Initial Experiments with Spiral MR maging of the Liver

B. E. Chapman[1], K. Gurleyik[1]

[1]Radiology, University of Pittsburgh, Pittsburgh, PA, United States

Introduction

Imaging the cirrhotic liver is an important radiological issue as the incidence of liver disease increases world-wide. Many important findings, such as early stage hepatocellular carcinomas (HCC), are very subtle and difficult to visualize. Rapid imaging of the liver would facilitate quantitative imaging techniques that have shown promise in other organ systems, notably the brain. However, MR imaging of the liver is challenging due to respiratory motion and field inhomogeneities. Spiral imaging is a potentially favorable technique for imaging the liver due to its rapid nature and oversampling of the center of k-space. However, spiral imaging may be excessively sensitive to off-resonance effects (Meyer CH, et al. MRM 28, 202-213; 1992). In order to explore the suitability of spiral imaging for assessing the liver, we have performed some preliminary experiments to map out feasible imaging parameters for a breath-hold limited sequence. Parameters we have examined include matrix size, number of interleaves, and echo time.

Methods

All imaging was performed on a GE 1.5T Signa scanner equipped with high performance gradients (40 mT/m peak gradient, 150 T/m/s slew rate). Spiral imaging sequences were generated using customized pulse programs. We imaged the same individual using a multi-slice 2D spiral technique. The body coil was used to both transmit and receive. We examined grid sizes of 128 and 256 and considered interleaves of 1, 4, 8, and 16. Images were acquired with TE=4.7 ms, TR=600 ms and a 90 degree flip angle. Ten 5 mm slices were obtained in a multislice manner. Acquisition time ranged from approximately 1 second for the single shot to 5 seconds for the 16 interleaves. (Multiple time frames were acquired for each image, so we report roughly the time required to obtain one time frame.)

Results

Example images acquired using a 128 matrix are shown in FIG. 1 with 1, 4, 8, and 16 interleaves. An example plot of edge sharpness is shown in FIG. 2. The single-shot spiral shows a significant amount of blurring. However, with only 4 interleaves image sharpness is obtained at a reasonable level, and 8 and 16 interleaves primarily show an improvement in signal-to-noise ratio (SNR). Example images for 256 matrix acquisitions are shown in FIG. 3 for 8 and 16 interleaves. The corresponding edge profiles are shown in Fig. 4, where it is apparent that even with 16 interleaves the acquisition has insufficient SNR. Because we were concerned about SNR and also because we wanted shorter TR values for T1 weighting, we ran a 3D technique for comparison. The images were obtained on a separate volunteer using a 3D stack of spirals. A 10 cm slab thickness was excited, and 20 slice-encodes were used to match the 5 mm sliced thickness of the 2D acquisition. TE was increased to 20 ms and TR was decreased to 50 ms. Other imaging parameters were similar: 5 mm slices, 128 in-plane matrix and 16 interleaves. An example image is shown in Fig. 5.

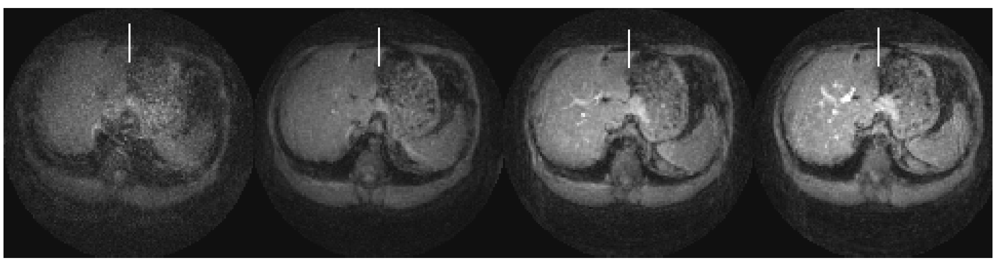

Fig. 1. Spiral acquisitions through the liver acquired with a 128 matrix. Moving from left to right the number of interleaves acquired for each image were 1, 4, 8, and 16. The bright line marks the sampling locations used to generate Fig. 2.

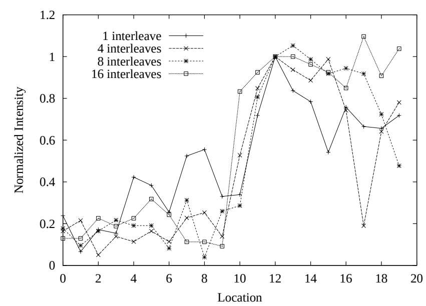

Fig. 2. Normalized intensity profiles for liver boundary. The single shot spiral shows a clearly degraded edge profile. However, even the 4 shot spiral seems to have obtained sufficient edge sharpness.

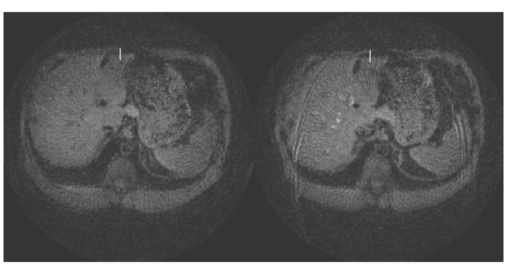

Fig. 3. Spiral acquisitions through the liver acquired at 1.5T with 256 matrix. Image on the left used 8 interleaves. Image on the right used 16.

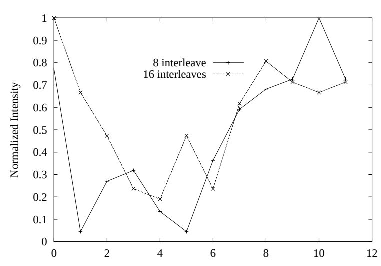

Fig. 4. Edge profiles for 256 matrix images. Both 8 and 16 interleaves showed similar edge sharpness.

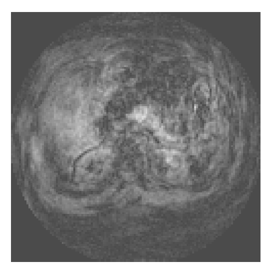

Fig. 5. Example image acquired with longer TE (20 ms) and a 3D stack of spiral technique.

Discussion

We have obtained preliminary spiral images of the liver. The spiral images can be obtained quite rapidly. If a modest number of interleaves are used with a short TE, it is apparent that high quality images can be obtained very rapidly. Sensitivity to off-resonant effects was observed, and a dramatic improvement in image quality was observed when TE was kept short. If acquisitions require a longer TE, a corresponding increase in the number of interleaves used might be needed to reduce the off-resonance effects. Similar experiments performed on a 3.0T system indicate the extreme sensitivity to off-resonance effects and the need to maintain both short TE and a larger number of interleaves. Still, acquisition times were short enough that high quality breath-hold images should be obtainable.