Analysis of Functional Partial Liver Volume Evaluations from Gd-EOB MRI; Comparison with Tc-99m-GSA Scintigraphy

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Purpose

Technetium-99m-galactosyl human serum albumin (Tc-99m-GSA) binds specifically to asialoglycoprotein receptors on the normal liver surface and is absorbed into the hepatocytes. Patients with various liver diseases have a reduced number of asialoglycoprotein receptors and thus less absorption of Tc-99m-GSA into the liver and increased blood concentration.

Most research on the assessment of hepatic functional reserve using Tc-99m-GSA scintigraphy has examined the liver as a whole\(^{(1)}\)(\(^{(2)}\)). Although there have been some assessments of partial function using SPECT\(^{(3)}\)-\(^{(11)}\), most of these have used simplified methods since both procedure and analysis tend to be complicated. In this study, we determine liver periphery and volume with a 35% cut off level based on the phantom study by Uchiyama, et al.\(^{(12)}\).

Gadolinium ethoxybenzyl diethylenetriaminepentaacetic acid (Gd-EOB-DTPA) has been widely reported on and used for diagnosis of hepatocellular carcinoma and other tumors since it was introduced in 2004. It was also incorporated into assessment of liver function, and recent studies have correlated liver/spleen signal ratio and signal increase (%) 20 minutes after introduction of an intravenous contrast agent with ICG testing and liver function assessment using Tc-99m-GSA liver scintigraphy\(^{(13-15)}\). While Gd-EOB-DTPA and Tc-99m-GSA share the characteristics of hepatocellular uptake and biliary excretion, the advantage of Gd-EOB-DTPA is that it has the potential to be used for both tumor diagnosis and preoperative functional volumetry in a single examination#

In this study, we assumed caudate lobe preservation and left lobe resection and investigated whether there was a correlation between liver resection rate derived using Tc-99m-GSA and liver resection rate derived using parenchyma signal weighted anatomical volume measured using EOB-MRI.
Methods and Materials

25 patients (17 men, 8 women; average age 69.7±7.48 years old, ranging from ages 42 to 85) who underwent both EOB-DTPA MRI (3T MRI) and Tc-99m-GSA liver scintigraphy between July 2008 and August 2010 prior to surgery.

There were 15 cases of hepatocellular carcinoma, seven cases of metastases, and three cases of intrahepatic bile duct carcinoma.

There were 20 Grade A cases and 5 Grade B cases according to Child-Pugh classification. Gd-EOB-DTPA and Tc-99m-GSA tests were conducted within a single month.

There were no cases of renal dysfunction.

<MRI>

MRI was performed using a 3.0-T MRI scanner (MAGNETOME Trio A Tim System 3.0T ; Siemens Medical Solutions, Erlangen, Germany) and body-matrix-coil or spine-matrix-coil 4ch. The imaging sequence was VIBE with fat suppression (CHESS) (TR, 3.29 ms; TE, 1.22 ms; flip angle, 13°; FOV, 350 mm; Matrix, 216×320; 56 slice; slice thickness, 3.5 mm; acquisition time 21s). Gd-DTPA-EOB (0.02mmol/Kg of body weight) was injected intravenously at 2mL/s and followed with 20-mL of physiological salt solution. Imaging was conducted prior to and 20 minutes after injection of the intravenous contrast medium.

Three 150cm$^2$ ROIs were set on each of the left and right lobes and average signal value for both lobes (right lobe (SR), left lobe (SL)) was determined based on average signal value of each ROI. The ROIs were set as S2,-4 upper (S2 and area crossing S7 and S8 of the same slice), middle (S4 and portal of the same slice), and lower (S3 and area crossing S5 and S6 of the same slice) parts of the right lobe. Liver contour was traced manually for each slice (axial image), and dividing the liver along the middle hepatic vein and cantlie line, total liver volume and anatomical partial liver function (right lobe VR, left lobe VL, total VT) were measured. The caudate lobe was included with the left lobe. Resection rate was then weighted according to three signal intensities. Including anatomical resection, there were four types of resection rates for Gd-EOB-DTPA.

1. Pure resection rate

Resection rate based on volume derived from simple volumetry without functional weighting:
2. Average signal increase ratio

Resection rate based on anatomical volume weighted by pre and post imaging signal increase:

\[ \text{resection rate} = \frac{(VL \times SL_{20\text{min}} / SL_{\text{pre}})}{(VR \times SR_{20\text{min}} / SR_{\text{pre}} + VL \times SL_{20\text{min}} / SL_{\text{pre}})} \]

3. Average signal

Resection rate based on anatomical volume multiplied by post imaging signal intensity:

\[ \text{resection rate} = \frac{(VL \times SL_{20\text{min}})}{(VR \times SR_{20\text{min}} + VL \times SL_{20\text{min}})} \]

4. Average signal increase amount

Resection rate based on anatomical volume multiplied by the difference in pre and post imaging signal intensity:

\[ \text{resection rate} = \frac{(VL \times (SL_{20\text{min}} - SL_{\text{pre}}))}{(VR \times (SR_{20\text{min}} - SR_{\text{pre}}) + VL \times (SL_{20\text{min}} - SL_{\text{pre}}))} \]

For items 2, 3, and 4 total signal change rate was calculated from pure resection rate in each case.

<RI>

Tc-99m-GSA (185MBq) was injected through the elbow vein and a dynamic study was conducted using an opposing two detector PRISM 2000XP (Philips (Picker)) scintigraphy camera and low energy high resolution collimator. Data was collected using dynamic SPECT with 64×64 matrix and continuous imaging was performed for 21 rotations (31.5 minutes) at 90 seconds per rotation. 35% was the cut off for the whole liver.

For each of the SPECT images taken 30 minutes after Tc-99mGSA injection, we determined the resection plane for each slice based on the CT image, constructed post resection image of the right lobe and calculated resection rate. Fig. 2 on page 5

<Comparison of resection rate>

We tested for statistically significant difference between the anatomical resection rate without weighting and the three resection rates with signal intensity weighting and functional resection rate derived from Tc-99m-GSA.
Images for this section:

Fig. 2

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Fig. 1

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Results

For Gd-EOB-DTPA, pre-imaging to post-weighting change rate of resection rate increased in the order of 2.Signal increase ratio<3. Average signal<4.Signal increase amount (Table.1 Table 1 on page 8). Figure 4 shows correlations between the four kinds of resection rates derived using Gd-EOB-DTPA and functional resection rate derived from Tc-99m-GSA.

There were significant correlations for all, although compared to 1.Pure resection rate (p<0.01) and 2.Signal increase ratio(p<0.05), correlation was higher for the more strongly weighted 3.Average signal and 4.Signal increase amount (p<0.001). The correlation coefficient for 3.Signal increase amount was slightly higher than for 4.Average signal(Fig.1a-d, Table.2 Fig. 3 on page 8 Fig. 4 on page 9 Fig. 5 on page 10 Fig. 6 on page 11 Table 2 on page 12 ).
Table 1

<table>
<thead>
<tr>
<th>change rate of resection rate</th>
<th>② average signal increase ratio</th>
<th>③ average signal</th>
<th>④ average signal increase amount</th>
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<tr>
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<td>2.73 ± 9.43</td>
<td>5.71 ± 5.25</td>
<td>9.38 ± 9.24</td>
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Correlation of resection rate between Tc-99 m-GSA and pure resection rate

R=0.538

Fig. 3

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Correlation of resection rate between Tc-99 m-GSA and average signal increase ratio

R = 0.504
Correlation of resection rate between Tc-99m-GSA and average signal

R = 0.671
Correlation of resection rate between Tc-99m-GSA and average signal increase amount

R=0.681
Table 2

The correlation coefficient for each parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>R</th>
<th>P-value</th>
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<tr>
<td>① Pure resection rate</td>
<td>0.538</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>② Average signal increase ratio</td>
<td>0.504</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>③ Average signal</td>
<td>0.671</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>④ Average signal increase amount</td>
<td>0.681</td>
<td>&lt;0.0005</td>
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Conclusion

Resection rates reflecting liver function and derived from signal intensity using Gd-EOB-MRI were highly correlated with Tc-99m-GSA scintigraphy. Gd-EOB-MRI has the potential for clinical applications like those for Tc-99m-GSA scintigraphy.
References


