Multiband-accelerated diffusion-weighted MR imaging of the abdominal organs: Initial experiences

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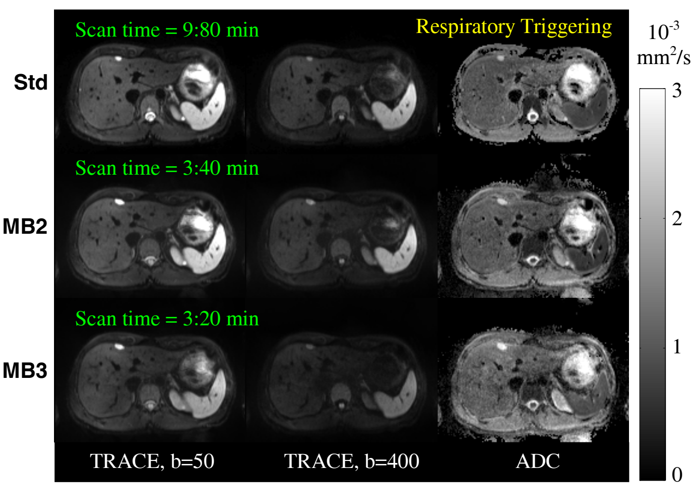
Target audience: Basic scientists and clinicians interested in abdominal diffusion imaging.

Purpose: Diffusion-weighted (DW) imaging has gained increasing importance in extracranial imaging for tissue characterization, lesion detection, and predicting and monitoring treatment response in a broad range of lesions and organs[1]. However, the measurement time required for acquisition of multiple slices still remains a problem for the application in clinical routine, especially if respiratory triggering is applied to reduce motion related artifacts in abdominal imaging. In the last years an approach for simultaneous multiband (MB) radiofrequency (RF) excitation and acquisition of multiple slices was introduced[2,3], which reduces the repetition time (TR) by the number of simultaneously excited slices. MB technique has been improved by the recently introduced blipped controlled aliasing in parallel imaging (blipped CAIPI) technique and has proven useful for DW imaging of the brain[4-6]. The aim of the present study was to assess the feasibilty of the MB technique for accelerated DW imaging of abdominal organs.

Methods: Four healthy volunteers were examined on a 1.5 T MR scanner (MAGNETOM Aera, Siemens Healthcare, Erlangen, Germany) using an 18-channel anterior body coil in combination with 12 elements of a 32-channel spine coil. DW imaging of the abdominal organs (e.g. liver, spleen, kidneys) was performed using a MB-accelerated DW echo planar imaging sequence (MB DW-EPI) previously described in details (3-5). Images were acquired with and without respiratory belt triggering using MB-factor values of 2 and 3 and compared to the standard DW-EPI sequence (Std) provided by the manufacturer. Thirty-six slices were acquired with the following parameters: thickness, 6 mm without intersection gap; field of view, 270×360 mm^2; acquisition matrix, 120×160; readout bandwidth, 1955 Hz/Pixel; parallel imaging factor, 2; partial Fourier factor, 6/8; number of averages, 4. Using the standard DW-EPI sequence required TR was 6900 ms in free-breathing and 2400 ms (with 3 concatenations) in respiratory triggered measurements. Required TR, applying a MB-factor of 2 was 2531 ms and 1686 ms when using a MB-factor of 3. Monopolar diffusion preparation according to the Stejskal-Tanner scheme[7] allowed for realizing a relatively short echo time (TE) of 50 ms. DW imaging was performed with diffusion gradient *b*-values of 0, 50, 400, and 800 sec/mm^2 applied in three orthogonal directions (three-scan trace). Trace-weighted (TRACE) and ADC images were calculated on a standalone PC using Matlab (Mathworks, Natick, USA). A qualitative analysis of image quality was performed by two experienced radiologists (N.S and C.S.) for standard and MB DW-EPI sequences.

Results: The applied MB DW-EPI sequence was feasible in all volunteers and acceptable image quality was observed with considerable reduction in acquisition time. Image quality decreased with higher MB-factors. MB DW with respiratory triggering provided images with adequate quality both for MB-factor 2 and 3. In free-breathing acquisitions MB-factor 2 provided sufficient image quality while in images with MB-factor 3 significant ghosting artifacts were observed leading to insufficient diagnostic image quality. The mean scan time in respiratory triggered measurements was 4:20 min for MB=2 and 3:50 min for MB=3, whereas it was 11:30 min for standard sequence. Measurements in free breathing were performed within 4:57 min for standard sequence and 2:09 min and 1:34 min for MB=2 and MB=3, respectively. Figure 1 shows DW images of the upper abdomen obtained with different MB-factors and with/without respiratory triggering in comparison to the standard sequence.



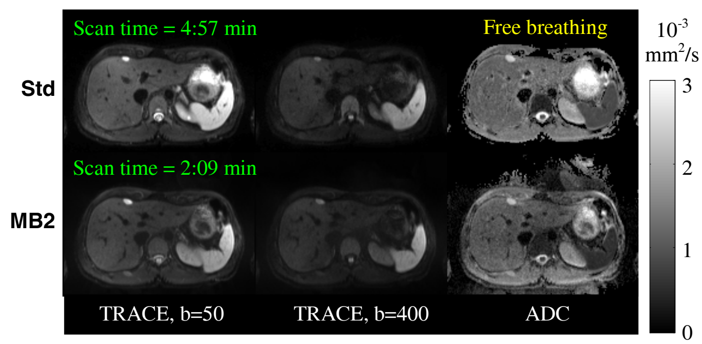


Figure 1: *Qualitative comparison of MB-accelerated and standard (Std) DW-EPI images and ADC maps. Measurements were performed with respiratory triggering* ***(left)*** *and under free breathing* ***(top)****. Images obtained with MB technique using respiratory triggering show an acceptable quality with considerable reduction in acquisition time.*

Discussion: DWI of abdominal organs is challenging due to respiratory movements and strong susceptibility artifacts, especially at higher magnetic fields (≥3 T). Application of respiratory triggering leads to long measurement times often difficult to realize in clinical routine. In the present work, the feasibility of the MB-accelerated DW-EPI technique for abdominal imaging could be demonstrated. A MB-factor of 2 permits acquisition of 36 slices along three diffusion gradient directions with an acceptable image quality within half time compared to the standard single-band measurements. Images obtained under free breathing showed pronounced image ghosting artifacts. The reason for this is most probably that in the applied MB approach only one single-band reference scan is acquired (serving for reconstruction of the other images). Currently, further developments of MB sequences and data post-processing are required for DWI of abdomen under free breathing. In conclusion, the MB technique seems to be a promising approach to reduce acquisition time in abdominal DWI. Reduction of measuring time at least by 50 % without compromising image quality seems achievable in applications with respiratory triggering/gating.

References: 1. Thoeny et al., Eur Radiol 2007;17:1385–93; 2. Moeller et al., Magn Reson Med 2010;63:1144–53; 3. Feinberg DA et al. PLoS One 2010;5(12):e15710; 4. Setsompop et al., Magn Reson Med 2012;67:1210–24; 5. Xu et al., NeuroImage 2013, doi/10.1016/j.neuroimage.2013.07.055; 6. Auerbach et al., Magn Reson Med 2013;69:1261–67; 7. Stejskal et al., J Chem Phys 1962;41:288–92.