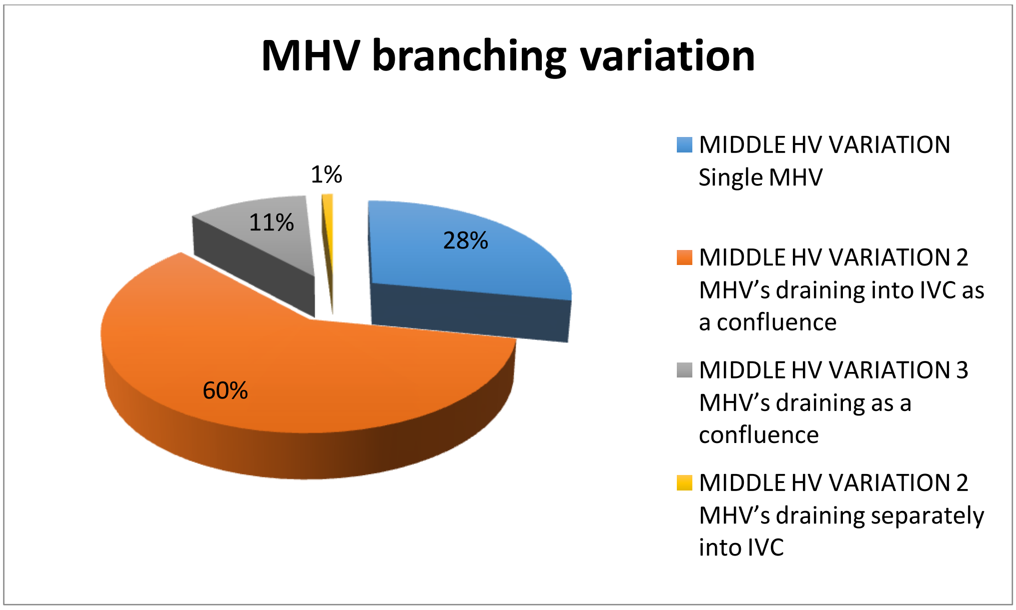


Fig 3: Pie chart showing MHV branching variation

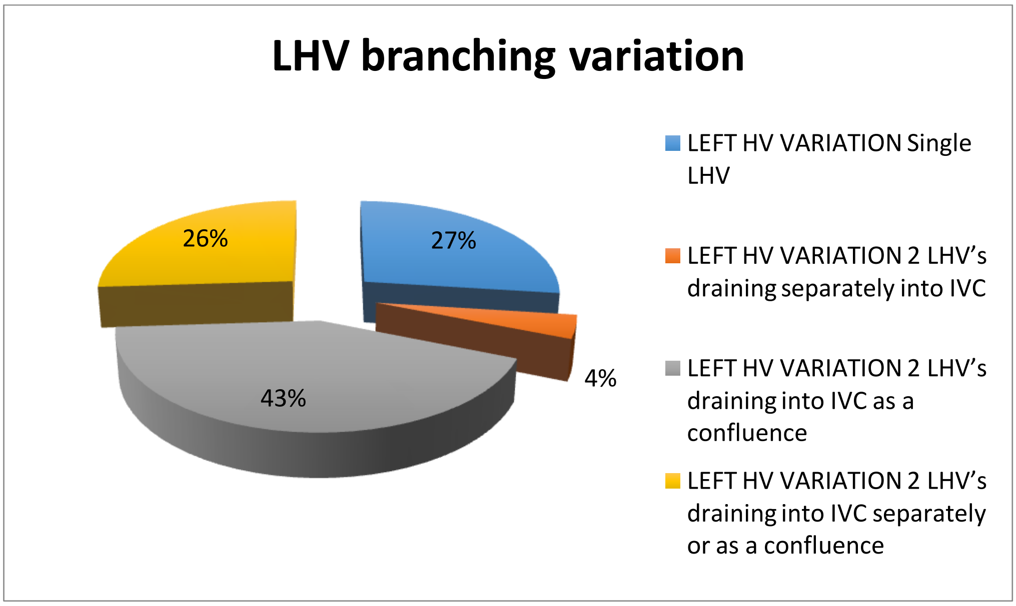


Fig 4: Pie chart showing LHV branching variation.

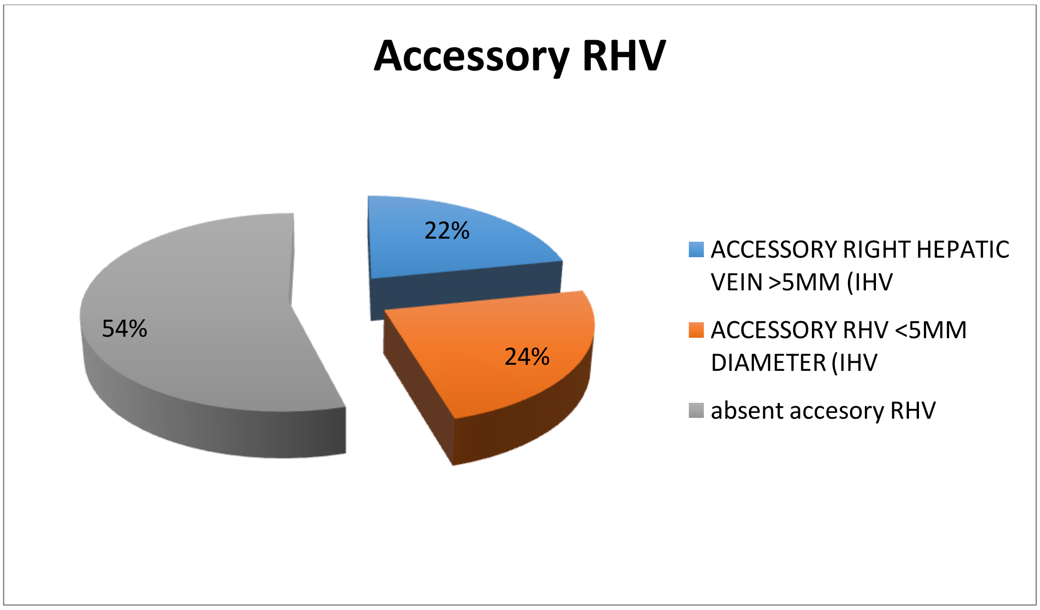


Fig 5: Pie chart showing Accessory RHV frequency.

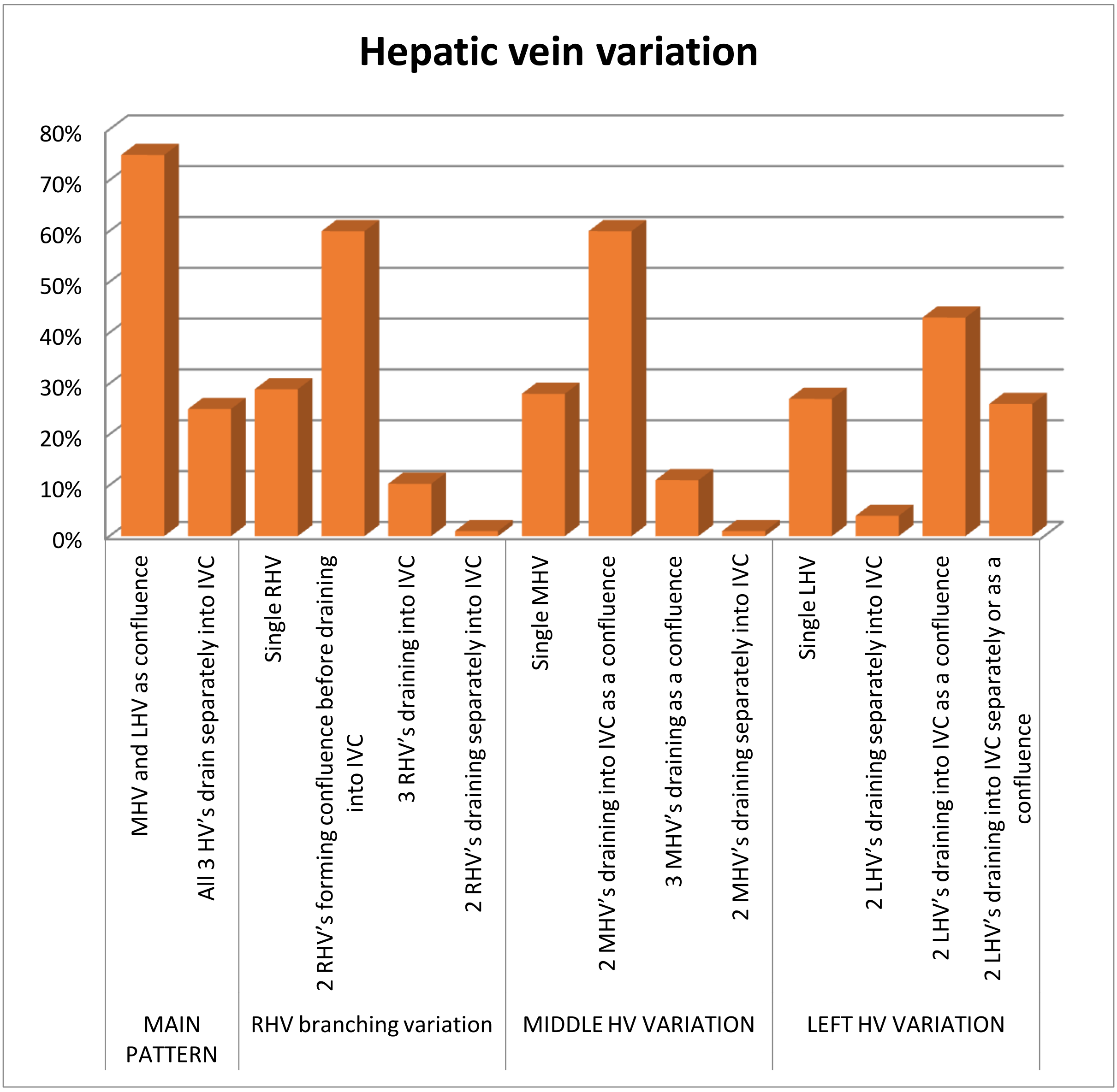


Fig 6:Bar diagram showing total distribution of hepatic vein variation

V. Discussion

It is important to depict the hepatic venous anatomy in a patient with hepatic tumours, to localize them with confidence in specific hepatic subsegments.(7,8)

Pre operative tumour localization helps greatly in surgical decision making, as it helps to plan the type of resection and allow pre-operative calculation of the estimated residual post- operative liver volume.(9,10)

Knowledge of variation in intra hepatic venous anatomy may influence the surgical approach. The presence of supernumerary hepatic veins or an inferior hepatic vein requires ligation during resection of right hemiliver.(11)

It also helps in preservation if retrohepatic IVC during liver transplantation in the liver recipient.(12)

Variations of the hepatic vein anatomy was first reported by Lafortune et al(13).

It was a study based on ultrasonographic evaluation of the hepatic veins.

Soyer et al studied hepatic venous anatomy and variations using helical CT scan with contrast. In that study, he found many variations in the hepatic vein, and also gave the schematic representation of the hepatic venous anatomic variation.

In our study, we have based and classified hepatic venous anatomic variations according to the scheme given by Soyer et al.(5)

In their study, Soyer *et al* found 95 percent of the patients showing confluence of the middle and left hepatic vein before entering the IVC, and 5% had separate opening into the IVC.

Orguc et al(14) studied hepatic vein variations in 100 patients using helical CT scan, and classified hepatic vein according the scheme provided by Soyer et al. in this study, they found the confluence of LHV and MHV in 80% of the patients, while separate opening of all 3 hepatic veins was found in 29% of the patients.
Rest of the hepatic vein variations involving the RHV, MHV and LHV were found. The frequencies of these variations were comparable with our study.
In our study, the confluence of the MHV and LHV was the most frequent pattern, found in 75% of the patient, with separate opening of all three HV's into IVC in 25% of the patients.
The RHV had 4 types of variation in its branching. Of these, 2 RHV's forming confluence before draining into IVC was the most frequent; found in 60 % (n=128) patients.
3 RHV's draining into IVC was found in significant number of patients; 10% (n=21), as compared to Orguc et al.
We also found2 RHV's draining separately into IVC in two patients (1%).
MHV variations were of four types, of these 2 MHV's draining into IVC as a confluence was the most frequent; found in 60% (128) of the patients.
LHV variations were also of four types with 2 LHV's draining into IVC as a confluence being the most frequent type; found in 43% (n=87) patients.
The supernumerary hepatic veins were found in 46% of the patients.
An inferior right hepatic vein was identified in 46% of the patients; of these the inferior RHV of diameter greater then 5mm was considered significant. 22% of the patients had inferior RHV of diameter greater then 5mm. 24% had an inferior RHV of < 5 mm diameter. Rest of the 54 % of patients did not have any accessory inferior RHV.
Small hepatic veins draining the caudate lobe (i.e. segment 1) and joining the anterior wall of IVC were depicted in 40 patients (20%).

VI. Summary And Conclusion

The hepatic vein is the key structures in determining the accurate anatomical divisions of the liver. The hepatic vein vary in their anatomy.

The knowledge of these anatomical variations is important for determining the location of a mass lesion, planning the resection plane, for planning the interventional procedures like TIPSS and DIPSS.

In our study, we studied the variation in the hepatic vein anatomy in 200 patients who underwent contrast CT scan of abdomen.

We studied the hepatic vein anatomy and found multiple variations. These we have classified according to the scheme determined by Soyer et al. our results were comparable to the previous studies, with some difference in the prevalence of the types of RHV, MHV and LHV branching variation.

The inferior RHV is an important variation, which we encountered in significant number of patients. Anatomical resection of segment VIII (SVIII) is one of the most difficult hepatectomies to perform. Although it is the best choice of surgical treatment for tumors located at SVIII, its feasibility can be compromised when the right hepatic vein (RHV) must be resected en bloc with SVIII. If a cirrhotic patient that was submitted to segmentectomy VIII in bloc with the main trunk of the RHV, due to hepatocellular carcinoma, the resection can only be performed because a well-developed inferior right hepatic vein (IRHV) was present. Liver surgeons to improve surgical results should use anatomical variations of the liver vascularization.

We found that contrast enhanced CT scan done in three phases i.e. arterial, portal and venous phase is a valuable tool in determining the exact anatomy of the hepatic vasculature including the portal vein and hepatic vein and their variation.

Adequate knowledge of these variations is important for radiologists owing to projected increasing demand of liver transplantation and hepatobiliary interventions in the future. Axial-oblique images with MPR and MIP reformations are particularly important in discriminating these variations and reduce procedure-related morbidity and mortality.

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FIGURES

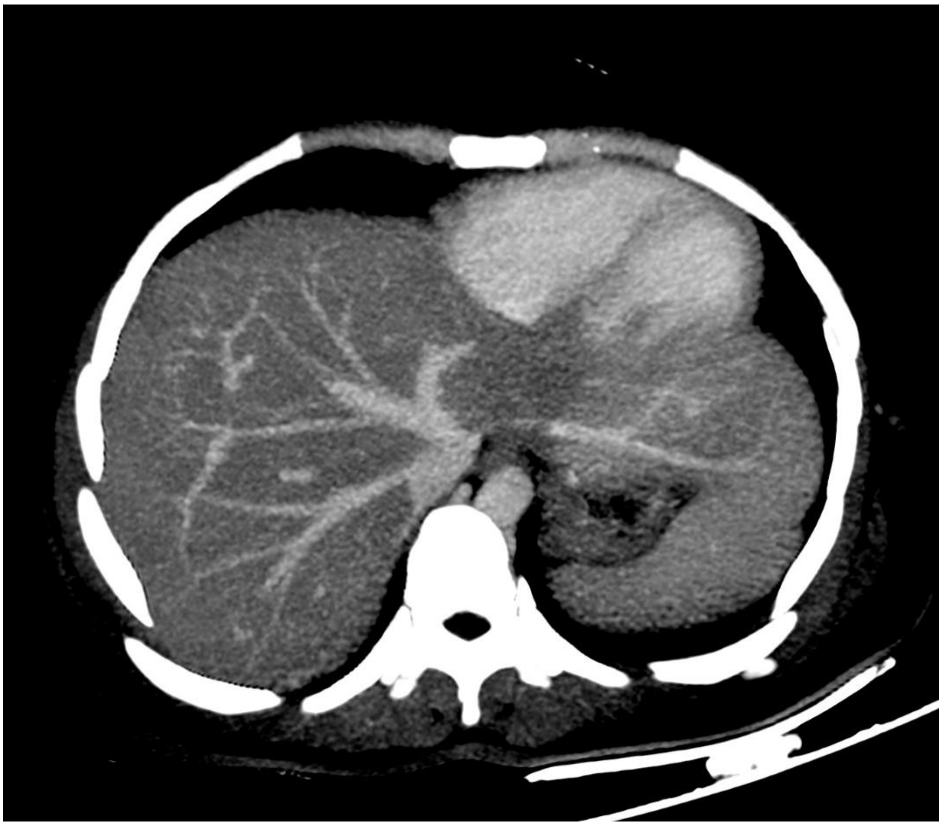

Fig 7: Axial CT showing hepatic vein anatomy with MHV and LHV opening into IVC as a confluence.

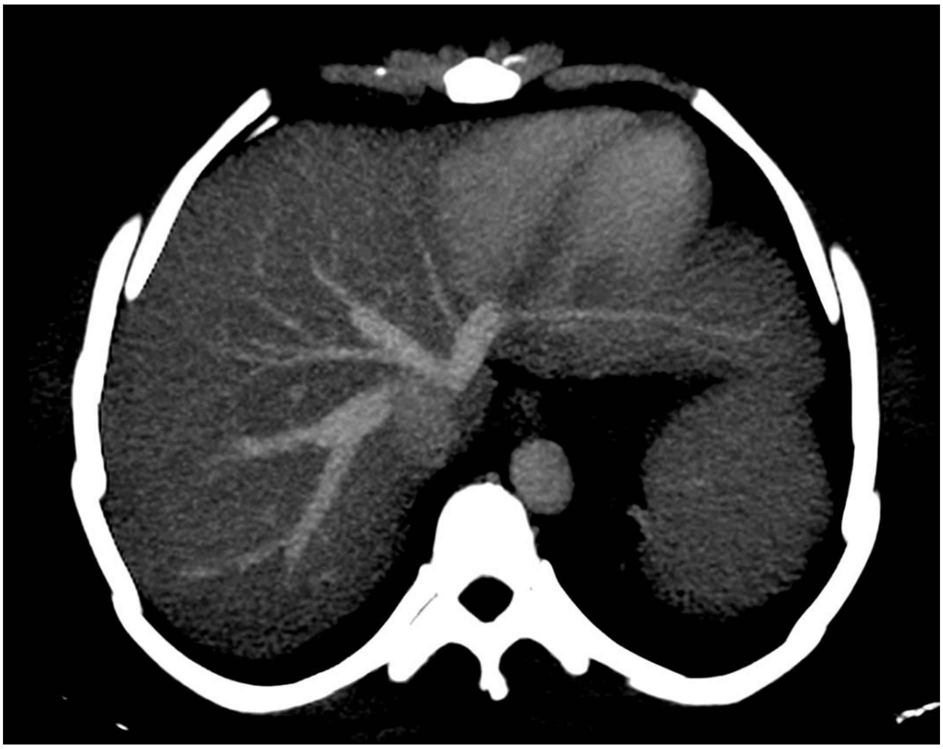

Fig 8: axial CT showing all 3 hepatic veins having separate opening into IVC

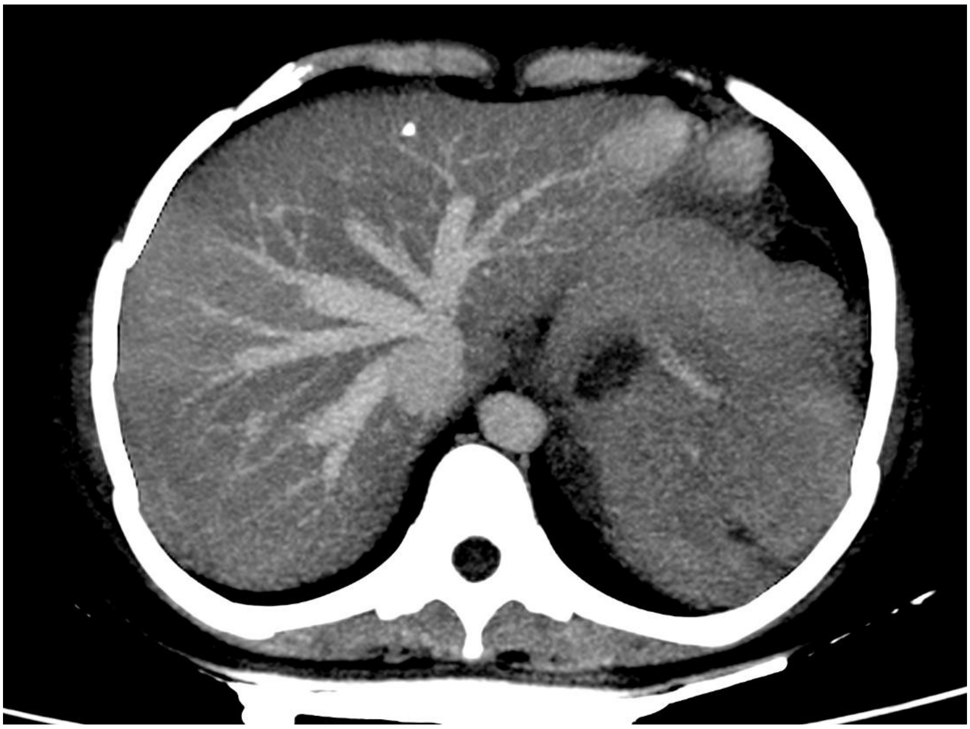

Fig 9: axial CT scan showing RHV bifurcation, MHV bifurcation, and LHV trifurcation.

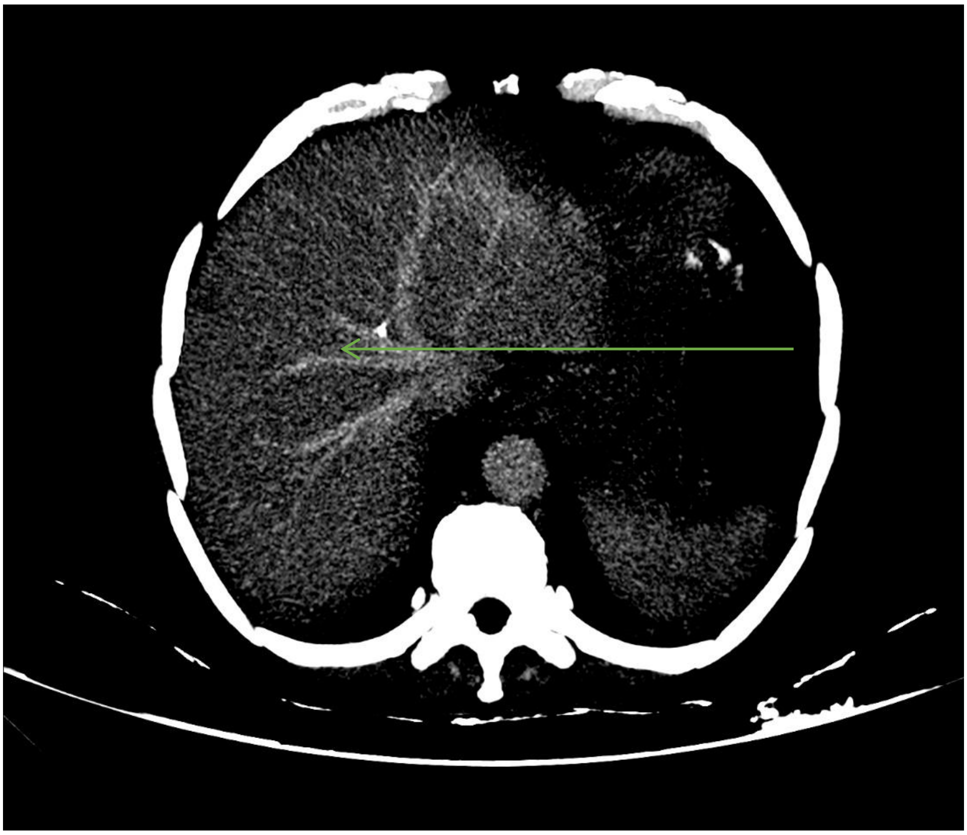

Fig 10: axial CT scan showing trifurcation of MHV (arrow).

Fig 11: Coronal CT showing RHV with bifurcation.

Fig 12: Axial CT showing inferior right hepatic veins (IRHV- yellow arrows)


Fig 13: Coronal CT scan showing IRHV (arrow).

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