Tag MRI of the liver as a new method to differentiate normal vs. cirrhotic livers

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Introduction: The prognosis and management of chronic liver diseases largely depend on the extent and the progression of liver fibrosis. Precise staging of hepatic fibrosis is paramount as it is the most important predictor of disease outcome and influences the decision to use antiviral therapy. Fibrosis of the liver is results in increased mechanical stiffness. The assessment of liver stiffness is a key feature of current noninvasive approaches, like ultrasound and MR Eastography [1-4]. Tag-MRI measures tissue strain; a technique is routinely used to quantify myocardial muscle motion by measuring myocardial strain. Because the heart lies immediately adjacent to the left lobe of the liver the cardiac motion induces liver motion. This is well known as a source of motion artifacts during MRI acquisitions. We hypothesize that transmitted cardiac pulsations result in liver motion that can be used to indirectly quantify liver stiffness. **The aim of this study is to use tag MRI to differentiate between normal vs. stiff cirrhotic livers.**

Methods: This study was approved by the Institutional Research Board. Cardiac magnetization-tagged MRI (tagMRI) was performed on 6 cirrhotic patients (62 ± 8 years old) with MRI imaging evidence of cirrhosis, and on 5 subjects (47 ± 16 years old) with no history of GI, hepatobiliary or cardiovascular disease and not receiving any regular medication. A peripheral pulse-gated (PPG) conventional tagMRI sequence was performed using a 1.5T scanner (Achieva, Philips Healthcare, Best, the Netherlands); images were acquired during 15 s expiratory breath holds. Tagged images were obtained through the cardiac cycle (tagging at end-diastole) using a fast gradient-echo cine sequence with the following parameters: FOV = 320x320 mm, matrix = 256x256, slice thickness = 10 mm, TE = 2 ms, TR 4.2 ms, tag spacing 8 mm. Tagged images were acquired in 3 coronal planes (Figure A) and 3 sagittal planes (Figure B) to cover the left lobe of the liver and the inferior wall of the heart. Commercially available software HARP (Diagnosoft), routinely used in cardiac imaging for strain measurements with tagMRI, was used for image analysis and strain calculation. CSPAMM and filters were used in K space (figure C). HARP allows tracking and analysis of the liver motion throughout the entire cardiac cycle (figure D). Three regions-of-interest (ROI) were selected: left lobe of the liver close to the heart (A), right lobe of the liver far from the heart (B), and left ventricular wall (C). The maximum and average strain for each ROI was calculated and used to generate a cardiac corrected strain gradient: (Amax-Bmax)/Cmax. The correction for the cardiac corrected strain was used in an attempt to compensate for the inherent differences in cardiac motion between the studied subjects. The maximum strain, average strain, and cardiac corrected strain of normal and cirrhotic livers were compared using t-test (significance $p < 0.05$).

Results: Figure A shows representative coronal and short-axis tagged images of the heart and liver at end-systole in a cirrhotic subject. Strain was measured as a percentage. The mean maximum strains in ROI A in normal and cirrhotic livers were 53±8% and 17±6% respectively ($p<0.01$). The mean average strains in ROI A in normal and cirrhotic livers were 21±9% and 4±5% respectively ($p<0.01$). The corrected strain gradients in normal and cirrhotic livers were 0.49±0.18 and 0.10±0.10% respectively ($p<0.01$). In normal livers the maximal strain in ROI A, the average strain in ROI A and the cardiac corrected strain gradient were all higher than in cirrhotic livers. This reflects the greater stiffness and resistance to stretching of the cirrhotic livers compared to normal livers.

Discussion: This study demonstrates that tagMRI can be used to differentiate normal vs. cirrhotic livers. Three different strain measurements (maximum strain, average strain, and corrected strain gradient) can be used to differentiate between normal and cirrhotic livers. This method is non invasive, does not require additional hardware, and can potentially be easily added to routine clinical abdominal protocols. Further investigation with pathologic correlation is necessary to determine if this method can differentiate between different fibrotic liver stages.

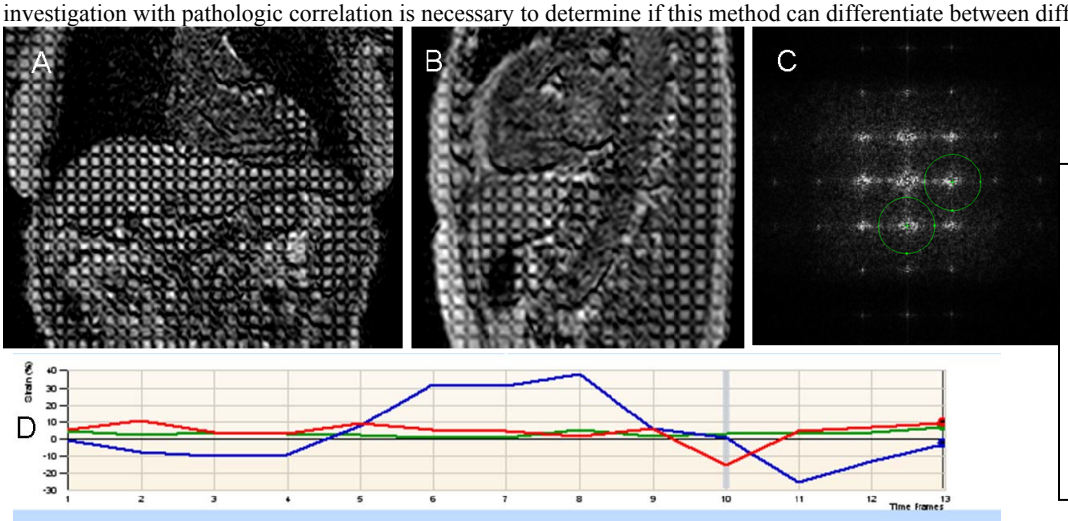

Figure D: Strains of the left lobe of the liver (ROI A, red), the right lobe of the liver (ROI B, green), the myocardium (ROI C, blue) during the cardiac cycle).
On the X axis is the time, the Y axis is the strain reported as %.

1. Pinzani M, et al. Technology Insight: noninvasive assessment of liver fibrosis by biochemical scores and elastography. Nat Clin Pract Gastroenterol Hepatol. 2008; 5:95–106.
2. Sandrin L, et al. Transient elastography: a new noninvasive method for assessment of hepatic fibrosis. Ultrasound Med Biol. 2003;29:1705–1713.
3. Mannelli L,et al. MR elastography: Spleen stiffness measurements in healthy volunteers--preliminary experience. AJR 2010 Aug;195(2):387-92.
4. Muthupillai R, et al. Magnetic resonance elastography by direct visualization of propagating acoustic strain waves. Science. 1995 Sep 29;269(5232):1854-7.