Differences in hepatic segmental volume distribution among major causes of liver cirrhosis: CT volumetric evaluation

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Purpose

Liver cirrhosis (LC) is a complication of various liver diseases that is characterized by irreversible replacement of a large amount of normal liver tissue with nonfunctioning scar tissue. Major causes of liver cirrhosis are alcohol abuse, infection of hepatitis virus, primary biliary cirrhosis, primary sclerosing cholangitis, Wilson’s disease, hemochromatosis, other unknown causes (cryptogenic liver cirrhosis), and some cases have combination of various causes. Virus induced hepatitis and liver cirrhosis are found at high incidence in Asia, and they require not only biochemical examination of blood but also subsequent imaging, because they are often complicated by hepatocellular carcinoma (HCC) [1]. Ultrasonography, CT and MRI are often used to evaluate liver disease. Many reports revealed that LC causes morphologic change of the liver and hepatic morphologic change can be different according to the cause of LC [2-14]. Okazaki et al.[9] reported enlargement of the caudate lobe and the presence of the right posterior hepatic notch on MR imaging are more frequent findings of alcoholic cirrhosis than of virus induced cirrhosis. Therefore, to discriminate the morphologic changes of LC on images is helpful to presume cause of LC, investigate pathogenesis and estimate prognosis. But, there is no report about differences among major causes of LC, especially HBV, HCV associated and cryptogenic LC. The purposes of this study are to investigate the difference of hepatic segmental volume distribution among the groups of alcoholic, hepatitis B virus-induced, hepatitis C virus-induced and cryptogenic cirrhosis and if the CT volumetric indices have capability to discriminate the etiology of the LC.

Methods and Materials

Patients

From June 2006 to June 2008, 541 patients with LC underwent multiphase hepatic CT scans. Liver cirrhosis was diagnosed by biopsy or by clinical evaluation including liver function tests, viral antigen test and antibody titration. We classified the patients according to the causes of LC. Four groups with alcohol, hepatitis B, hepatitis C induced LC and cryptogenic LC were chosen. We excluded the patients with biliary tree disease, lymphoma, leukemia, previous liver operation or therapeutic interventional procedures, and combined causes of cirrhosis. In addition, if CT images demonstrated malignant neoplasm such as HCC, and cholangiocellular carcinoma, portal vein thrombosis and ambiguous landmarks to divide each segment which could affect liver volume, the patients with that CT scans were excluded.

Finally, 90 patients (62 men and 28 women; mean age, 43.0 years; range, 41-81 years) were included in this study. We named the group of alcohol-induced LC group A, the group of hepatitis B induced LC group B, the group of hepatitis C induced LC group C
and the group of cryptogenic LC group D. The number of patients in each group were 28 (27 men and 1 woman; mean age, 57.0), 23 (15 men and 8 women; mean age, 53.8), 20 (11 men and 9 women; mean age, 61.7) and 19 (9 men and 10 women; mean age, 64.6), respectively.

CT protocol and Measurement

CT examinations were performed with 16 channel and 64 channel MDCT scanners. After acquisition of an unenhanced CT scan with 5mm slice thickness, 2cc/kg of iopromide were injected to patients with 2cc/sec velocity through vein of upper extremity and we acquired images of arterial, portal and delayed phase with 5mm slice thickness.

On a clinical workstation, a 15-year experienced abdominal radiologist measured liver volume on portal phase images without any clinical data. If the landmarks were considered indistinct, images of other phases were used. Outline was drawn with computer mouse and the inferior vena cava, hepatic veins, portal veins, gall bladder and detectable space occupying lesions such as cystic lesions, hemangiomas were excluded. Then multiplication of each slice area and the slice thickness were calculated. Each volume of anterior, posterior, medial and lateral segment was measured using hepatic veins as landmarks to determine the borders. The boundary of caudate lobe was defined as straight line between the inferior vena cava and the right branch of portal vein according to C/RL-r, suggested by Awaya, H. et al.[2]. And Modified CR ratio was measured using distance between the line drawn through the right lateral wall of the bifurcation of the right portal vein and the most medial margin of the caudate lobe[2]. The volumetric indices including each segment (anterior, posterior, medial, and lateral) to the whole liver volume ratio, anterior to posterior segment ratio and lateral to medial segment ratio were calculated.

Statistical analysis

ANOVA and multiple comparison tests were performed to compare mean volume of each segment, modified CR ratio and volumetric indices to determine which parameter could discriminate among four groups. Diagnostic performance of significant volumetric indices was evaluated using receiver operator characteristic (ROC) method (Medcalc for Windows, version 11.4.3). A p value of less than 0.05 was considered statistically significant and SPSS statistics software package (version 12.0 SPSS) was used.

Results

The mean volume of each segment (anterior, posterior, medial, and lateral), the six evaluated volumetric indices and modified CR ratio were summarized in the Table 1. The mean values of the right anterior segment to whole liver volume ratio in the C group
(39.80%), the left medial segment to whole liver volume ratio in the D group (19.90%) and the left lateral segment to whole liver volume ratio in the B group (33.59%) were significantly greater ($p < 0.001$, $p = 0.001$, $p < 0.001$) than the other groups, respectively. Modified CR ratio did not show significant differences among the four groups. All of the six evaluated volumetric indices showed significant difference between group B and C by ANOVA and multiple comparison test ($p < 0.05$). The mean values of the anterior segment to whole liver volume ratio (29.84), the medial segment to whole liver volume ratio (18.72), the right anterior/posterior segment ratio (2.29) were significantly greater ($p = 0.000$, $p = 0.000$, $p = 0.002$) and posterior segment to whole liver volume ratio (21.68), the lateral segment to whole liver volume ratio (19.23), the left lateral/medial segment ratio (1.45) in the C group were significantly less ($p = 0.041$, $p = 0.000$, $p = 0.000$) than those (29.84, 12.11, 1.36, 23.80, 33.59, 3.06) in the B group, respectively. Among these indices, lateral segment to whole liver volume ratio showed highest diagnostic performance in ROC analysis (area under the ROC curve = 0.926) (Fig. 1).

We calculated the sensitivity, specificity, and accuracy of the lateral segment to whole liver volume ratio between group B and group C, using ROC curve with cut-off values of 21.96%, 27.45%, and 30.74%, respectively (Table 2). A cut-off value of 27.45% gave the highest accuracy with sensitivity, specificity, and accuracy of 95.0%, 82.6%, and 88.4% ($p < 0.001$), respectively. Thus, from a practical point of view, we took the cut-off value of 27.45%.

The mean value of lateral segment to whole liver volume ratio of the group A and B were 27.30 and 33.59, respectively, and it was only significantly different index ($p = 0.016$) between two groups. Anterior to posterior segment volume (1.38, 2.29), lateral to whole liver (27.30, 19.23), medial to whole liver (12.67, 18.72), anterior to whole liver volume ratio (33.15, 39.80) showed significant differences between group A and C ($p < 0.05$). Medial to whole liver volume ratio was different between alcoholic cirrhosis (12.67) and cryptogenic cirrhosis (19.90) ($p = 0.02$).

Images for this section:
**Fig. 1:** Table 1. The mean volume of each segment, modified CR ratio and volumetric indices in the groups with alcoholic, hepatitis B, hepatitis C induced and cryptogenic liver cirrhosis.

<table>
<thead>
<tr>
<th></th>
<th>A (Alcohol)</th>
<th>B (HBV)</th>
<th>C (HCV)</th>
<th>D (Cryptogenic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients number</td>
<td>28</td>
<td>23</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Mean age</td>
<td>57</td>
<td>53.8</td>
<td>61.7</td>
<td>64.6</td>
</tr>
<tr>
<td>Anterior segment volume (mm$^3$)</td>
<td>385127.9</td>
<td>277247.9</td>
<td>405790.5</td>
<td>300761.6</td>
</tr>
<tr>
<td>Posterior segment volume (mm$^3$)</td>
<td>319248.0</td>
<td>211131.5</td>
<td>210991.5</td>
<td>220363.9</td>
</tr>
<tr>
<td>Medial segment volume (mm$^3$)</td>
<td>145145.5</td>
<td>107011.5</td>
<td>191983.3</td>
<td>188576.1</td>
</tr>
<tr>
<td>Lateral segment volume (mm$^3$)</td>
<td>312135.5</td>
<td>295293.9</td>
<td>188115.3</td>
<td>218913.4</td>
</tr>
<tr>
<td>Total volume (mm$^3$)</td>
<td>1170171.1</td>
<td>895690.3</td>
<td>1002164.6</td>
<td>936359.1</td>
</tr>
<tr>
<td>Ant/ Total (%)</td>
<td>33.15</td>
<td>29.84</td>
<td>39.80</td>
<td>32.52</td>
</tr>
<tr>
<td>Post/ Total (%)</td>
<td>26.09</td>
<td>23.80</td>
<td>21.68</td>
<td>22.77</td>
</tr>
<tr>
<td>Med/ Total (%)</td>
<td>12.67</td>
<td>12.11</td>
<td>18.72</td>
<td>19.90</td>
</tr>
<tr>
<td>Lat/ Total (%)</td>
<td>27.30</td>
<td>33.59</td>
<td>19.23</td>
<td>23.90</td>
</tr>
<tr>
<td>Ant/ Post ratio</td>
<td>1.38</td>
<td>1.36</td>
<td>2.29</td>
<td>1.76</td>
</tr>
<tr>
<td>Lat/ Med ratio</td>
<td>2.29</td>
<td>3.06</td>
<td>1.45</td>
<td>1.56</td>
</tr>
<tr>
<td>Modified CR ratio</td>
<td>1.03</td>
<td>0.98</td>
<td>0.97</td>
<td>1.05</td>
</tr>
</tbody>
</table>

**Fig. 2:** Table 2. The sensitivity, specificity and accuracy according to variable cut-off values of lateral segment to whole liver volume ratio to discriminate between hepatitis B and hepatitis C induced cirrhosis group: numbers indicate percentage

<table>
<thead>
<tr>
<th>Cut-off value</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.96</td>
<td>70.0</td>
<td>95.7</td>
<td>81.4</td>
</tr>
<tr>
<td>27.45</td>
<td>95.0</td>
<td>82.6</td>
<td>88.4</td>
</tr>
<tr>
<td>30.74</td>
<td>100.0</td>
<td>60.9</td>
<td>76.7</td>
</tr>
</tbody>
</table>
Fig. 3: Fig.1. ROC curve of the lateral segment to whole liver volume ratio between HBV and HCV group. Area under the ROC curve (AUC) is 0.926. On the criterion of less than 27.45%, the sensitivity, specificity, and accuracy were 95.0%, 82.6%, and 88.4%, respectively (p < 0.001).
Conclusion

The results showed differences of hepatic segmental volume distribution among the four groups classified by causes of liver cirrhosis. The lateral segment to whole liver volume ratio showed potential ability to discriminate between HBV cirrhosis and HCV cirrhosis.

References


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