7T liver MRI in humans: initial results.

L. Umutlu[1], A. K. Bitz[2], S. Maderwald[3], S. Orzada[3], S. Kinner[4], O. Krafft[5], I. Brote[5], S. C. Ladd[6], G. Antoch[6], M. E. Ladd[3], H. H. Quick[3], and T. C. Lauenstein[6]

[1]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Essen, Germany, [2]Erwin L.Hahn Institute for Magnetic Resonance Imaging, Essen, Germany, [3]2Erwin L.Hahn Institute for Magnetic Resonance Imaging, [4]1Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, [5]Erwin L.Hahn Institute for Magnetic Resonance Imaging, [6]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen

Introduction

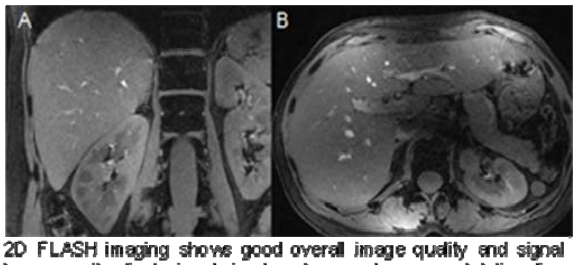
With the introduction of ultra highfield MR imaging at 7T, the initial interest has transitioned from neuro imaging and musculoskeletal imaging to whole body investigations. First approaches in 7T whole-body MRI have recently been published (1,2), demonstrating the potential of ultra highfield imaging and the need for coil and sequence optimization. The aim of this study was to investigate the feasibility of 7 Tesla ultra-high-field MR imaging of the liver in humans, with optimization and implementation of a dedicated examination protocol utilizing a custom-built eight-channel RF transmit/receive body coil suitable for RF shimming.

Methods

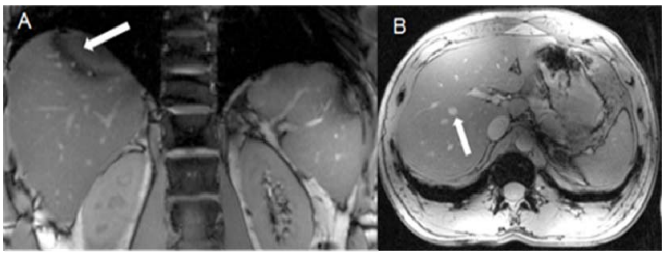
Eight healthy volunteers (average age: 29.5 years, range 26-33 years) were enrolled in this trial. Examinations were performed in supine position on a 7T whole-body MR system (Magnetom 7T, Siemens Healthcare Sector, Erlangen, Germany). For image acquisition, a custom-built 8-channel RF transmit/receive body coil was used, constructed of two arrays with 4 elements each placed ventrally and dorsally on the upper half of the abdomen. The examination protocol included 1) fatsaturated 2D FLASH sequences (TR/TE = 130/3.57ms, FOV 400 x 400 mm, flip 70°, BW 410 Hz/pixel, 13 slices, matrix 512 x 512 interpolated to 1024 x 1024, resulting in an uninterpolated in-plane resolution of 0.8 x 0.8 mm2, a slice thickness of 2 mm, and an acquisition time of 31 sec), 2) fatsaturated 3D FLASH sequences (TR/TE = 2.9/1.02 ms, FOV 400 x 400mm, flip 10°, BW 920Hz/pixel, 27 slices, matrix 320 x 320 interpolated to 640 x 640, resulting in an uninterpolated in-plane resolution 1.3x1.3mm2, a slice thickness of 1.6 mm, and an acquisition time of 27 sec) 3) T1w in and opposed phase imaging (TR/TE = 140/2.04 / 3.57 ms, FOV 340 x 255mm, flip 65°, BW 920 / 980 Hz/pixel, 20 slices, matrix 320 x 240 interpolated to 640 x 480, resulting in an uninterpolated in-plane resolution 1.1 x 1.1 mm2, a slice thickness of 3 mm, and an acquisition time of 20 sec) 4) TRUEFISP imaging (TR/TE = 3.48/1.53 ms, FOV 400 x 400 mm, flip 50°, BW 977 Hz/pixel, 21 slices, matrix 320 x 256 interpolated to 640 x 512, resulting in an uninterpolated in-plane resolution 1.3 x 1.6 mm2, a slice thickness of 4 mm, and an acquisition time of 19 sec) and 5) T2w TSE imaging (TR/TE = 3060/99 ms, FOV 350 x 240 mm, flip 120°, BW 130 Hz/pixel, 16 slices, matrix 256 x 176 interpolated to 512 x 382, resulting in an uninterpolated in-plane resolution 1.4 x 1.4 mm2, a slice thickness of 5.5 mm, and an acquisition time of 34 sec). Visual evaluation of the image quality for each sequence type was performed by two senior radiologists with 11 and 8 years experience in abdominal MRI using a three-point scale (1 = poor, 2 = moderate, 3 = good quality). All sequences were evaluated based on (1) the delineation of the liver vessels as well as (2) the overall image quality. Additionally, presence of artifacts including 1) chemical shift, 2) B_1 inhomogeneities, 3) susceptibility and 4) motion artifacts as well as their consequent image impairment was assessed using a three-point scale (1 = no or insignificant impairment, 2 = moderate impairment, 3 = strong impairment of image quality). For statistical analysis, a Wilcoxon rank test was used.

Results

2D FLASH imaging demonstrated its diagnostic superiority by delivering best mean scores with regards to overall image quality (mean score 2.63) and vasculature delineation (mean score 2.81). T2-weighted TSE imaging revealed strongest image impairment with a mean score of 1.83, proving statistical difference to the 2D and 3D FLASH images with p-values < 0.0005. 3D FLASH proved to be the sequence least prone to artifacts (mean score 1.17). This value was significantly lower compared to the TrueFISP, in and opposed phase and TSE sequences with p-values < 0.0005.



2D FLASH imaging shows good overall image quality and signal homogeneity, displaying defined anatomy and very good delineation of liver vasculature.



TrueFISP imaging (A) provided a good anatomical overview. Arrowpoints at slightly impeding banding artifact at the margins of the field-of-view and at air/tissue interfaces. T1-weighted 2D opposed phase MRI (B) provided typical sharply defined black rim around organs with a fat/water interface and excellent conspicuity of liver vasculature (arrow).

Discussion

This pilot study of dedicated hepatic imaging at 7 Tesla demonstrates the feasibility of in vivo ultra-high-field liver imaging, providing good overall image quality and very good delineation of non-enhanced vasculature at acceptable examination times. Especially non-enhanced angiographic applications appear promising. Further optimization of RF sequences, shim techniques, and dedicated RF coil concepts are expected to better cope with the physical effects associated with high magnetic field strength and enable the acquisition of even higher image quality with clinical diagnostic value.

References:

1. Snyder CJ. Initial results of cardiac imaging at 7 Tesla. Magnetic Resonance in Medicine 2009; 61(3):517-524.Vaughan JT, Snyder CJ,
2. DelaBarre LJ, et al. Whole-body imaging at 7T: Preliminary results. Magnetic Resonance in Medicine 2009; 61(1):244-248.