Morphology and Morphometric Analysis of the Caudate Lobe of Human Liver in Eastern India: A Cross-sectional Cadaveric Study

TAPATI ROY*, RITUPARNA BASU²

ABSTRACT

Introduction: The unique feature of caudate lobe of liver is that it has a dual blood supply. Since it is supplied both by branches of portal vein and hepatic artery, it may undergo compensatory hypertrophy in different hepatic diseases like cirrhosis of liver. In addition, excessive localised growth of the liver may be manifested as accessory lobules. Previous studies in different settings had implied an ethnic predisposition affecting the morphology of the liver. All these factors revealed an urgent need for further research regarding the surface variations and morphometry of the caudate lobe.

Aim: To study the morphological variations and morphometric measurements of the caudate lobe of the human liver in eastern India.

Materials and Methods: A descriptive cross-sectional study was undertaken on 51 formalin fixed adult human livers in Department of Anatomy, Medical College, Kolkata, West Bengal, India from March 2021 to September 2021. Vernier calliper was used to measure the Transverse Diameter (TD), Vertical Diameter (VD) and Anteroposterior Diameter (APD) of caudate lobe. In addition, the TD and APD diameters of Porta hepatitis and TD of the right lobe of liver were also measured. Morphological variations were noted. The morphometric measurements and morphological variations of caudate lobe of liver were entered in Excel sheet which were further transported to IBM Statistical Package for Social Sciences software (SPSS) version 12.0 (free version) for further analysis. Morphometric measurements were analysed by using descriptive statistics. Caudate to right lobe (CRL) ratio was calculated manually.

Results: Most common type of shape of caudate lobe was rectangular (37.25%). Mean values (in cm) of TD, VD, APD of caudate lobe were 2.4±0.54, 4.7±0.75, 1.9±0.51 respectively. The value of mean CRL (caudate to right lobe) ratio was 0.30.

Conclusion: A detailed anatomical knowledge of the caudate lobe would be helpful to the surgeon to suitably plan hepatic resections and may also guide the radiologist regarding correct interpretation of imaging technique.

INTRODUCTION

The caudate lobe or Couinaud’s segment I is that segment of the liver which is bounded by the fissure for ligamentum venosum and groove for inferior vena cava on each side and the porta hepatitis inferiorly [1]. As shown in [Table/Fig-1], it consists of two parts when viewed from the visceral surface, namely, the Spiegel’s lobe and the paracaval portion bridged by the caudate isthmus [2]. It is a unique well-defined anatomical segment of the liver as it is supplied by both the branches of portal vein as well as the hepatic artery and hence, may be differently affected in pathologies of the liver such as liver cirrhosis [1].

A detailed morphological and morphometric study of the caudate lobe would not only enlighten the knowledge of anatomists to facilitate anatomical teaching but also the surgeon, radiologist and clinician during diagnosis and treatment of liver diseases. Although there have been many previous studies which have observed variations in the morphology and morphometric measurements of the caudate lobe, on repeated search, no such study was found to have been based in eastern India [7-9]. Hence, the aim of the current research was to study the detailed morphology and morphometry of caudate lobe of liver specimens at tertiary medical college of eastern India. In addition, TD and APD of porta hepatitis and TD of right lobe were also determined.

Keywords: Couinaud’s segment I, Measurements, Surface variations

* Anatomy Section

MATERIALS AND METHODS

A cross-sectional study was conducted on 51 formalin fixed adult liver specimens from Department of Anatomy, Medical College, Kolkata, West Bengal, India during the period between March 2021 to September 2021. Institutional Ethical Clearance as well as permission from competent authority (Ref no. MC/KOL/IEC/NON-SPON/1181/08/2021 dated 25/08/2021) was obtained before conduction of the study.

Inclusion criteria: Only well-preserved adult human livers were selected for the study.

Exclusion criteria: Diseased, surgically resected liver specimens, or those whose shape was distorted during preservation and storage or due to traumatic injury were excluded.

Sample size calculation: Assuming the population standard deviation 6.8, 95% level of confidence with margin of error 2, this study would require estimated sample size of 48 [10]. However, over a period of seven months (March 2021 to September 2021), 51 well-preserved liver specimens were collected to conduct the study.

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Procedure

The variables of morphometric measurements under study were Transverse Diameter (TD), Anteroposterior Diameters (APD) and Vertical Diameter (VD) of caudate lobe, TD and APD of porta hepatitis and TD of right lobe of liver. For determination of these morphometric measurements of caudate lobe, the method used by H.Ibrahim was adopted for the present study [8]. Before taking all measurements, portal vein and its bifurcation as well as the entire region under study was carefully dissected and cleared to determine the important anatomical landmarks. Vernier calipers, pins and cotton thread were used to measure all the parameters of liver. For each measurement, three observations were made, and their average was taken to minimize subjective error.

Transverse diameter: To determine the transverse diameter of caudate lobe, midpoint of hepatic part of Inferior Vena Cava (IVC) was taken as a reference point and same reference point was used to determine the TD of right lobe of liver. These two transverse diameters were used to calculate CRL. TD was measured as the distance between mid-point of fissure for ligamentum venosum to mid-point of hepatic part of IVC.

Vertical diameter: VD was measured between mid-point of inferior border of caudate lobe to mid-point of its upper border [9].

Anteroposterior diameter: APD of caudate lobe was measured as the distance between right lateral margin of portal vein trunk at the bifurcation to its posterior most projection from liver [9]. [Table/Fig-2a,2b] illustrates the measurement of transverse and vertical diameters of caudate lobe, whereas [Table/Fig-2c,2d] shows the measurement of right lobe diameter and transverse diameter of porta hepatis.

Porta hepatitis: As elaborated in the study by Sago MG et al., [11] the axis of measurement passing through the portal venous trunk before its bifurcation was considered for measurement of the greatest vertical diameter of porta hepatitis. In addition, in order to determine the greatest TD of porta hepatitis, the axis of measurement was also taken at the level of the main portal vein just before its bifurcation. The medial limit of the TD of porta hepatitis was taken to correspond with most medial aspect of the caudate lobe.

The study also included variations in morphology of caudate lobe with regard to its shape, shape of its caudate and papillary processes and presence/absence of fissures, notches. Variations in shapes of caudate lobe in the form of rectangular, pyriform, triangular, oval [Table/Fig-3a-3d] as revealed by previous studies [6,12-16] were noted in this study also. In addition, presence of caudate notch [Table/Fig-4a,4b] and a caudate fissure [Table/Fig-5a-5d] as mentioned by Auh YH et al., [15] were noted in this study.

After observation of morphological variations of caudate lobe of liver and determination of morphometric measurement of study variables, the results were tabulated and analysed.

STATISTICAL ANALYSIS

All the study variables were entered in excel sheet which were further transported to IBM SPSS software version 12.0 (free version) for...
further analysis. CRL ratio was calculated manually. Morphometric measurements were analysed by using descriptive statistics.

RESULTS
On examination of the morphology of 51 liver specimens, most common shape of caudate lobe was found to be rectangular 19 (37.25 %) and other shapes were triangular 5 (9.80%), pyriform 17 (33.33%), oval (7.84%), wedge shaped (11.76%) [Table/Fig-6]. [Table/Fig-3] illustrates the different shapes of caudate lobe obtained in the present study.

Notches and fissures were present in 9.8% and 23.52% cases respectively [Table/Fig-7]. [Table/Fig-4] shows two liver specimens, A and B, where notches were found at left border and inferior border of caudate lobe respectively. In addition, both liver specimens presented fissures at the inferior border of caudate lobe. Also, [Table/Fig-5a-5d] shows fissure at the inferior border, fissures extending from inferior and superior borders of liver, fissures at the inferior and right borders and presence of fissure at the right border.

Present study also noted differences in shapes of caudate process. Elongated shape 31 (60.78%) was the most common type and tongue shape 1 (1.96%) was the least common type. Other shapes were pointed 11 (21.56%) and rounded 7 (13.72%). Caudate process was absent in 1 (1.96%) case [Table/Fig-9].

Regarding morphometric measurements, the mean values (in cm) of following variables were observed: TD of caudate lobe 2.45±0.54, VD of caudate lobe 4.7±0.75, APD of caudate lobe 1.9±0.51, TD of right lobe of liver 8.1±0.93, TD of porta hepatitis -3.2±0.44, APD of porta hepaticus 1.8±0.42. Range of above mentioned variables were as follows - 1.55-3.91, 3.3-5.9, 1.2-2.9, 5.93-9.96, 2.26-4.04 and 0.89-2.74 respectively [Table/Fig-10]. The value of mean CRL ratio was calculated to be 0.30.

Variations of shapes of caudate lobe.

<table>
<thead>
<tr>
<th>Shape of caudate lobe</th>
<th>Number (n)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangular</td>
<td>19</td>
<td>37.25%</td>
</tr>
<tr>
<td>Triangular</td>
<td>5</td>
<td>9.80%</td>
</tr>
<tr>
<td>Pyriform</td>
<td>17</td>
<td>33.33%</td>
</tr>
<tr>
<td>Oval and wedge shaped</td>
<td>10</td>
<td>19.60%</td>
</tr>
</tbody>
</table>

Variations of papillary process were also observed in present study. Most common variety of shape was papillary process were tongue shaped 9 (17.64%) and pointed 13 (25.49%). Papillary process was absent in 11 (21.56%) cases [Table/Fig-8].

<table>
<thead>
<tr>
<th>Caudate lobe</th>
<th>Present n (%)</th>
<th>Absent n (%)</th>
<th>Special features n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notch</td>
<td>5 (9.8%)</td>
<td>46 (90.19%)</td>
<td>1 (1.96%)</td>
</tr>
<tr>
<td>Fissure</td>
<td>12 (23.52%)</td>
<td>34 (66.66%)</td>
<td>4 (7.84%)</td>
</tr>
</tbody>
</table>

DISCUSSION
The caudate lobe is an exclusive part of the liver which is supplied both by branches of hepatic artery and portal vein. Because of this special feature, it is distinctly affected in diseases of liver [11]. In fact, there are many pathologies like Budd Chiari syndrome and liver cirrhosis where the caudate lobe of the liver may undergo compensatory hypertrophy [17,18]. Although there are many advanced diagnostic imaging techniques which are available, nevertheless cadaveric studies for evaluation of liver are still held in high esteem [19,20]. Previous studies have revealed morphological variations of the caudate lobe with respect to its shape, its caudate and papillary processes and presence of notches and/or fissures as well as variations in its morphometric measurements [8,9].

Kogure K et al., noted notches in 50% of caudate lobes in patients undergoing hepatectomy [13]. In the study carried out by Joshi SD et al., [21], 18% of livers examined revealed notching along inferior border of caudate lobe and in 30% of livers, vertical fissures were noted. In addition, accessory fissures were found which were more common in the right lobe. In the study by Patil S et al., [6] also, accessory fissures were found in right lobe, quadrato lobe and

### Table/Fig-10: Morphometric measurements of liver (N=51).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean (cm)</th>
<th>Range (cm)</th>
<th>Mean CRL ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caudate lobe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse diameter</td>
<td>2.45±0.54</td>
<td>1.55-3.91</td>
<td></td>
</tr>
<tr>
<td>Vertical diameter</td>
<td>4.7±0.75</td>
<td>3.3-5.9</td>
<td>0.30</td>
</tr>
<tr>
<td>Anteroposterior diameter</td>
<td>1.9±0.51</td>
<td>1-2.9</td>
<td></td>
</tr>
<tr>
<td>Transverse diameter of right lobe of liver</td>
<td>8.1±0.93</td>
<td>5.93-9.96</td>
<td></td>
</tr>
<tr>
<td>Porta hepatitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse diameter</td>
<td>3.2±0.44</td>
<td>2.26-4.04</td>
<td></td>
</tr>
<tr>
<td>Anteroposterior diameter</td>
<td>1.8±0.42</td>
<td>0.89-2.74</td>
<td></td>
</tr>
</tbody>
</table>
caudate lobe. As compared to these studies, in the present study, notching was seen along inferior border in five liver specimens (9.8%) whereas one liver specimen showed notching at left border of caudate lobe. Presence of fissures in the caudate lobe were documented at inferior border in 23.52% liver specimens while four liver specimens showed presence of fissures at left border, extending obliquely above and below.

Chavan NN and Wabale RN et al., [12] observed absence of papillary process in their entire study population, whereas Sahni D et al., [14] reported papillary process in 33.5%. Ahu YH et al., [15] found that on Computed Tomography (CT), papillary process sometimes can be mistaken as enlarged porta hepatis. Enlarged papillary process can displace gastric antrum and duodenum anteriorly mimicking right-sided retroperitoneal mass. In their study, Sarala HS et al., [7] found prominent papillary process in 21% of the livers while Joshi SD et al [21] also found prominent papillary process in 32% of the livers in their study. In the present study, with the exception of 21.56% liver specimens, all other liver specimens presented with a papillary process. Most common shape of papillary process was found to be round shape (33.33%) and least common shape was conical (1.96%).

Variations of shape of caudate lobe in the form of rectangular, triangular, square, inverted flask shaped, oval and pear shaped was seen by Chavan NN and Wabale RN, [12] in their study. The most common shape observed by Ibrahim H [8], in his study was rectangular. One case of dumbbell-shaped caudate lobe was found by Mamatha Y et al., [22] as also in Nayak SB et al., study [23]. Joshi SD et al., [21] reported 58% rectangular, 20% biconcave, and an assortment of pear shaped, quadrate, oblong, heart shaped, square, and inverted pear-shaped caudate lobes in the remaining 22% of liver specimens in their study. Rectangular, pyriform and irregular shaped caudate lobes were seen in the study by Sagoo MG et al., [11] also. Rectangular shape (46%), columnar or elongated caudate lobes and triangular caudate lobes in equal proportion (16%) and dumbbell-shaped lobes were observed in 14% liver specimens studied by Syamala G et al., [10]. In the present study also, we found five different shapes of caudate lobes, namely, rectangular, pyriform, triangular, oval and wedge shaped. Most common shape of caudate lobe observed was rectangular (37.25 %) followed by pyriform shape (33.33%). Elongated shape of caudate process was the most common type (60.78%). Thus, findings of the morphological variations of the liver in the present study are congruent to previous studies [10,11,12,25].

Regarding morphometric measurement of the liver specimens in the present study, we noted that the mean values in cm of TD, VD and APD of caudate lobe were 2.45, 4.6, and 1.9 respectively. Chavan NN and Wabale RN [12] observed TD to be 2.5 cm which was almost similar to present study. The CRL ratio (mean) of our study was 0.30. This ratio was slightly lower than that found by Gardner MT et al., [2] in their study where they documented the mean CRL ratio to be 0.34. Arora NK et al., [16] noted a CRL ratio of 0.36 which was higher than the present study. Syamala G et al., [10] have measured 50 formalin fixed adult liver in south Indian population where they found the mean CRL ratio to be 0.17 which is lower than the present study. This regional variation might be due to small sample size. Further evaluation is required to obtain the exact knowledge of regional variation among Indian population. In their study, Ilione T et al., [24] suggested the use of CRL ratio as a trusted parameter for the diagnosis of liver cirrhosis even in the early asymptomatic stages. Literature review revealed many studies where this ratio (CRL ≥ 0.65) was utilized to diagnose cirrhosis of liver [2,15,23,24,25]. In their study, Syamala G et al., [10] mentioned that cirrhotic livers may show ratio over 0.65 and noted that the mean length and breadth of the caudate lobes they examined were 5.3 cm and 2.58 cm respectively. Although these values were more than the present study but mean breadth (7.39 cm) for right lobe of their study was less than the present study. Ibrahim H [8] stated in his study that CRL ratio was 0.30 which was exactly similar to the present study. But mean values of other parameters like VT (57.45±4.74 mm), TD (27.49±2.82 mm) and diameter of right lobe (90.58±7.76 mm) were slightly higher than the present study. Findings of the current study were compared with similar studies conducted in other settings and regions [10-12,25] [Table-Fig-11].

Limitation(s)

The cadaver samples were predominantly received from the state of West Bengal and limited samples were received from other states of eastern India. This might affect the representation of eastern India. It would be relevant to study with bigger sample size with less margin of error.

CONCLUSION(S)

The present study of caudate lobe of liver in eastern India would enhance the knowledge of the anatomists, radiologists and surgeons regarding its probable morphological and morphometric variations in this region. In addition, since morphometric measurements revealed certain points of similarities as well as differences with other similar studies conducted in different regions and settings, it is recommended that observations of the regional variations of morphometric measurements should further be analysed by extensive studies and meta-analysis in order to obtain a standardised national value.

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Tapati Roy and Rituparna Basu, Morphology and Morphometry of Caudate Lobe in Eastern India

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Was informed consent obtained from the subjects involved in the study? No
For any images presented appropriate consent has been obtained from the subjects. No

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Author Origin

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Plagiarism X-checker: Mar 01, 2022
Manual Googling: May 09, 2022
iThenticate Software: Jun 23, 2022 (6%)

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