The repeatability of the Magnetic Resonance Elastography derived stiffness value in the liver

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Target Audience Researchers and clinicians interested in liver imaging and disease, with a particular interest in Magnetic Resonance Elastography.

Purpose Magnetic Resonance Elastography (MRE) has gained prominence recently for its ability to stage liver fibrosis. MRE measures the propagation of acoustic shear waves, generated by a passive driver, through liver tissue using a phase contrast imaging technique(1). MRE gives estimates of liver stiffness, which have been shown to directly correlate with fibrosis grade in preliminary studies(2,3). In order to accurately stage disease and track changes in disease progression over time, the variability of the parameters of interest must be known. In this study, MRE repeatability was assessed in a cohort of normal volunteers and cirrhotic patients imaged twice in one scanning session.

Methods Ten volunteers with no known history of abdominal disease and fifteen cirrhotic patients participated in this study. Volunteers and patients each underwent two MRE examinations within the same scan session. Slices were represcribed between scans while the subject remained in the scanner. A passive driver was placed over the liver and attached to an acoustic waveform generator. Imaging was acquired on a 1.5T GE scanner with the following parameters: Vibration Frequency=60Hz, Thickness=8mm, 4 slices, TE/TR=21.8/50ms, FOV=36-50cm, matrix = 196x252, and Flip Angle=30°. Following acquisition, phase difference images were post-processed to generate wave images, which were converted to shear stiffness images (Elastograms) using a mathematical inversion algorithm. Creation of regions of interest (ROIs) was a three-step process. First, the liver was outlined on the magnitude images making sure to avoid the edges of the liver and large hepatic vessels. These ROIs were then transferred to the wave images and regions of poor wave propagation were excluded. Finally, these modified ROIs were transferred to the Elastograms where mean stiffness values were extracted. Repeatability was analyzed with both the within subject and between subjects coefficient of variation (wCV and bCV respectively). CV is defined as the standard deviation divided by the mean. Low CV equates to high repeatability. Stiffness was also compared between normal and cirrhotic livers.

Results Results are summarized in Figures 1 and 2. Mean stiffness values for volunteers and cirrhotic patients were 2.46 (0.05) kPa and 5.89 (0.33) kPa respectively. The standard error is shown in parentheses. Cirrhotic livers were significantly stiffer than normal livers (two-sample t-test, $P < 0.0001$). Repeatability was excellent for both the volunteers and cirrhotic patients. Volunteers had a wCV=0.029 and bCV = 0.093. Cirrhotic patients had a wCV=0.085 and bCV = 0.31.

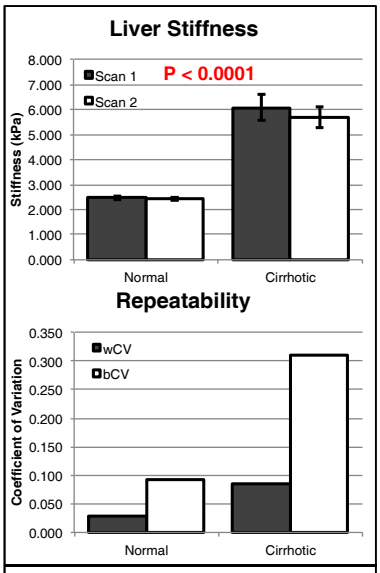

Figure 1. Liver stiffness (top) and repeatability (bottom) results. Error bars represent standard error. Stiffness is shown separately for the two MRE scans. wCV = within subject CV; bCV = between subject CV.

Discussion Repeatability was high for volunteers and cirrhotic patients indicating MRE is a reliable technique to measure liver stiffness. The wCV and bCV were both higher in cirrhotic patients compared to controls. For wCV, this may be due to additional complications stemming from chronic liver disease, including problems with patients holding their breath and ascites (fluid build-up in the abdomen) affecting the scans. The higher bCV in patients could be a result of the known differences in morphologic distributions in the disease. Finally, MRE was able to separate cirrhotic livers from normal livers with 100% sensitivity and specificity.

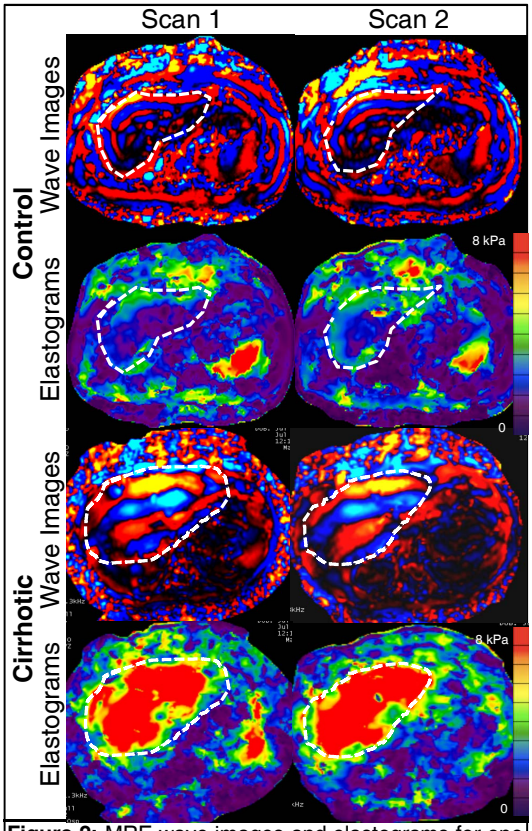

Figure 2: MRE wave images and elastograms for one control subject (top two rows) and one cirrhotic patient. ROIs are shown as dashed white outlines.

Conclusion MRE proved very repeatable. These results indicate changes must be larger than ~10% to be significant for longitudinal studies and ~10-30% to be significant for between group studies.

References 1. Muthupillai, R. *Science.* 269:1854-1857, 1995. 2. Yin M et al. *Clin Gastroenterol Hepatol.* 5(10):1207-1213, 2007. 3. Sudhakar K, *JMRI.* 37(3):544-55 5, 20 13.