Tagged MRI of the Liver in the Diagnosis of Liver Cirrhosis, preliminary study.
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Introduction: Hepatic fibrosis results in increased mechanical stiffness, and assessment of this stiffness is a key feature of current noninvasive approaches, such as ultrasound elastography and phase contrast based Magnetic Resonance (MR) elastography [1-3]. Both of these existing approaches, however, have several limitations. These include limited evaluation of the right lobe of the liver only, as well as detrimental adverse effects in the presence of iron deposition, ascites and high body mass index. Magnetization tagged MRI (tag-MRI) measures tissue strain. Strain is a description of deformation in terms of relative displacement of pixels within the body. Strain is dimensionless and is usually expressed as a percentage. When measuring axial strain, this percentage represents the change in length of an object compared to its original length. The tag-MRI technique is routinely used to quantify myocardial muscle contractility by measuring myocardial strain after application of tags. Tissue strain and stiffness are inversely proportional in that the stiffer a tissue is, the less deformable it becomes. The principal strain represents the amount of the greatest elongation or stretch of the tissue at a given location [4]. Since the liver becomes increasingly stiffer as chronic liver disease progresses, increments in liver stiffness should be reflected by changes in liver strain, which can be quantified using tag-MRI [5]. The motion of the heart lying immediately adjacent to the left lobe of the liver, a well-known source of motion artifacts during MRI acquisitions, is known to induce liver deformation. We hypothesize that liver deformation due to transmitted cardiac pulsations can be detected and quantified by tag-MRI and subsequently be used to indirectly quantify liver stiffness. The purpose of this study is to measure the average, maximal, and cardiac corrected liver parenchyma strain using tag-MRI in segment II of the liver and to determine whether there are significant differences in cardiac-induced liver strain in normal livers and livers with MRI evidence of advanced cirrhosis.

Methods: 10 subjects with history of chronic liver disease (CLD) and 8 subjects with no history of CLD were included in this study. The clinical diagnosis of cirrhosis was used to include the patients in the CLD. Seven patients were Child Pugh class A cirrhotic and three patients were class B. The subjects with CLD had liver cirrhosis secondary to chronic viral hepatitis C (n = 4), alcoholic hepatitis (n = 3), chronic viral hepatitis B (n = 1), hemochromatosis (n = 1), alcohol + chronic viral hepatitis C (n = 1). None of the patient had known history of cardiac disease. MR imaging of the liver was performed using a 1.5 T clinical system using a phased-array coil. All patients were examined in supine position and had a peripheral pulse detector placed on the third finger of the left hand. A peripheral pulse-gated (PPG) conventional cardiac tagged MRI sequence was acquired. Images were obtained throughout the cardiac cycle (tagging at end-diastole) using a fast gradient-echo (FIGGE) imaging, however is exploited by the tag-MRI technique to measure liver strain. In this study, we compared advanced cirrhotic livers to normal livers. Unlike phase contrast elastography techniques, this did not limit strain measurement as tagged MRI is based on short echo T1 weighted sequences, which are less affected by iron deposition than are phase contrast sequences. Furthermore, strain measurements do not rely on direct signal quantification, but instead on tag tracking and analysis, which is not as affected by signal intensity changes. This is a main difference between tag MRI and phase contrast based elastography, where iron overload can lead to insufficient signal and poor quantification [30]. Hepatic iron overload is typical in patients with primary hemochromatosis, and often seen in lesser severity in patients with cirrhosis of other etiologies. Since the strain is approximately four-fold different, with no overlap in measured values, we speculate that this technique can potentially be used to stratify intermediate grades of liver fibrosis.

Results: See table.

Discussion: In this study we demonstrated that tag MRI can be used to differentiate normal from cirrhotic liver. Three different strain measurements (maximum strain, average strain, and corrected strain gradient) were able to differentiate between normal and cirrhotic livers. We also demonstrated that magnetization tagged MRI can to quantify cardiac induced liver strain. The inferior wall of the left ventricle lies in contact with the diaphragm, just above segment II of the liver. This contiguity is common source of motion artifact in liver MR imaging, however is exploited by the tag-MRI technique to measure liver strain. In this study, we compared advanced cirrhotic livers to normal livers. Unlike phase contrast elastography techniques, this did not limit strain measurement as tagged MRI is based on short echo T1 weighted sequences, which are less affected by iron deposition than are phase contrast sequences. Furthermore, strain measurements do not rely on direct signal quantification, but instead on tag tracking and analysis, which is not as affected by signal intensity changes. This is a main difference between tag MRI and phase contrast based elastography, where iron overload can lead to insufficient signal and poor quantification [30]. Hepatic iron overload is typical in patients with primary hemochromatosis, and often seen in lesser severity in patients with cirrhosis of other etiologies. Since the strain is approximately four-fold different, with no overlap in measured values, we speculate that this technique can potentially be used to stratify intermediate grades of liver fibrosis.