

Noninvasive Liver Stiffness Assessment with Tagged MRI in Cirrhotic Patients with Child-Pugh scores

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Introduction: Liver fibrosis is an important prognostic factor in patients with liver disease, and its assessment can be used to guide therapy. It is known to result in increased mechanical stiffness, so that the assessment of liver stiffness is a key feature of current noninvasive approaches, for example, by detecting the motion of the liver with ultrasound or MRI [1-3]. In our previous study [3], we described a new noninvasive approach for the assessment of liver stiffness by using magnetization-tagged MRI (tMRI) [4] to measure the cardiac-induced motion and deformation in the liver. In this work, we applied our method to 45 cirrhotic patients with Child-Pugh scores.

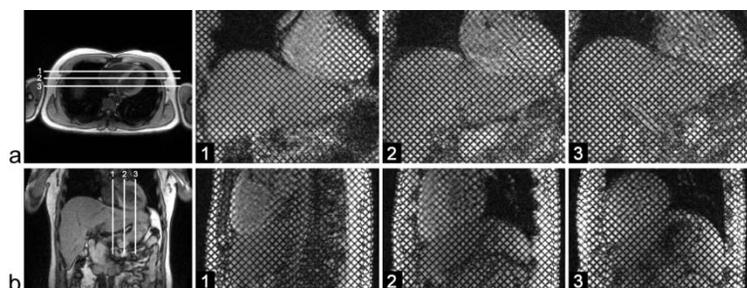


Figure 1. a: Axial localizer image with the three coronal imaging planes (white lines), and corresponding grid-tagged images. b: Coronal localizer image with the three sagittal imaging planes (white lines), and corresponding grid-tagged images.

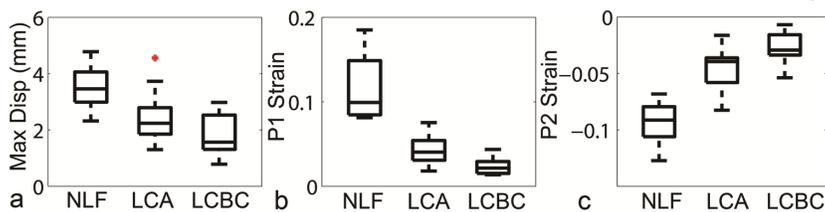


Figure 2. Boxplots for a: Max Disp, b: P1 strain and c: P2 strain ($p < 0.001$ for all).

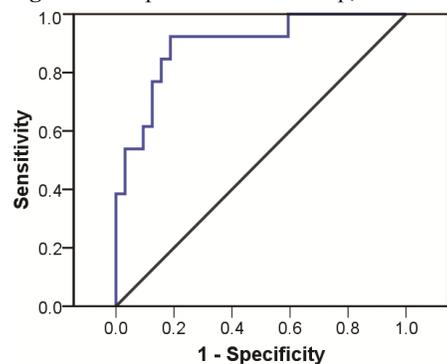


Figure 3. ROC curve between LCA and LCBC.

stiffness in cirrhotics with Child-Pugh scores. It showed a high sensitivity (92%) and specificity (81%) for distinguishing between LCA and LCBC groups. Future work should include age-matched comparison between controls and patients.

References: [1] M. Tristan, et al., *Ultrasound Med Biol.* 1986; [2] Y. Mariappan, et al., *MRM.* 2009; [3] S. Chung, et al., *MRM.* 2010; [4] L. Axel and L. Dougherty, *Radiology.* 1989; [5] S. Chung, et al., *Proc. ISMRM.* 2007;

Method: Cardiac tMRI was performed on 8 healthy volunteers with normal liver function (NLF) (30 ± 5 years old) and 45 patients (60 ± 10 years old) with MRI evidence of cirrhosis. Patients were classified into 2 groups as follows: liver cirrhosis with Child-Pugh A (LCA; $n = 32$) and liver cirrhosis with Child-Pugh B and C (LCBC; $n = 11$ and 2 , respectively). Subjects were scanned using a 3T MRI system (Tim Trio; Siemens) with breath-holding by the subjects. Tagged MR images were acquired in 3 coronal and 3 sagittal planes encompassing both the liver and the heart, as shown in Fig. 1. A Gabor filter bank [5] was used to calculate the displacement and strains within the liver. The local maximum P1 and minimum P2 strains as well as the maximum displacement (mm) (Max Disp) were found over the cardiac cycle within the regions of interest chosen in liver regions below the diaphragm where the greatest average value occurred. Receiver operating characteristics

(ROC) and multivariate discriminant analysis for Child A and Child BC patient groups were calculated.

Results: In Fig. 2, the boxplots show statistically significant differences in the Max Disp, P1 and P2 strains among groups (Mean \pm SD; Max disp 3.5 ± 0.8 , 2.4 ± 0.7 , 1.9 ± 0.8 ; P1 strain 0.1 ± 0.04 , 0.04 ± 0.01 , 0.02 ± 0.01 ; P2 strain -0.09 ± 0.02 , -0.05 ± 0.02 , -0.03 ± 0.01 ; NLF, LCA, LCBC, respectively; $p < 0.001$ for all). Figure 3 shows the ROC curve between LCA and LCBC. The area under the curve was 0.897 ± 0.052 (sensitivity 92%, specificity 81%; $p < 0.001$).

Discussion: This study used a noninvasive quantitative approach, using tMRI to measure cardiac-induced motion and deformation in the liver, to assess liver