Quantitative CT hepatic perfusion measurement: comparison of couinaud liver segments

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Authors: X. Wang, H.-D. Xue, B.-Y. Su, Z. Jin; Beijing/CN
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Purpose

To compare the quantitative liver computed tomography perfusion (CTP) differences among eight hepatic segments.
Methods and Materials

This retrospective study was based on 60 acquired upper abdomen CTP scans for detecting suspected pancreas tumor. Patients with primary or metastatic liver tumor, any focal liver lesions but simple cyst (< 3 cm in diameter) and calcification, history of liver operation or splenectomy, or evidence of liver cirrhosis were excluded. The final analysis included 46 patients (M: F=19:27, mean age=43.0 years, 15-76 years).

All CT images were acquired using a second-generation dual-source 128-slice CT scanner (Somatom Definition Flash; Siemens Healthcare (SMS), Forchheim, Germany). For the perfusion study, 50 ml of iopromide (Ultravist 300, 370 mg/ml, Bayer Schering Pharma, Berlin, Germany) was injected in an antecubital vein through an 18-G needle at a flow rate of 5 ml/s followed by 20 ml saline solution. After a delay of 6 seconds, multiple scans within the defined scan range were obtained using the 4D spiral-mode. The scan range was chosen to be 14.8 cm, from the inferior border of pancreas upwards, with the aim to cover as wide range of liver as possible.

Arterial liver perfusion (ALP), portal-venous perfusion (PVP), total hepatic perfusion (THP=ALP+PVP), and hepatic perfusion index (HPI) of each hepatic segment were calculated and compared.

ALPs, PVPs, THPs and HPIs obtained with the eight hepatic segments were compared by means of one-way analysis of variance (ANOVA) and the LSD method.

SAS (version 8.02) was used for statistical analyses. Quantitative variables were expressed as mean±SD, and statistical significance was established at a p value of <0.05.
**Fig. 1:** Definition of the regions of interest (ROI) in the spleen and vessels for quantitative perfusion assessment in a 69-year-old man with histologically diagnosed islet tumor in tail of pancreas. Upper left: arterial enhancement was determined by the ROI in the abdominal aorta (red circle) at the level of the hepatic hilum. The green line shows the outlines of the liver volume of interest (VOI). Upper right: the time-density curves (TDCs) of artery, liver VOI (white) and outer tissue (yellow) enhancement. Lower left and right: ROIs and corresponding TDCs for the portal vein (dark blue) and spleen (green or light blue)

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Results

The entire liver could be imaged in 23 of 46 (50%) patients. In 18 patients, the most cranial parts of hepatic segments 2, 4, 7 and 8 were not included in the scan range. The entire hepatic segment 2 was missed in 2 patients. The most cranial part of hepatic segments 7 and 8, and the most caudal part of hepatic segments 5 and 6 were out of scan range in 3 cases as well.

Mean ALPs, PVPs, THPs and HPIs of eight hepatic segments were shown in Table 1. Representative case was shown in Fig. 2.

Compared to hepatic segments 5, 6, 7 and 8, segments 2 and 3 showed a tendency of higher ALPs, lower PVPs, lower THPs and higher HPIs with significant difference ($P<0.05$). Compared to hepatic segments 1 and 4, segments 2 and 3 had higher HPIs as well ($P<0.05$). Higher ALP and HPI was showed in hepatic segment 1 compared to segments 5, 6, 7 and 8 ($P<0.05$) (Table 1 and Figure 3).

Table 1 Estimated perfusion values of eight hepatic segments

<table>
<thead>
<tr>
<th>Segment</th>
<th>N</th>
<th>ALP (ml/min/100 ml)</th>
<th>PVP (ml/min/100 ml)</th>
<th>THP (ml/min/100 ml)</th>
<th>HPI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>11.3±5.3$^b$</td>
<td>89.9±26.5</td>
<td>101.1±26.1</td>
<td>12.6±6.7$^a,b$</td>
</tr>
<tr>
<td>2</td>
<td>44</td>
<td>12.1±8.3$^b$</td>
<td>80.1±29.3</td>
<td>92.2±27.5</td>
<td>16.3±14.1$^c,d$</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>14.7±9.8$^a,c$</td>
<td>78.8±26.0</td>
<td>93.4±27.2</td>
<td>17.7±11.0$^c,d$</td>
</tr>
<tr>
<td>4</td>
<td>46</td>
<td>9.7±5.1$^b$</td>
<td>88.9±27.7</td>
<td>98.6±27.8</td>
<td>10.8±6.1$^a,b$</td>
</tr>
<tr>
<td>5</td>
<td>46</td>
<td>8.3±5.1$^a,b,c$</td>
<td>99.7±28.4$^a,b$</td>
<td>108.1±28.3$^a,b$</td>
<td>8.8±5.8$^a,b,c$</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
<td>8.5±4.0$^a,b,c$</td>
<td>101.6±32.6$^a,b,d$</td>
<td>110.1±32.6$^a,b$</td>
<td>8.8±4.7$^a,b,c$</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>6.9±3.6$^a,b,c,d$</td>
<td>99.7±34.6$^a,b$</td>
<td>106.6±35.8$^a,b$</td>
<td>7.4±5.2$^a,b,c,d$</td>
</tr>
<tr>
<td>8</td>
<td>46</td>
<td>7.8±3.4$^a,b,c$</td>
<td>98.6±29.2$^a,b$</td>
<td>106.4±30.0$^a,b$</td>
<td>8.2±4.7$^a,b,c$</td>
</tr>
</tbody>
</table>
a $p<0.05$ compared with hepatic segment 2

b $p<0.05$ compared with hepatic segment 3

c $p<0.05$ compared with hepatic segment 1

d $p<0.05$ compared with hepatic segment 4

Mean CTDIvol and DLP for CTP were 95.8 ± 0.7 (mGy, range: 95.1-96.9) and 1475.0 ± 2.1 (mGy*cm, range: 1472-1477), respectively. Calculated effective radiation dose for the perfusion scans was 22.1 mSv.
Fig. 2: Axial, coronal, and sagittal stacks of the temporal maximum intensity projection (MIP) images and color images of quantitative perfusion parameters including arterial liver perfusion (ALP), portal-venous perfusion (PVP) and hepatic perfusion index (HPI) are shown. Note the reduced PVP, increased ALP and HPI in the segments 2 and 3.

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Fig. 3: Graphs showing distribution of the significant differences among eight hepatic segments for perfusion parameters including arterial liver perfusion (ALP), portal-venous perfusion (PVP), hepatic perfusion index (HPI) and total hepatic perfusion (THP). *=statistical difference (P

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Conclusion

Inter-hepatic-segmental perfusion differences exist in normal hepatic parenchyma especially between left and right liver. This might have potential clinical significance in liver-perfusion-related protocol design and result analysis.
References


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Personal Information

Dr. Xuan Wang, the Department of Radiology, Peking Union Medical College Hospital, Dongcheng District, Beijing, People's Republic of China, 100730. E-mail: wx8203@yahoo.com.cn