Simultaneous Multislice Accelerated Free-Breathing Diffusion-Weighted Imaging of the Liver at 3T

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Target Audience: Radiologist and physicist interested in Liver/Abdominal DWI.

Purpose: Diffusion-weighted imaging (DWI) is commonly used in the abdomen, particularly in the evaluation of focal and diffuse liver diseases[1,2]. Liver echo planar (EPI) DWI acquisition can be performed in a breath-hold or in free breathing with either multiple signal-averaging to reduce the effects of motion or with respiratory and/or cardiac triggering. Studies have shown free-breathing DWI of the liver is reliable and has better image quality compared to breath-hold, and is more efficient than respiratory triggered acquisition. However, one of the limitations is relatively long acquisition time. Multiband approach can decrease the repetition time (TR) and has been shown to accelerate DW in brain[3] and is feasible for liver imaging at 1.5 T[4]. The purpose of this prospective study was to perform dedicated reader blinded study with head-to head comparison between accelerated multiband diffusion acquisition (mb2-DWI) and conventional non-accelerated diffusion acquisition (c-DWI) in patients undergoing clinically indicated liver MRI at 3T.

Methods: 22 consecutive patients (12 Male and 10 Female) with mean age 56 years (range 33 to 83 years) underwent clinically indicated liver MRI on a 3-T system (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany). Indications for MRI were known or suspected history of cirrhosis (n=14) and evaluation of suspected or known focal liver lesion (n=8). Scans were performed using an 18-channel body matrix receive coil. Transverse free-breathing single shot EPI acquisitions with monopolar tri-directional trace-weighting diffusion gradients was performed prior to contrast administration with matching matrix, voxel size, b-values, and frequency selective fat saturation. for multiband (mb-DWI) and conventional DWI sequences. C-DWI was performed with following parameters: TR/TE 4500/66 msec, matrix 164 x 123, voxel size (interpolated) 2.3 x 2.3 x 5 mm, 34 axial 5 mm slices with inter-slice gap of 0.5 mm, bandwidth 1386 Hz/pix, parallel imaging factor of 2, 3 b values (0,400, and 800 sec/mm2), and 4 averages. For multiband sequence with acceleration factor of 2 (mb2-DWI) two slices were acquired simultaneously using blipped CAIPIRINHA (relative slice shift = FOV/3) and individual slices are reconstructed using split slice GRAPPA reconstruction[5]. TR reduced to 2400 msec with mb2-DWI. Other parameters were same as c-DWI as mentioned above. An acquisition time for mb2-DWI was 88 sec, versus 149 sec for c-DWI.

Image Analysis: Sequence and patient related information was removed for mb2-DWI and c- DWI sequences in 22 patients. De-identified randomized diffusion weighted acquisitions were independently reviewed by 3 blinded board certified radiologist. Various parameters of image quality were scored on a 5 point scale with higher score indicating more desirable exam. Each reader also noted presence or absence of a lesion on review of diffusion weighted images. A round region of interest with an average diameter of 4 cm was placed by another reader in the right lobe of the liver on the ADC maps which were generated in-line at the scanner with monoexponential fitting of signal-intensities at all b-values. Mean and ADC values were recorded for each acquisition. The image quality parameters were compared between the DWI schemes using exact paired Wilcoxon signed rank tests from each reader and averaged over the three readers. Bland Altman Analysis was performed to compare ADC from the different sequences.

Results: The multiband mb2-DWI was 40.9% faster than c-DWI. Despite shorter acquisition time overall image quality score (averaged over the three readers) was significantly higher for mb-2 compared to c-DWI for b=0 s/mm^2 (3.48 ± 0.52 vs. 3.21 ± 0.54; p= 0.001) and for b=800 s/mm^2 (3.24 ± 0.76 vs. 3.06 ± 0.86; p= 0.010). Image quality scores of other parameters are shown in the **Table**. Total of 25 hepatic lesions were visible on mb2-DWI and c-DWI, with identical lesion detectability, an example is depicted in **Figure 1**. There was no significant difference in liver ADC between mb2-DWI and c-DWI (p= 0.12). Bland Altman plot demonstrates slight lower liver ADC with mb2-DWI compared to c-DWI (0.043 x 10^{-3} mm^2/sec).

	Mb2-DWI	C-DWI	Mb2-DWI	C-DWI
	b = 0 s/mm^2		b = 800 s/mm^2	
Overall Image Quality	3.48 ± 0.52	3.21 ± 0.54	3.24 ± 0.76	3.06 ± 0.86
Clarity Intrahepatic Vessels	3.06 ± 0.79	2.92 ± 0.62	2.77 ± 0.98	2.70 ± 0.96
Sharpness Right Lobe	3.80 ± 0.79	3.61 ± 0.72	3.76 ± 1.00	3.61 ± 1.04
Conspicuity Left Lobe	3.53 ± 0.63	3.48 ± 0.62	3.12 ± 0.87	2.82 ± 0.82
Motion Robustness	3.20 ± 0.52	3.11 ± 0.44	3.32 ± 0.58	3.20 ± 0.44

Table: Image quality comparison between mb2-DWI and c-DWI for b =0 and b=800 s/mm^2. Scores are averaged over three readers

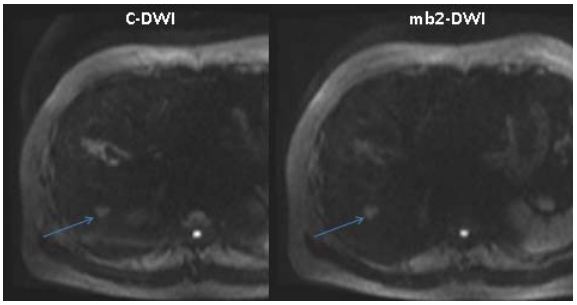

Figure: Right hepatic lobe hepatocellular carcinoma (arrow) was visualized on c-DWI and mb2-DWI by all readers

Conclusion and Future Direction: Our study demonstrates multiband sequence with acceleration factor of 2 (mb2-DWI) decreases acquisition time by approximately 40 to 50% compared to conventional diffusion weighted acquisition for liver imaging at 3-T. Despite shorter acquisition time, mb2-DWI had higher scores for overall image quality compared to c-DWI with identical lesion detectability. Thus, mb2-DWI can replace the conventional DWI sequence in the liver.

References: **1**. Bharwani N et al. Cancer imaging 2013. **2**. Namimoto T et al. Radiology 1997. **3**. Setsompop K. et al. MRM.2012. **4**. Bhat H et al. ISMRM 2013. 593. **5** Cauley et al. MRM 72:93–102, 2014