Utilizing Magnetic Resonance Elastography in the Evaluation of Liver Donors

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Purpose: To determine accurate biopsy-validated Magnetic Resonance Elastography threshold values that distinguish normal from abnormal liver (due to fibrosis and/or inflammation). We focus specifically on pre-operative evaluation of liver donors prior to transplant.

Introduction: The need for living donor transplants has increased significantly over the past 10 years due to a shortage of cadaveric organs[1]. Donor livers must be carefully screened prior to surgery, for the presence of both fibrosis and inflammation (such as steatohepatitis), which result in poor post-transplant outcomes[5]. Identifying the presence of either condition in donor livers precludes transplant candidacy. Accurate pre-transplant diagnosis is paramount, so as to avoid unnecessary operative risks, high medical costs, and patient morbidity associated with poor post-transplant outcomes. However, the presence of significant disease may otherwise be occult on all current noninvasive tests. As such, liver biopsy currently holds a central role in the screening process, as the diagnostic gold standard. Unfortunately, liver biopsy has several important disadvantages which include: 1) potential life-threatening complications such as hemorrhage and infection, 2) associated medical costs, and 3) risk of sampling error that may lower diagnostic accuracy[4]. These issues bring forth a need for an efficacious but noninvasive exam. Magnetic Resonance Elastography (MRE) is currently utilized for noninvasive characterization of liver fibrosis. Prior studies have demonstrated significant differences between fibrosis and normal livers[2]. However, the clinical utility of MRE in accurately diagnosing liver inflammation has not been studied. A previous study in animal models suggests that MRE values are higher in liver inflammation compared with normal liver, but this has not been confirmed in human subjects[3]. Our study evaluates the correlation of MRE values with biopsy diagnosis of normal liver or liver inflammation in human subjects, in hopes of establishing clinically useful thresholds as a non-invasive alternative for accurate pre-transplant diagnosis.

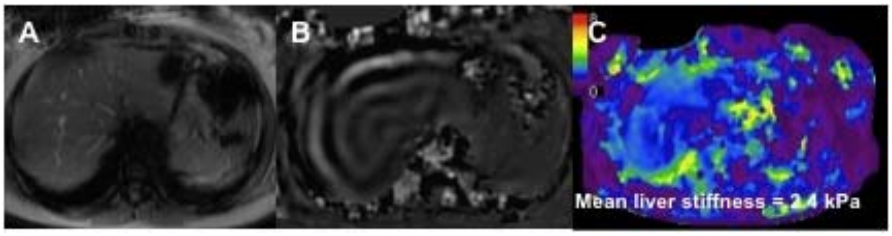

Fig 1: Normal Liver. Anatomy image (a) shows normal hepatic contour. Wave image (b) shows thin, narrowly-spaced waves propagating through the liver. Elastogram (c) shows the color of stiffness towards the normal end (i.e. blue)

Materials and Methods: Following Institutional Review Board approval, we recruited 22 patients undergoing pre-operative evaluation as potential liver donors. All patients underwent MR elastography and a liver biopsy as a part of the donor evaluation criteria. 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 an inversion recovery algorithm. MRE was performed on all patients on the same day or within 1-2 days pre or post biopsy. Mean hepatic shear stiffness in kilopascals (kPa) was obtained for each donor via an average of two measurements from the MR elastogram. A large region of interest was utilized to include the majority of the liver, excluding visible large vessels. Quantitative analysis of the data was performed on a GE AW workstation. Mean hepatic shear stiffness was then compared with the biopsy results. Biopsy results were categorized as either 1) normal or 2) inflammation. A Receiver operator characteristic (ROC) curve was calculated to assess test accuracy. Multiple threshold values were also interrogated to determine the MRE cut-off that yielded the highest accuracy (as determined as the average of sensitivity and specificity) to distinguish normal from inflammatory liver. Normal and inflammatory group mean MRE values were also compared with a t-test ($p < 0.05$).

Results: Out of 22 patients, 16 donors had a normal liver biopsy while 6 had findings of inflammation. Abnormal findings associated with inflammation included steatohepatitis (n= 3) and presence of lipogranulomata (n=3). No biopsies contained liver fibrosis. A threshold value of greater than or equal to 2.6 kPa diagnosed the presence of inflammation with sensitivity of 100%, specificity of 87.5%, and overall accuracy 93.8% (95% confidence intervals from 61.7% to 98.4%). Area under the curve (AUC) was 0.97. Inflammatory liver values (mean=3.28) were significantly higher than normal liver (mean=2.15) ($p < 0.0001$).

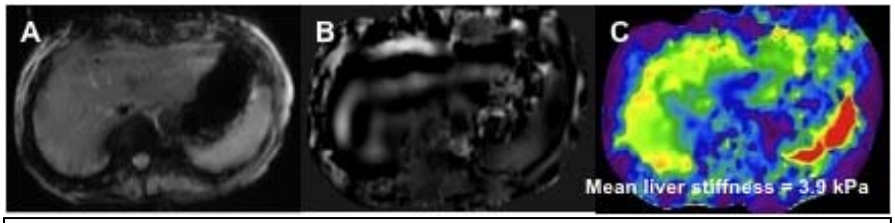

Fig 2: Abnormal Liver. Anatomy image (a) shows normal hepatic contour. Wave image (b) shows thick, relatively widely-spaced waves propagating through the liver. Elastogram (c) shows the color of stiffness is elevated towards the stiffer end of the spectrum (ie, predominantly green).

Conclusion: Our results demonstrate the utility of MRE to non-invasively and accurately differentiate normal from inflammatory liver, and suggest that MRE may provide a screening technique to stratify potential donors for possible subsequent biopsy. Further studies are ongoing to confirm results in a larger patient population.

References:

1) Liver Transplantation 2000; 6 (1) issue 1, 3-20
2) Radiology August 2006; 240:440-448
3) Radiology October 2009; 253:90- 97
4) Radiology October 2009; 253:1
5) Liver Transplantation 2002; 8(10) 174-188