Dynamic whole-liver imaging using a spiral acquisition technique: feasibility and initial results in assessment of liver fibrosis

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Introduction Dynamic contrast enhancement MRI (DCE-MRI) techniques require high temporal resolution and strong signal-to-noise imaging ratios. These techniques can be limited when attempting to image an entire, large organ. In this study, we assess the feasibility in the use of a spiral acquisition technique for dynamic imaging of the whole liver using a liver-specific contrast agent in the assessment of liver fibrosis. A spiral acquisition was chosen because it allows imaging of the whole liver in a short breath-hold while maintaining adequate resolution and SNR without the use of parallel imaging. Combined with a golden ratio based view order and sliding window reconstruction, a high temporal update rate can be achieved, significantly increasing the ability to observe the various enhancement sub-phases in the liver. Liver fibrosis is an exaggerated wound healing process that can progress to cirrhosis, and liver failure, and is the 7th leading cause of death in the United States. Liver biopsy remains the clinical standard for quantifying fibrosis, despite the problems with sampling error if fibrosis is patchy. Because fibrosis is considered a disease of the whole organ, there is a need for a whole-liver imaging technique that can characterize the degree of disease progression. Gd-EOB-DTPA is an MRI contrast agent unique due to its significant hepatocyte uptake (50% excretion through bile in healthy subjects). We hypothesize that the spiral acquisition technique has sufficient temporal resolution and signal to characterize the enhancement curves in normal and diseased subjects.

Methods IRB approval was obtained. Normal and diseased subjects were prospectively recruited. Images were acquired using a 3D spiral sequence with the following parameters: TR/TE=5.6ms/0.4ms, 856 sampling points per spiral leaf, 48 leaves, 256x256x24 acquisition matrix, 40cm FOV, 8mm slice thickness, readout bandwidth ±125kHz, spectrally selective fat saturation, partial slice encoding factor of 0.7 and a golden ratio base view order. Starting at 10 seconds post a 1cc/s injection of contrast at standard dose, 3 acquisitions were performed in approximately the first minute, each with a 16s breath-hold, followed by a single acquisition every minute for 20 minutes. Transmit and receive gain and shimming parameters were kept constant for all scans post injection. Each of the three acquisitions immediately after injection were reconstructed into five phases using a sliding window reconstruction, resulting in a temporal update rate of 2 seconds. In total, 34 3D volumes were acquired and processed for further analysis. The Brix 2-compartment pharmacokinetic model was used to analyze the DCE-MRI uptake curves. The model contains the parameters: A(signal amplitude), kep(exchange rate between plasma and extravascular extracellular space (EES) in min-1), and kel(elimination rate in min-1). A single time intensity curve of the entire liver was obtained in each subject. Analysis software was written in-house using IDL 8.1(Excelis Visual, Boulder,CO) to fit the time intensity curves.

Results Enhancement curves in the two populations are shown in Figure 1. Signal intensity ratios are of the entire liver. Curves shown are fits of datapoints to the Brix model, and demonstrate differences in the two populations that are increasingly pronounced on delayed imaging. The normal subject liver demonstrates a progressive rise in concentration of contrast agent, while the diseased liver demonstrates a plateau. Figures 2 and 3 are single, delayed images in a normal subject and in a subject with biopsy-proven cirrhosis. A trained radiologist (K.J.) documented no evidence of cirrhosis in either case based on the morphologic appearance of the liver.
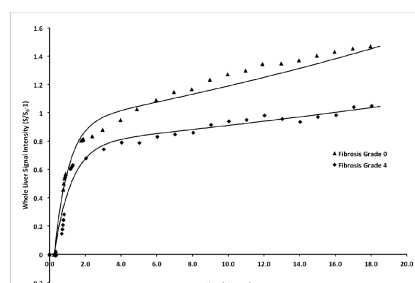

Figure 1. Data points show signal intensity ratios of the entire liver over time post contrast in a normal subject (grade 0), and in a subject with cirrhosis (grade 4). Curves are fits to the Brix 2-compartment pharmacokinetic model.

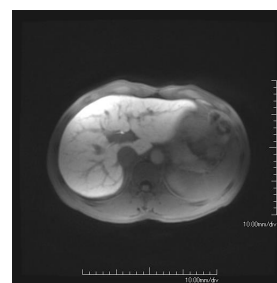**Figure 2**. 20 min post contrast image in normal subject

Figure 3. 20 min post contrast image in diseased subject

Conclusion This feasibility study demonstrates that the spiral acquisition technique provides sufficient temporal resolution and signal to enable dynamic contrast enhancement imaging of the whole liver. Early data demonstrates that utilizing a liver-specific contrast agent, differences in enhancement curves can be observed between normal and cirrhotic subjects, and which may provide a greater ability to discriminate the two populations than the morphologic appearance of the liver on MRI. The results are in concordance with related studies, but which have used a limited number of liver slices or different contrast agent. The ability to assess the entire organ potentially negates the risk of sampling errors, and makes this technique worthy of further exploration. This data is part of an ongoing study in which additional normal and diseased subjects are being recruited.

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