MR Elastography: Reproducibility of Measurements of Mean Liver Stiffness

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Purpose: To evaluate the reproducibility of measurements of mean liver stiffness using MR Elastography (MRE).

Background: MRE is a phase contrast MRI technique that evaluates the stiffness of tissues by directly visualizing and measuring propagated mechanical shear waves in tissues. MRE generates quantitative measurements and colorized spatial maps of shear wave displacement. The initial wave images are processed to generate an elastogram, which displays the quantitative values of the shear modulus of tissues on a color coded spatial map. MRE has been used to evaluate liver fibrosis which shows higher stiffness than normal liver parenchyma. It is possible that MRE can be used to monitor patients with underlying liver disease to establish disease stability, progression, or response to therapy. In order to use MRE in these clinical settings the reproducibility of MRE measurements of liver stiffness needs to be established.

Materials and Methods: Fifty-five patients were underwent serial MRE on different dates. The median time interval between MRE was 3 months (range 0.5 – 12months). MRE was performed on a 1.5T GE HDx or MR 450 scanner using a 19-cm diameter 1.5-cm thick cylindrical passive driver placed against the abdominal and chest wall overlying the liver at the level of the xiphoid process of the sternum. The passive driver was held in place with an abdominal binder. Continuous acoustic vibration at 60 Hz was transmitted from an active driver to the passive driver through a flexible vinyl tube. The propagating shear waves were imaged with a modified phase contrast, gradient-echo sequence for collection of axial wave images. MRE sequence parameters included TR 50 ms, TE 24.6 ms, bandwidth 31.25 kHz, flip angle 30 degrees, matrix size 256x64, and slice thickness 10 mm, gap 1 mm. Four axial MRE slices were obtained each requiring a single 20 second breath hold. MR Elastogram was generated by processing the acquired wave image to produce a quantitative map of tissue shear stiffness measured in kilopascals. Mean shear stiffness of liver parenchyma was calculated by manually drawing a region of interest (ROI) over the liver on each slice. The average mean liver stiffness was recorded for each patient. All measurements of mean liver stiffness were made by one radiologist. For each patient the measurements of mean liver stiffness were compared by calculating the percent change in measurements between exams.

Results: The mean liver stiffness for all examinations was 5.2 kPa (range 1.7 – 11.0). On MRE the mean liver stiffness was normal in 15 patients. Mean liver stiffness was mildly elevated (3-4 kPa) in 8 patients, moderately elevated (4.1-6 kPa) in 12 patients and markedly elevated (>6 kPa) in 20 patients. Overall the percent change in measured liver stiffness on serial MRE examinations was 12% (range 0% - 48%. In two patients improper placement of the MRE driver led to inadequate shear waves within the liver. After excluding these two patients with technical problems the percent change in MRE measurement of liver stiffness was 11% (range 0 % - 29%). For patients with normal liver stiffness the mean percent change in serial measurements was 9%. For patients with mildly increased liver stiffness the percent change in serial measurements was 8%, compared to 10% for those patients with moderately increased stiffness, and 11% for those patients with markedly increased liver stiffness. Reproducibility of MRE measurements was similar for the HDx and MR 450 1.5T scanners which showed 7% and 11% difference in mean liver stiffness respectively. Nineteen patients who underwent serial MRE on the HDx followed by the MR450 scanner also showed an 11% difference in mean liver stiffness.

Conclusions: MR Elastography is a robust technique with measurements of liver stiffness that are highly reproducible on serial examinations in the same patient. Reproducibility of measurements was independent of the degree of liver stiffness and of the type of 1.5T GE MR scanner used for data acquisition. Attention to close apposition of the MRE driver to the abdominal wall using an elastic abdominal binder is essential for generating effective shear waves within the liver. These results will be important in establishing the use of MRE to monitor disease progression or response of liver fibrosis to future therapies.

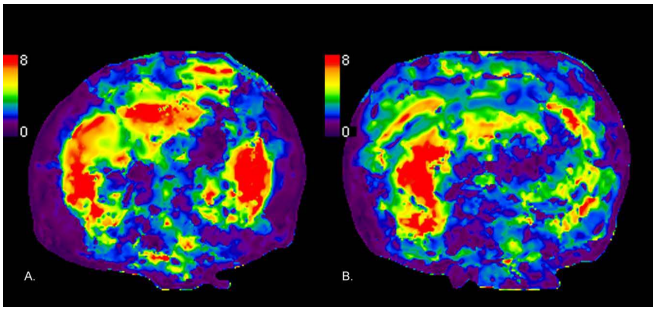

Figure 1: 55 year old man with history of cirrhosis. MRE (A) performed in September 2009 shows mean liver stiffness 5.9 kPa. Follow up MRE (B) performed in February 2010 shows mean liver stiffness 5.3 kPa.

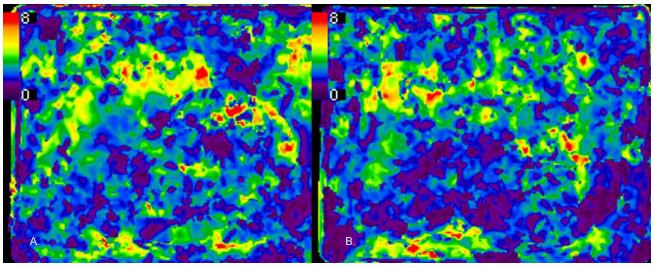

Figure 2: 53 year old man with Hepatitis C. MRE (A) performed in June 2010 shows mean liver stiffness measuring 3.13 kPa. Follow up MRE (B) performed in October 210 shows a mean liver stiffness measuring 3.15kPa.

References: [1] Rouvière O, et al. MR Elastography of the Liver: Preliminary Results. Radiology 2006;240:440-448.
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