Can diffusion-weighted MRI substitute T2-weighted turbo spin-echo in the detection of hepatic nodules?

Poster No.: C-1836  
Congress: ECR 2011  
Type: Scientific Exhibit  
Keywords: MR-Diffusion/Perfusion, MR, Abdomen, Neoplasia, Liver  
DOI: 10.1594/ecr2011/C-1836

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Purpose

Evaluate the sensitivity and calculate the agreement between the MRI sequences: DWI and T2TSE in the detection of hepatic nodules and also verify if DWI in association with post-gadolinium phases (VIBEpc) can substitute T2TSE associated with post-gadolinium VIBE in the routine abdominal magnetic resonance (MR) examination for the detection of focal liver lesions (FLL).

VIBE sequences have already shown in previous studies to provide excellent spatial resolution [1-2]. Previous studies have already compared VIBE to other known MRI sequences, [2-3] in which it proved its superiority over the T2W images and T1 weighted 2D images. Because of its well known sensitivity in the detection of FLLs, we choose to include post-gadolinium VIBE in association to either T2TSE or DWI in the comparison for FLL detection.

There are no published studies comparing the detection rate of FLL with DWI to both T2TSE and VIBE images. Thus, the purpose of our study was to retrospectively compare the sensitivity and agreement in the detection rate of FLLs with DWI, T2TSE and post-gadolinium VIBE images.
Methods and Materials

This retrospective study was approved by our ethics committee and review board. Waiver of informed consent was given.

Patients and FLLs

- MR examinations that included at least one typical or confirmed FLL with a greater diameter of at least 0.5cm and in which the MR examination included a DWI sequence of the liver (DWI became a routine MR sequence in either facility).

- The selected examinations included 44 patients (24 men, 20 women) and ranged from January 31st 2008 to May 08 2008.

- The final cohort included 60 FLLs; range, 5-156mm; mean 27mm, from 35 individual patients (21 women, 14 men), with a mean 1.71 FLLs per patient.

MRI

- MRI of the abdomen, always including the liver, was performed using two 1,5T clinical diagnostic systems

- DW-MRI - Triggered fat-suppressed single-shot echo-planar DWI was performed in the transverse plane with tri-directional diffusion gradients by using three values of b (0, 50,700 sec/mm2) within the same acquisition.

- T2TSE MRI - Axial T2-weighted turbo spin-echo (T2TSE) with fat saturation and respiratory triggering technique images were obtained.

- Post-gadolinium VIBE - All patients were imaged by using a transverse breath-hold three-dimensional T1-weighted fat-suppressed spoiled gradient-recalled-echo sequence (volumetric interpolated breath hold examination - VIBE) before and after dynamic injection of 0.2 mL/kg of gadoteric acid 0.5 mmol/ml followed by a 20 mL saline flush (2 mL/sec) with a power injector.

Image Analysis

S.M.G., MD (Rad1) and J.F.F., MD (Rad2), both with more than seven years of experience in abdominal MRI reviewed DWI, T2TSE and post-gadolinium VIBE images on a commercial workstation independently, at first, and in consensus, later. The observers were blinded to clinical MRI reports, clinical history, and pathologic results.
All images were randomly analyzed in different sessions separated by at least 10 days to minimize recall bias. T2TSE, DWI and post-gadolinium VIBE data sets were read separately, and, as such, each data set was not accessed when reading another one. For FLL detection with DWI, they used images with b values of 0, 50 and 700 sec/mm².

For lesions not visualized on DWI, the location was determined by using post-gadolinium VIBE images, which we used as our gold standard.

**Statistical Analysis**

Simple kappa coefficients were used to assess the agreement between the analyzed sequences for lesion detection (0.00-0.20 indicated slight agreement; 0.21-0.40, fair agreement; 0.41-0.60, moderate agreement; 0.61-0.80, substantial agreement; and 0.81-1.00, almost perfect agreement) [59]. Sensitivity, specificity, positive predictive value and accuracy were determined.
Results

Overall, 60 lesions with an average diameter of 2.7 cm (range, 0.5-15.6 cm) were detected at image reading. There was an average of 1,71 FLLs per patient, within the 35 included patients (14 men, 21 women). The diagnosis and characterization of a benign or malignant FLL was based on typical MRI findings [47, 60-66], but was not the purpose of our study.

With the post-gadolinium VIBE MR sequences 58 out of 60 (98.6%) FLLs were detected. The T2TSE MR sequence identified 47 (78.3%) and DWI, 51 (85.0%).

There was slight agreement between post-gadolinium VIBE and DWI at b0, b50 and b700 sequences and the corresponding ADC maps, relative to the visualization of FLLs (Table 1).

There was also slight agreement between post-gadolinium VIBE and T2TSE sequences relative to the visualization of FLLs (Table 2).

There was substantial agreement between DWI and T2TSE sequences relative to the visualization of FLLs (Table 3).

When we look at our sequences results in pairs, there was substantial agreement between T2TSE plus post-contrast VIBE and DWI plus post-contrast VIBE (Table 4).

When we plot our results in terms of detection rate, using post-contrast VIBE as our gold standard, we found a higher detection rate for the DWI in comparison to T2TSE (Table 5).
Images for this section:

**Table 1** – Comparison between DWI and post-contrast VIBE MRI sequences for the detection of FLLs.

<table>
<thead>
<tr>
<th>MRI sequence</th>
<th>(+) Detected VIBE</th>
<th>(-) Not detected VIBE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Detected DWI</td>
<td>49</td>
<td>2</td>
<td>51</td>
</tr>
<tr>
<td>(-) Not detected DWI</td>
<td>9</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>58</strong></td>
<td><strong>2</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

kappa index: 0.05

**Fig. 0**

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**Table 2** – Comparison between T2TSE and post-contrast VIBE MRI sequences for the detection of FLLs.

<table>
<thead>
<tr>
<th>MRI sequence</th>
<th>(+) Detected VIBE</th>
<th>(-) Not detected VIBE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Detected T2TSE</td>
<td>46</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>(-) Not detected T2TSE</td>
<td>12</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>58</strong></td>
<td><strong>2</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

kappa index: 0.08

**Fig. 0**

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**Table 3** – Comparison between DWI and T2TSE MRI sequences for the detection of FLLs.

<table>
<thead>
<tr>
<th>MRI sequence</th>
<th>(+) Detected DWI</th>
<th>(-) Not detected DWI</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Detected T2TSE</td>
<td>47</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>(-) Not detected T2TSE</td>
<td>4</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>51</strong></td>
<td><strong>9</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

kappa index: 0.78

**Fig. 0**
Table 4 – Comparison between DWI plus post-contrast VIBE and T2TSE plus post-contrast VIBE MRI sequences for the detection of FLLs.

<table>
<thead>
<tr>
<th>MRI sequence</th>
<th>(+) Detected DWI+VIBE</th>
<th>(-) Not detected DWI+VIBE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Detected T2TSE+VIBE</td>
<td>59</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>(-) Not detected T2TSE+VIBE</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>0</td>
<td>60</td>
</tr>
</tbody>
</table>

Fig. 0

Table 5 – Detection rate of FLLs in 35 patients with DWI, T2TSE, post-contrast VIBE, T2TSE plus post-contrast VIBE and DWI plus post-contrast VIBE.

<table>
<thead>
<tr>
<th>MRI Sequences</th>
<th>Detection rate (n=60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2TSE</td>
<td>78,3% (47/60)</td>
</tr>
<tr>
<td>DWI</td>
<td>85,0% (51/60)</td>
</tr>
<tr>
<td>VIBE</td>
<td>96,6% (58/60)</td>
</tr>
<tr>
<td>T2TSE+VIBE</td>
<td>98,3% (59/60)</td>
</tr>
<tr>
<td>DWI+VIBE</td>
<td>100,0% (60/60)</td>
</tr>
</tbody>
</table>

Fig. 0

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**Fig. 0:** Figure 1 - D.F.T.T., 37yo, with a 16mm hepatic cyst localized on segment VII. On arterial VIBE (A) MR sequence, liver cyst show low signal intensity. With T2TSE (B) MR sequence, the lesion demonstrates high signal intensity. At DWI (C) MR sequence, the same lesion can be depicted with high signal intensity. ADC MAP of the same exam show high values on the cystic area, indicating no diffusion restriction.

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**Fig. 0:** Figure 6 - M.S.S., 19yo, female. Although this patient’s 34 mm hepatic adenoma was detected in arterial VIBE (A), T2TSE (B), DWI (C) and portal VIBE (D) sequences, we can clearly see how it is much more visible on T2TSE and DWI (B,C), and almost impossible to miss after the disappearance of the blood vessels on the DWI image (C).

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Fig. 0: Figure 5 - M.B., male. This patient had a HCC, seen in all MR sequences: arterial VIBE (A), T2TSE (B), DWI (C), portal VIBE (D).

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**Fig. 0:** Figure 4 - P.S., male. This patient had multiple hepatic abscesses, the greatest of those is shown in all MR sequences [arterial VIBE (A), T2TSE (B), DWI (C), portal VIBE (D)], we can appreciate how it is easily detected on DWI (C), and detectable but harder to find at T2TSE (B).

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**Fig. 0:** Figure 2 - K.H., male. This cirrhotic patient with a recently discovered HCC on the right liver lobe had his 28mm FLL well seen on either MR sequences [arterial VIBE (A), T2TSE (B), DWI (C), ADC MAP (D)].

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Fig. 0: Figure 3 - J.M., male. This patient with a known adenocarcinoma colon cancer, found this 116mm metastatic left lobe FLL. The lesion is seen in all sequences [arterial VIBE (A), T2TSE (B), DWI (C), portal VIBE (D)], but its limits are better appreciated on the DWI sequence (C). This patient also had a big upper pole right kidney simple cyst.

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Fig. 0: Figure 8 - S., female. This patient had multiple right lobe hepatic hemangiomas. Seen in all MR sequences [arterial VIBE (A), T2TSE (B), DWI (C)]. ADC MAP (D), shows high values, indicating low diffusion restriction. We can also appreciate how the smaller lesions are very well seen on DWI (C).

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**Fig. 0:** Figure 7 - R.G., male. This patient 34 mm right lobe hepatic hemangioma (*) is detected in all MR sequences, with progressive globular filling on post-contrast VIBE images [arterial (A), portal (B), late phase (C)] and high signal intensity on DWI (D) and T2TSE (E).

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Conclusion

Previous studies [4-7] have already shown improved detection rates of both malignant and benign FLLs when using DWI with a small b value compared with standard breath-hold T2W imaging, particularly for small malignant lesions measuring 1-3 cm [7].

We compared long T2TSE sequences with DWI at b0, b50 and b700. The results were similar to those we expected. DWI detected 51 lesions among the 60 total, while T2TSE detected 47 lesions among the 60 total. Even though the visualization of FLLs agreement between then was significant (kappa: 0.78) (Table 3), DWI outnumbered T2TSE by four lesions: T2TSE identified 47 (78.3%) and DWI, 51 (85.0%), showing an 8.5% increase in the detection rate relative to T2TSE.

Our study was not trying at any time to prove the superiority of DWI over post-contrast VIBE in detecting FLLs, but by adding post-contrast VIBE, we could find out, as shown in "Table 4", that the pair post-contrast VIBE plus DWI shows increased FLL detection rates relative to T2TSE and can be used in lieu of T2TSE in liver MR examination protocols for the detection of FLLs.


Detection of liver lesions with gadolinium-enhanced VIBE sequence in comparison with SPIOenhanced MRI. Rofo 2003, 175(10):1376-1383.


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