Original Article

An anatomical evaluation of venous drainage of liver by multi-slice spiral computed tomography

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Abstract

Living-donor liver transplantation (LDLT) is a surgical option for patients who are deteriorating clinically while awaiting cadavericdonor liver. In LDLT, anatomy of hepatic venous system is important, not only to carry out complex reconstructions, but also to avoid graft congestion after liver transplant in the graft recipient. Hence pre-operative evaluation of venous drainage and awareness of probable complications is a pre-requisite for transplantation surgeries. We evaluated 100 abdominal CT scans retrospectively, studying the number of hepatic veins, their length and diameter and if any confluence among hepatic veins was present. We observed that the number of hepatic veins draining into IVC varied from 2 (51%), 3 (48%) and 4 (1%), depending upon the confluence pattern and presence of accessory hepatic vein. Out of 100 cases, 63 showed confluence, and were grouped into six categories. Category-1(confluence between left and middle hepatic veins) was most common (57%). Other patterns were also found, which had serious implications regarding suitability for living donor hepatectomy. The right hepatic vein was the largest (mean diameter-11.36mm), followed by middle (mean diameter-9.49mm), and the left (mean diameter-8.41mm) hepatic vein was the smallest. Hence in liver transplantation, pre-operative evaluation of venous drainage of liver of donor and recipient is necessary for reconstruction anastomoses and to avoid major hemorrhage during surgery.

Key Words: Confluence of hepatic veins, hepatic veins, hepatic venous reconstruction anastomosis, liver transplantation surgery, Living-donor liver transplantation (LDLT).

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INTRODUCTION

Liver is the first organ to develop in humans to meet with the increasing metabolic demands of the growing embryo.[1] It can get affected with several pathologies which can lead to end-stage liver diseases like cirrhosis and hepatocellular carcinoma. For such patients, Living Donor Liver Transplantation (LDLT) has emerged as a critical surgical option in recent decades. The concept of LDLT is based on the remarkable regenerative capacity of human liver and widespread shortage of cadaveric livers for patients awaiting transplants.[2,3] In liver transplantation, hepatic resection is typically performed in aplane parallel to the middle hepatic vein.[4] Venous drainage by middle hepatic vein is more complex and shows several anatomic variations. The hepatic veins are arranged in upper and lower groups. Upper group has usually large veins and commonly called as the right, middle and left hepatic veins. The lower group varies in number and extent of distribution.[5] An accessory right-middle or inferior hepatic vein maybe found rarely. When present, such veins are of surgical importance. In liver transplant, venous reconstruction is needed. These veins must be anastomosed to the recipient IVC to ensure adequate venous drainage and to prevent postoperative liver dysfunction.[4] In liver transplantation surgeries, vascular complications still account for considerable mortality and morbidity.[6] A detailed knowledge of hepatic angio-architecture is thus considered a pre-requisite for successful liver transplant surgeries.[1] The main aim of pre-operative imaging is to provide a vascular road map for transplantation surgery.[7] Various methods have been used to study the hepatic venous architecture-one of them

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being cadaveric liver dissection. O Fersia[8] *et al* (2010) and S D Joshi[9] (2010) studied the number of hepatic veins, diameter of right and left hepatic veins by dial caliper in cadaveric livers. O Fersia [8] *et al* (2010) also studied the confluence of hepatic veins and presence of accessory veins. Few scientists, Wind P[10] *et al*, 1999, D Singh[11] *et al*, 2012 and Ulziisaikhan T[12] *et al*, 2014 used the injection corrosion-cast method, to study the confluence among hepatic veins. With advanced imaging techniques, few attempted the use of CT scans to evaluate the venous architecture. Among them, Yogesh Diwan[13] *et al*, 2013 classified the pattern of confluence, which has been used in the present study too. The present study also includes the total number of hepatic veins and the diameter of the right, middle and left hepatic veins.

MATERIALS AND METHOD

CT scans of normal liver were taken on a Philips brilliance 64 slice spiral CT after intravenous administration of 100-120 ml of non-ionic contrast agent Iohexol 350 at a flow rate of 5 ml/s. 100 such multi-slice spiral CT scans of normal livers, taken over a period of 18 months' duration, after obtaining clearance and permission from the Ethics committee and the head of Radio-diagnosis department of a tertiary health care center, were studied retrospectively. Cases operated for hepatic resection or any other operation in the region of the liver, were excluded. Terrarecon software was used for measurements. CT scans were studied in axial, coronal, sagittal and oblique planes. The frames were frozen along the long and short axis of the hepatic veins, for maximum visualization and then the measurements were made. An average of 3 readings was taken to minimize the errors, and then confirmed by a Radiologist. Scans with poor visualization of the venous architecture were rejected and discarded.

OBSERVATION AND RESULTS

The following parameters were studied

1. On an Axial scan, the number of major hepatic veins draining into the IVC was noted. Normally they are 3-right, middle and left hepatic vein, [Fig. 1.] and sometimes 4, if an accessory hepatic vein is present. However, in some cases, two or more veins joined with each other creating a confluence (Fig. 2) before draining into the inferior vena cava, thus creating a wide variation in their number and pattern.

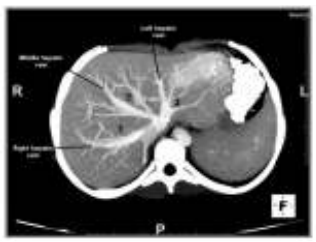

Figure 1

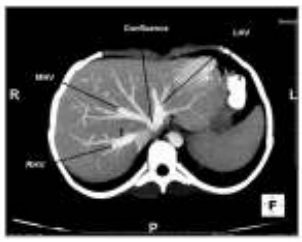

Figure 2

Legend

Figure 1: Three major hepatic veins without confluence Confluence;

Figure 2: Two major hepatic veins with confluence of left (LHV) and middle (MHV)

1. 51% of cases had **2 major hepatic veins** indicating the presence of a confluence.
2. In 48% of cases, **3 major hepatic veins** were present. They either showed -
   a) Confluence with presence of accessory vein(12 cases), out of which 10 cases were with left and middle confluence, 1 case with left and accessory confluence and 1 with right and middle confluence. Or,
   b) No confluence – 36 cases
3. Remaining 1% of cases showed **4 major hepatic veins** right, middle, left and an accessory hepatic vein.

(2) The **confluence pattern** was also studied**,** as some major veins joined with each other and then drained by a common stem into the IVC (Fig no. 2). Confluence patterns were categorized as follows -

1. **Category-1 - Middle and left hepatic veins joined** while the right hepatic vein drained independently into the IVC –seen in 57% patients.
2. **Category-2- Right and middle hepatic veinsjoined** while the left hepatic vein drained independently into the IVC –seen in 2% patients.
3. **Category-3-No confluence present** and all the three major hepatic veins drained independently into the IVC –seen in 37% patients.
4. **Category-4- Left and accessory veins joined** while the right and middle drained independently into the IVC –seen in 2 % patients.
5. **Category-5- Middle, left and accessory veins** joined while right hepatic vein drained independently into the IVC -seen in 2% patients.
6. **Category-6-Three major hepatic veins joined with eachother** and drained into IVC

by forming a common stem. Though this variation has been described in previous literature, this wasn't observed in the present study.

(3) Diameter of the major hepatic veins, at their confluence with IVC was also measured [fig. 3] as shown in table no. 1-

4. **Table No.1 - Descriptive statistics of the diameter of Hepatic Veins**

Table 1: Descriptive statistics of the diameter of Hepatic Veins

Hepatic vein	Mean diameter (mm)	Standard deviation	Median	Mode	IQR	Minimum	Maximum
RHV	11.36	3.15	11.30	11.5	4.63	6	20.3
MHV	9.49	2.41	9	9	3	4.6	15.5
LHV	8.41	2.26	8.3	8.5	2.5	4	13

RHVs were larger with most of the values within the range of 10-15mm while the middle (54) and the left (74) hepatic veins' diameter ranged between 5-10mm.

Figure 3: Diameter of Right Hepatic Vein

DISCUSSION

Number of major hepatic vein

Knowledge of hepatic venous architecture is necessary in surgeries like liver transplantation and hepatic resection to prevent graft rejection and to reduce post-operative mortality. Evaluation of number of hepatic veins helps in deciding the plane of cleavage and gives an idea about probable vascular complications during surgeries. In the present study, the number of major veins was 2 in 51% of cases, 3 in 48% of cases while only 1% of cases showed 4 major veins. O Fersia [8] *et al*. (2010) in her study, found 50% of cases with 2 major hepatic veins while remaining 50% had 3 major hepatic veins. S D Joshi [9] *et al*. (2010) reported 2 hepatic veins in 65% cases, 3 veins in 33% cases and only two cases with 4 hepatic veins. The present study findings are very close to these studies.

Confluence of hepatic veins

Surgeons must know the presence of confluence for selective hepatic veins' clamping in liver transplantation surgeries. The confluence pattern helps to decide whether middle hepatic vein should be included in the right liver graft or not**.** The confluence of hepatic veins has been studied extensively especially the one between left and middle hepatic veins. The comparison of results of present study with others is shown in table no. 2.

Table 2: Confluence between left and middle hepatic vein in different studies

Author	Method	Number Of Specimens	Left And Middle Confluence
Cheng Y F [14] *et al*, 1996	Ultrasonography	200	70%
Wind P [10] *et al*,1999	Injection corrosion cast method	64	84%
Jose Roberto Ortale [15], 2003	Anatomical dissection	40	77.5%
Matsubara k [16] *et al*, 2006	Multi-detector row CT	102	17%
Peschaud [17] *et al*, 2009	Anatomical dissection	30	70%
O Fersia [8] *et al*, 2010 *et al*, 2010	Anatomical dissection	30	50%
D Singh [11] *et al*, 2012	Injection corrosion cast method	30	3.33%
Fang CH [18] *et al*, 2012	Three dimensional CT	200	61%
Liu J [14] *et al*,2013	41 fresh adult livers, 43 formalin fixed and 9 corrosion casts	175	60.3%
Yogesh Diwan [13] *et al*, 2013	Spiral CT abdomen	100	74%
Ulziisaikhan T [12] *et al*,2014	Injection corrosion cast method	40	77.5%
Present study	Multi-slice spiral CT	100	57%

As seen in Table no. 2, the findings of the present study are quite similar to the ones by Fang CH[18] *et al*, 2012 and Liu J[14] *et al*, 2013. In the present study, left and middle hepatic vein confluence was found in 57% of cases while Fang CH[18] *et al*, 2012 and Liu J [14] *et al*, 2013 reported the same confluence in 61% and 60.3% cases respectively. Yogesh Diwan[13] *et al* (2013) categorized the hepatic veins into six different categories on the basis of confluence. The same classification was used to study the hepatic veins in the present study too. Category 1 was commonest in both the studies (Table no. 3). While

Yogesh Diwan[13] *et al* (2013) reported 74% cases in category -1, the present study showed 57% cases.

Table 3: Comparison of categories based on confluence

Categories	Yogesh Diwan[19] *et al* (2013)	Present study (2014)
Category – 1	74%	57%
Category – 2	2%	2%
Category – 3	21%	37%
Category - 4	-	2%
Category - 5	-	2%
Category - 6	3%	-

Diameter of right hepatic vein

Knowledge of the diameter of hepatic veins is necessary while performing anastomoses because the territory of the small caliber vessels can be taken over by large caliber veins. The hepatic veins with wider diameter can also cause alarming hemorrhage if not clamped properly during surgery. Prior knowledge of this can help the surgeons in taking precautions during hepatic surgeries. RHV was reported to be with the largest diameterin 65% of cases, followed by MHV, in 21% of cases and LHV in 6% of cases. Remaining 8 cases showed two hepatic veins with equal diameter. In liver transplantation, the right lobe graft is harvested with incorporation of RHV only, but if the MHV diameter is larger than the RHV, then MHV needs to be incorporated along with RHV.[20,21]

In the present study,

1. The range of diameter of RHV was 6 to 20.3 mm while S. D. Joshi[9] *et al*. (2010) reported the range between 8 to 27 mm.
2. The mean diameter of RHV was 11.36 ± 3.19 mm while Liu J[19] et. al. (2013) reported it to be 13.8 ± 3.5mm.S.D. Joshi[9] *et al*. (2010) calculated the median diameter of RHV as 15mm.
3. O Fersia[8] *et al*. 2010 reported maximum number of cases (66.6%)with the diameter of RHV within the range of 15 to 25 mm, while in the present study maximum cases (54 %) were between 10 to 15 mm.

Diameter of middle and left hepatic veins

In the present study, the diameter of MHV ranged between 4.6 to 15.5 mm with the mean as 9.49 ± 2. The diameter of LHV ranged from 4 to 13mm with the mean being 8.41 ± 2.25mm.The comparison of findings of present study with other studies is shown in Table no. 4.

Table 4: Diameter of middle and left hepatic veins in different studies

Study	Mean diameter of MHV in mm	Mean diameter of LHV in mm
Appel and Loeweneck[22] *et al*.(1987)	10	10
Wind P[10] *et al*, 1999	8.7± 1.8	8.6± 2
Jose Roberto Ortale[15] *et al*.(2003)	10 ± 2.5	10.7 ± 2.4
Liu J[19] et. al. (2013)	10.1 ± 2.9	9.1 ± 1.6
Present study	9.49 ± 2.41	9.49 ± 2.41

S.D. Joshi[9] *et al*. (2010) reported the range of diameter of MHV between 5 to 15mm, with the median value at 11 mm, while that of LHV between 7 to 26 mm and median as 8.3mm. The commonest (72.2%) range of diameter for LHV by O Fersia[8] *et al*. (2010) was 10 to 20mm while in the present study it was 5 to 10 mm.

CONCLUSION

There are many variations in the number, diameter and confluence pattern of hepatic veins. Hence it is imperative for operating surgeons to evaluate the hepatic vasculature of donors and recipients preoperatively, for proper anastomoses of hepatic graft and for avoiding major hemorrhage and complications during liver transplantation surgery.

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