Vascular anatomy of Segment IV of Liver in Live Liver Donors

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Abstract

Studies on the anatomy of liver has helped surgeries like liver resection. Liver resection is of significance in liver transplantation. In liver resection, the anatomy of segment IV is very important as it is more prone to ischemia.

Aim: The primary objective is to study the anatomical variations of hepatic artery and hepatic vein of Segment IV from MDCT images of the hepatic vasculature in live liver donors. This study aims to document the anatomy of hepatic artery supplying the segment IV its venous drainage in 300 live liver donors.

Material's & Methods: In this retrospective study 600 MDCT images of hepatic vasculature are observed and the interpretations were recorded. The origin of artery to segment IV was documented. The observations of the Hepatic vein were tabulated as classified in Nakamura’s study.

Results: Segment IV artery originates from LHA in 72% of the cases and RHA in 23%. Hepatic venous drainage of segment IV is of type I, type II and, type III in 14.33%,53.67% and, 30% cases respectively. Type I anatomy of hepatic vein is preferred in both right and left lobe liver transplantation as the drainage from Segment IV is safe.

Conclusion : Vascularity to segment IV is key in Live liver Donors as donor safety is of upmost importance in case of Living donoe Liver Transplantation

Categories: Radiology, Gastroenterology, Anatomy

Keywords: multi-detector computed tomography (mdct), living donor liver transplantation (ldlt), segment iv, hepatic vein, hepatic artery

Introduction

Liver transplantation, as explained by Dilip [1] was once an experimental procedure that has evolved into a lifesaving operation for increasing the life span in patients with chronic liver diseases where medical interventions have reached their limits. Donor safety is of the highest priority in LDLT. Hence a thorough preoperative donor evaluation is highly recommended to provide safety to the donor in LDLT. A clear understanding of the segmental and vascular anatomy facilitates a successful liver resection. Donor selection is purely dependent on the clinical and radiological evaluation done preoperatively. Preoperative imaging of the donor’s liver, guides a surgeon to identify an appropriate donor thereby contributing to donor safety. Sahani expresses that a comprehensive amount of information about the vascular anatomy of liver is obtained from Multidetector CT Images [2]. The vascular anatomy of segment IV in Liver donors is documented in many Western and East Asian studies. This study focuses on the segment IV arterial supply and venous drainage in Indian live liver donors.

Materials And Methods

This retrospective study was done in 300 liver donors who underwent LDLT. The data was collected from Department of Radiology, Amrita Institute of Medical Sciences, Kochi, which comprises of 600 images taken from liver donors. These images were taken for preoperative evaluation in donors who underwent hepatectomy from 2006 to 2014 and collected from their pre-operative evaluation records available in AMRITA MEDVISION SOFTWARE OF AIMS. Images were taken using a 64 multidetector CT scanner (SIEMENS SENSATION CARDIA-64). The pre-contrast series were taken using 5mm slice thickness and post-contrast series are taken after injecting 80 ml of low osmolar non-ionic contrast medium (Omnipaque 350mg) at a flow rate of 5ml/second. The post-contrast series were taken at 6s, + 20s, + 30s CT images for arterial and venous phases were taken. The source images had undergone 3 phase dual enhancement are processed to maximum intensity projections (MIP) and reconstructed to Volume rendering (VR) for final assessment and documentation. The interpretations from the MIP images were done with the guidance from a Gastrointestinal surgeon and a Radiologist. The source of the segment IV artery is identified and recorded. The venous drainage to segment IV was classified according to the existing standard classification done by
Nakamura (Table No 1)[3]. The findings that are recorded is done to help surgeons in liver resection done in LDLT

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Segment IV drains predominate into LHV</td>
</tr>
<tr>
<td>II</td>
<td>Segment IV drains predominate into LHV and MHV</td>
</tr>
<tr>
<td>III</td>
<td>Segment IV drains predominate into MHV</td>
</tr>
</tbody>
</table>

**TABLE 1: Nakamura's Classification of Hepatic venous drainage of segment IV**

Results

**RESULTS**

**SEGMENT IV ARTERY**

In the current study, the artery to segment IV originated mainly from the Left Hepatic Artery (LHA) in 217 cases (72.33%). Right hepatic artery (RHA) supplies segment IV in 69 cases (23%). in 10 cases (3.33%), Segment IV received its blood supply from both the LHA and RHA. Segment IV artery arose from Common Hepatic Artery (CHA) in 2 cases (0.67%) and an accessory hepatic artery in 2 cases. The hepatic vein draining segment IV was of type I in 43 cases (14.33%), type II in 161 cases (53.67%), type III in 90 cases (30%). (Table 1)

The hepatic vein draining segment IV was of type I in 43 cases (14.33%), type II in 161 cases (53.67%), type III in 90 cases (30%). (Table 2)

The images given below shows MDCT Axial Oblique view showing the segment IV drainage predominantly into the middle hepatic vein -TYPE III (Figure 1), MDCT Coronal MIP image of the normal hepatic arterial anatomy (Figure 2) and MDCT Axial Oblique view showing the segment IV drainage predominantly into the left hepatic vein -TYPE I (Figure 3)
FIGURE 1: MDCT Axial Oblique view showing the segment IV drainage predominantly into the middle hepatic vein (TYPE III)

MDCT: Multidetector Computed Tomography

(the figures are from the patients included in the current study)
FIGURE 2: MDCT Coronal MIP image of the normal hepatic arterial anatomy

MDCT: Multidetector Computed Tomography
MIP: Maximum Intensity Projection

(The figures are from the patients included in the current study)

The tables given below shows the number of cases in the current study that showed an variant arterial anatomy and hepatic venous drainage of segment IV in the live liver donors.

<table>
<thead>
<tr>
<th>ARTERY TO SEGMENT IV</th>
<th>No of Cases (N)</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>LHA</td>
<td>217</td>
<td>72.33%</td>
</tr>
<tr>
<td>RHA</td>
<td>69</td>
<td>23.00%</td>
</tr>
<tr>
<td>LHA + RHA</td>
<td>10</td>
<td>3.33%</td>
</tr>
<tr>
<td>CHA</td>
<td>2</td>
<td>3.33%</td>
</tr>
<tr>
<td>ACC</td>
<td>2</td>
<td>0.67%</td>
</tr>
</tbody>
</table>

TABLE 2: ARTERY TO SEGMENT IV
<table>
<thead>
<tr>
<th>TYPE</th>
<th>No of Cases (N)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
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<td>161</td>
<td>53.67</td>
</tr>
<tr>
<td>III</td>
<td>90</td>
<td>30.00%</td>
</tr>
</tbody>
</table>

**TABLE 3: HEPATIC VENOUS DRAINAGE OF SEGMENT IV**

**FIGURE 3: MDCT Axial Oblique view showing the segment IV drainage predominantly into the left hepatic vein (TYPE I)**

MDCT: Multidetector Computed Tomography

(The figures are from the patients included in the current study)

**Discussion**

**DISCUSSION**

The importance of Liver resection is increasing from the standpoint of treating several liver diseases. LDLT has given a new dimension for liver resection. Sahani states that the success rates in liver surgeries have been accomplished with evolving protocols in surgery, anesthesia and, critical care, in addition to the better anatomical evaluation. Preoperative mapping of the liver and its vasculature helps the surgeon perform...
complex surgery with ease. Even the smallest detail of the hepatic vasculature will benefit the recipient and donors in LDLT. With the emergence of MDCT, it is preferred for assessing a potential liver donor [2]. The artery to segment IV is of very important in transplant surgery as segment IV is spared in the surgery [3]. To assess the results in the current study hepatic artery is classified on the basis of the source artery to segment IV and segment IV venous drainage is classified according to a classification sourced from Nakamura’s [4].

In this study, LHA Supplies segment IV in 72% (N=217) of cases. This finding is supported in studies done by Salisoy et al, Ali et al, Ahmed, and Elkholy et al with a prevalence of 75% [5-8].

In 2005 Sayilsoy et al studied 52 potential liver donors in Turkey and reported that the artery to segment IV originated from the LHA in 39 patients (75%), and RHA in 13 patients (25%) [5]. Ali et al (2012) in Egypt studied MDCT images of 43 potential donors and identified that in 24 cases (75%) the artery to segment IV was from the LHA and in 8 cases (25%) from the RHA [6]. Ahmed in 2012 did a retrospective study in 1000 post-contrast CT scans of abdomen. The segment IV was supplied from LHA in 759 patients (75%), RHA in 203 (20%) cases and, CHA in 34 cases (3.4%) [7]. Elkholy et al in 2013 evaluated 20 potential living donors with MDCT images and studied the dominant arterial branch to segment IV was a branch from the LHA in 15 cases (75%), whereas it branched from the RHA in five cases (25%) [8].

Kamel et al (2001), did a study of MDCT images in 40 patients in Boston. In 25 (62.5%) cases RHA was the parent artery to segment IV [9]. Kishi et al in 2004 studied MDCT images of 20 potential donors and reported that the dominant arterial branch to segment IV was a branch from the LHA in 15 cases (75%), and from the RHA in five cases (25%) [10]. Tsang et al in 2008 dissected 62 livers and studied the segment IV artery. Segment IV artery took origin from RHA in 33 cases, LHA in 20 cases, PHA in 2 cases, and both RHA and LHA in 6 cases [11]. Tsang et al in 2008 studied 102 potential liver donors who underwent CT angiography in China and found that artery to segment IV from the RHA in 23 donors (22.5%) and from the LHA in 77 (75.5%) and in 2 cases from a branch originated at the bifurcation of the PHA [12]. Ugurel et al in 2010 did a retrospective study of the abdominal aorta and its branches in 100 patients from CT angiography in Turkey and documented that the artery to segment IV originated from RHA in 35% of cases and 65% in the LHA [13].

In our study, the right hepatic artery sourced segment IV in 23% (N=69) of the cases. Segment IV received dual blood supply from both PHA and LHA in 10 of the cases. Guang reported a dual supply to segment IV in 6 cases [3]. The CHA gave rise to the segment IV artery in 0.67% in the present study and Ahmed had reported a prevalence of 5.4% of the same [7]. Segment IV supply may be variable and hence their precise origin must be identified as these branches will cross the transection plane, especially when they arise from Right Hepatic artery in cases of right lobe donation [1].

The hepatic venous anatomy is studied giving importance to the drainage of segment IV. We obtained a significantly higher distribution of Type II in 53.67% (N=161) while in Nakamura’s study it is 56% [4] and Chang’s study 36.7% [14]. Type III distribution is seen in 50% (N=90) whereas Nakamura [4] and Chang [14] obtained 5.8%. In our study, 2% were drained by an accessory vein that drained the segment IV directly into the IVC. The present study shows 14.33% (N=43) of Type I anatomy of the venous drainage whereas Nakamura [4] and Chang [14] reported a prevalence of 57%. Nakamura’s type I is the best-suited anatomy for liver transplantation.

The sample size gives an advantage to the study. Another strength of this study is that the anatomy of the hepatic artery and hepatic vein of segment IV identified in the MDCT images have been confirmed intraoperatively. This is also the first study conducted on live liver donors in an Indian setup. The only limitation of the study is that the study population includes on donors who underwent liver resection previously.

**Conclusions**

**CONCLUSION**

In our study we aimed at identifying the common variants encountered in the in the hepatic vasculature targeted mainly on segment IV of the liver, in specific to live liver donors. In our study majority of the patient images showed that segment IV received blood supply from the left hepatic artery and the venous drainage of segment IV of liver was by the Middle hepatic vein and the left hepatic vein. This study also aims to focus on how a detailed evaluation of the hepatic vascular anatomy in LDLT is essential to ensure successful postoperative results. The advent of triphasic CT protocol using 64 detector-row has shown a way to surgeons, specially to transplant surgeons, where the anatomy of vasculature to the organ is of supreme importance for postoperative viability of the organs received by the recipients. In the current study a comprehensive and more accurate assessment of the detailed hepatic vascular anatomy in liver transplant potential donors prevents surgical complications arising from vascular variations.

**Additional Information**

**Disclosures**
Human subjects: Consent was obtained or waived by all participants in this study. Institutional Ethical Committee- Amrita Institute of Medical Sciences issued approval NA. The thesis Protocol Submitted by Dr Shruthy K M, PG resident in Anatomy, titled A Study on Anatomical Variations of Hepatic Artery, Hepatic vein and portal vein in Live Liver Donors from Multidetector CT Scan’ has been reviewed and found that there are no Ethical, Financial or Scientific Concerns involved in this study. Study can Proceed. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References