Accuracy of hybrid iterative reconstruction for liver volumetry on computed tomography

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Aims and objectives

To avoid the postoperative hepatic failure, preoperative evaluation of the liver volume is essential for hepatic surgery such as living donor transplantation [1-5] and hepatic resection in cases with malignant liver tumors [6]. For approximately 30-40% of the original liver volume or a minimum of 40% of the standard liver mass, that is estimated from the patient's body surface, is required to avoid the postoperative liver failure [7]. Thus the accurate preoperative liver volumetry is mandatory. The computed tomography is now routinely used for liver volumetry because of its superior spatial resolution [8]. But there is an inter-observer or intra-observer difference in CT volumetry. Though the inter-observer agreement was relatively small as reported to be 1.25% (0.45%-2.2%) [9], the smaller the inter-observer difference is, the better the reproducibility or accuracy of the liver volumetry is. Among many factors such as operators experience, liver volume and extent of the contrast enhancement, the image noise can be one reason for the difference. Iterative reconstruction (IR) is a recently introduced method of image reconstruction for CT. That enables the images to have less noises compared with traditional filtered back projection (FBP) method under the same tube current. We hypothesized that IR image with less image noise may lead to less inter-observer difference than FBP dose.
Methods and materials

Between September 2012 and March 2013 we enrolled 19 patients (12 men and 7 women; mean age, 70.3 years; range, 44-82 years) with chronic hepatitis or liver cirrhosis and without liver tumor. All underwent contrast-enhanced dynamic CT to exclude the malignancy especially hepatocellular carcinoma.

CT imaging

CT images were acquired on a 256-slice multi-detector CT (MDCT) system (Brilliance iCT, Philips Healthcare, Cleveland, OH). The scan parameters were: tube voltage, 120 kV; tube current, about 400 mA with automatic modulation; field of view, 30 to 36 cm; slice collimation and acquisition, 5 mm. A nonionic contrast material (100 mL; Iopamiron 370, Bayer Schering Pharmacy, Osaka, Japan) was injected intravenously at 3.5 mL/s, followed by a saline flush delivered at the same injection rate. Arterial-phase images were acquired 10 sec after reaching a threshold in the descending aorta on the level of the left atrium. The image acquisition delay between the arterial- and portal venous phase and the portal venous- and venous phase was 15 and 80 sec, respectively. A radiologist with 15 years of experience in body CT evaluated the degree of enhancement of the liver parenchyma during the portal venous- and the venous phase and selected the phase with better contrast enhancement of the portal- and hepatic vein. Then the two image set, one was reconstructed with FBP and the other with the hybrid iterative reconstruction (HIR) algorithm (iDose⁴, Philips Medical Systems, Best, the Netherlands), with a slice thickness of 1.25 mm were reconstructed and used for whole liver volumetry.

Image noise

For each image sets, image noise was measured as the average of CT values’ standard deviation inside the three circular regions of interest with 1.5cm diameter assigned on the different position of the liver parenchyma.

Volumetry

One radiologist and one radiological technologist independently performed volumetry of the whole liver. We used a dedicated workstation (Synapse Vincent; Fuji Film Co., Tokyo, Japan).

Statistical analysis
We performed Bland-Altman analysis [8] to evaluate the agreement between FBP and hIR. Inter-observer agreement for FBP and hIR were also assessed by Bland-Altman analysis. P values less than 0.05 were considered to be statistically significant. For statistical analysis we used statistical software (MedCalc version 11.3.7.0; MedCalc Software bvba, Belgium).
Results

Image noise of liver parenchyma of FBP and hIR was 21.2 and 12.1 respectively. There was a statistically significant difference (p<0.01). Our volumetry results are listed in Table 1. A Bland-Altman plot between FBP and hIR is shown in figure 1. Bland-Altman analysis revealed there was no systemic bias. The limit of agreement was -32.5 to 52.3ml corresponding -2.6 to 4.2% to the mean volume thus satisfying compared with the previously reported difference between preoperatively measured liver volume by CT and operatively resected liver volume (9%) [5]. Figure 2 and 3 shows the inter-observer difference of FBP and hIR. For hIR, the mean difference and limit of agreement were -28.3ml and -78.3 to 21.7ml respectively while the mean difference and limit of agreement for FBP were -31.2ml and -92.3 to 30.0ml respectively. The volumetry from hIR image had the less mean difference and narrower limit of agreement between two observers than that from FBP indicating that hIR had the better reproducibility.

<table>
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<tr>
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<th>observer 1</th>
<th>observer 2</th>
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<tbody>
<tr>
<td>FBP</td>
<td>1241.7 (816.6 - 1797.1)</td>
<td>1272.8 (809.5 - 1830.4)</td>
</tr>
<tr>
<td>hIR</td>
<td>1233.2 (782.3 - 1761.3)</td>
<td>1261.5 (791.4 - 1798.8)</td>
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*Table 1. The results of volumetry.* The results are the median. Data in parentheses are the minimum value and the maximum. The unit is ml.
Fig. 1: Fig.1 Bland-Altman plot for FBP and hIR. Bland-Altman analysis revealed there was no systemic bias.

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Fig. 2: Fig.2a Bland-Altman plot for inter-observer difference of FBP.

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Fig. 3: Bland-Altman plot for inter-observer difference of hIR. Note that the limit of agreement was narrower than that of FBP.

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Conclusion

Liver volumetry with hIR is a good alternative to that with FBP showing better reproducibility.
References


