Purpose: To compare mean shear hepatic stiffness calculations using a new inversion algorithm and confidence threshold mask.

Introduction: Chronic liver disease, regardless of etiology, can be associated with liver fibrosis and its resultant complications, including cirrhosis, sequelae of portal hypertension, and hepatocellular carcinoma (1). The current gold standard to detect and stage liver fibrosis remains liver biopsy, a relatively painful and invasive technique. Significant complications, defined as requiring hospital admission or prolonged hospital stay, occurs in 1–5% of patients with a mortality rate of between 1:1,000 and 1:10,000 (2-3). In addition, the liver biopsy is prone to sampling error because only 1:50,000 of the organ is sampled. These issues bring forth a need for an efficacious but noninvasive alternative. Magnetic resonance elastography (MRE) is emerging technology that takes advantage of the differences in propagation of shear acoustic waves in normal and diseased tissue to quantify liver stiffness. The mechanical properties of liver tissue (its elasticity or stiffness) have been shown to strongly correlate with fibrosis (4-8). However, the introduction of a newer inversion algorithm (multi-model direct inversion; MMDI), which has improved resolution and processing time compared to the older algorithm (multi-scale direct inversion; MSDI), and a confidence threshold mask (localizing valid hepatic regions for stiffness calculation) may require modification of currently suggested cut-off values for discriminating normal from diseased liver and individual histologic liver fibrosis stages. The purpose of this study is to compare calculated mean shear hepatic stiffness calculations between the two inversions algorithms and assess inter- & intraobserver variability between two measurement techniques (ie, confidence threshold mask versus free-hand ROI).

Materials and Methods: Following Institutional Review Board approval, MRE was performed on 49 patients (25 w/chronic liver disease; 24 healthy liver transplant donors). Via a pneumatic compression driver positioned over the liver, shear waves were propagated and then imaged using a modified phase contrast MR sequence. This was quantified in an image called an elastogram, created using a direct inversion algorithm. MRE data was processed twice, once with the current (MSDI) and once with the new inversion algorithm (MMDI). Mean shear hepatic stiffness values in kilopascals (kPa) were then calculated using an average of four measurements, creating the following datasets: a) Observer 1: free-hand ROI using old algorithm (MSDI); b) Observer 2: free-hand ROI using MSDI; c) data set #2 repeated 2 weeks later; d) Observer 2: threshold mask using MMDI; e) data set #4 repeated 2 weeks later; f) Observer 2: same threshold mask defined area placed on MSDI & MMDI inversion algorithms. Intraclass correlation coefficient (ICC) was calculated to assess inter-/intra- observer variability.

Results: Mean/Median/StdDev (kPa) for dataset: a) 3.42/4.14/1.74; b) 3.64/3.02/1.39; c) 3.75/3.16/1.32; d) 3.63/3.15/1.44; e) 63/3/05/1.44; f) 3.95/3.32/1.55 (MSDI) vs 3.63/3.15/1.44 (MMDI). Average stiffness difference between old (MSDI) and new (MMDI) inversion algorithm using standardized threshold mask method was 0.35 kPa (9%). There was less intraobserver variability [ICC = 0.98 (95% CI: 0.96-0.99)] as compared to interobserver variability [ICC = 0.92 (95% CI: 0.86-0.96)]. In addition, there was less variance on repeat assessment with using the confidence mask [ICC = 0.995 (95% CI: 0.991-0.997)] versus the free-hand ROI technique, either with calculations performed by the same observer [ICC = 0.98 (95% CI: 0.96-0.99)] or a different observer [ICC = 0.92 (95% CI: 0.86-0.96)].

Conclusion: The use of the confidence mask reduces calculated mean shear hepatic stiffness variability, which impacts MRE’s use for evaluating therapy response and longitudinal assessment of chronic liver disease. Average kPa variance between the old (MSDI) and new (MMDI) inversion algorithms is 9%.

References:

Figure 1. (A) MR Elastography anatomy image; (B) color stiffness map with superimposed confidence mask; (C) elastogram (old algorithm: MSDI), and (D) elastogram (new algorithm: MMDI). A freehand ROI drawn on the anatomy image, avoiding the liver periphery and large vessels (A; orange dashed line) was used to generate data sets “a-c.” The confidence mask, highlighting valid regions with adequate SNR (B; white dashed line), was used to generate data sets “d-f.” Both drawn ROI’s were pasted onto the elastogram image processed with MSDI (C; orange & white dashed line) to calculate shear hepatic stiffness in kilopascals (kPa). Pasted ROI (as defined by the confidence map in fig B) was also placed on the elastogram image processed with MMDI (D; white dashed line).