Characterization of liver neoplasms with a fast radial-FSE imaging technique.

N. G. Knowles[1], E. K. Outwater[2], and M. I. Altbach[2]

[1]Department of Radiology, University of Arizona, Tucson, Arizona, United States, [2]Department of Radiology, University or Arizona, Tucson, Arizona, United States

Introduction: T2 weighted magnetic resonance imaging is used clinically to differentiate malignant liver lesions from benign lesions such as cysts and hemangiomas. Currently, radiologists use visual methods to characterize the T2 characteristics of a given lesion based on its intensities on moderately and heavily T2-weighted images. However, it has been demonstrated that quantitative methods for measuring T2 values are superior to visual evaluation for the characterization of liver lesions [1-4]. Each of the proposed methods for measuring T2 values in the body has at least one of the following problems: long imaging times, motion-induced errors, misregistration of images acquired in different breath holds, low spatial resolution and/or low number of measured points on the T2 relaxation curve. A novel method for imaging the upper abdomen with multi-shot radial fast spin echo (FSE) overcomes the above limitations for quantitative T2 imaging. The method provides high spatial resolution, motion insensitive images, and T2 mapping based on the fast acquisition of a single data set [5,6]. The method is fast and convenient enough to easily be applied to clinical practice. In this study we present the results of the radial FSE method for the characterization of liver lesions in a group of 28 patients.

Technique: With radial MRI every line of data samples the center of k-space. The technique is robust to motion because the effects of motion are distributed along two dimensions instead of accumulating along a single dimension as occurs with conventional Cartesian filling of k-space. This results in less blurring and fewer ghosting artifacts. In addition, with radial imaging, there is a higher density of sampled points in the center of k space than with Cartesian methods. This allows averaging of the data at the center of k space, reducing phase errors due to motion and providing excellent spatial resolution. Because of the method's robustness to motion, a small amount of diffusion weighting can be incorporated to suppress bright signal from blood vessels within the liver which increases lesion conspicuity.

In radial FSE, the central part of k-space has data from all acquired TEs. Images at various T2-weighted contrast can be generated by partitioning a full radial k-space data set into subsets that have in the center only the data from lines acquired at a specific TE (i.e., TE_{eff}) with data at other TEs being added progressively in successive tiers as shown in Fig. 1. The radius on each tier of data satisfies the Nyquist criteria. In this manner, high-resolution images at various TE_{eff} values are obtained from a single radial FSE k-space data set [5-7]. T2 maps are then calculated from the TE_{eff} images by fitting the pixel intensities on each image to a single exponential curve. With this method T2 maps are obtained from data acquired in a breath hold. The method has the added benefit that T2 values are calculated from 8-16 TE_{eff} values, something that would be extremely time-consuming with conventional T2 imaging.

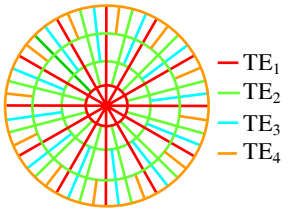

Fig. 1. Partial radial FSE k-space data sets with T2-weighted contrast corresponding to TE_{eff}=TE_1.

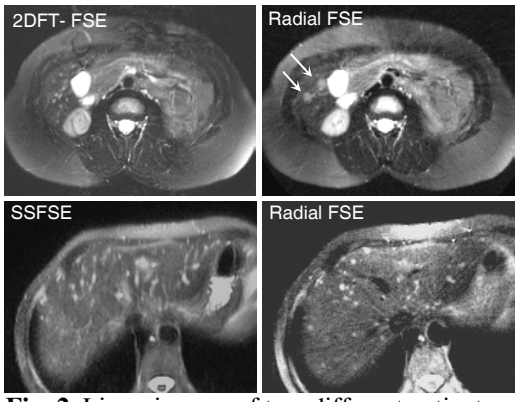

Fig. 2. Liver images of two different patients with metastatic lesions

Methods: Data for 28 patients was acquired. Written consent was obtained according to University Arizona IRB regulations. Radial FSE data was acquired with ETL=16, 192-256 radial lines, TR=2000-1500 ms and NEX=1. Small diffusion gradients (b=1.2 s/mm2) were used to improve flow suppression. With these imaging parameters, 6-7 slices were acquire in one breath hold. T2 data for 43 liver neoplasms (24 primary and metastatic malignancies, 6 hemangiomas and 13 cysts) were obtained using the method described in [6].

Results: The advantages of radial FSE over conventional T2-weighted methods for abdominal images are illustrated in Fig. 2. In Fig. 2 (*top*) the two metastatic lesions (arrows) are only seen in the image acquired with radial FSE and not in the image acquired with the conventional FSE (2DFT-FSE) method. In the latter, flow artifacts completely mask these two lesions. Radial FSE is also superior to the conventional single shot FSE (SSFSE) method (Fig. 2, *bottom*). In the image acquired with SSFSE, blurriness and the bright signal from blood vessels reduce the conspicuity of the lesions. The radial FSE image has higher resolution, and flow is suppressed via diffusion. Thus lesions are easily visualized. It should be pointed out that the lesions in Fig. 2 (*bottom*) are very small (< 0.3 cm^2). More importantly, our results on 43 liver neoplasms show that the T2 values obtained with radial FSE discriminate malignancies (**M**) from hemangiomas (**H**) and cysts (**C**) with no overlap for benign and malignant lesions (Fig. 3).

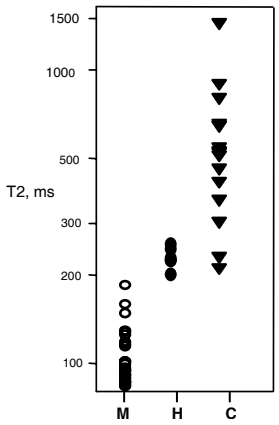

Fig. 3. T2 values of malignancies (**M**), hemangiomas (**H**), and cysts (**C**).

Conclusion: In this work we demonstrate that radial FSE techniques overcome most of the problems associated with the current clinically used T2 weighted sequences for the evaluation of the upper abdomen. Radial FSE is more robust to motion, provides better spatial resolution and can provide quantitative T2 mapping, all from a data set obtained in a single breath hold. This novel method is fast and may prove to be a very valuable tool for the clinician in the detection and characterization of liver neoplasms.

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References: [1] Goldberg MA *Am J Roentgenol*. 160:1011, 1993. [2] Olcott EW *JMRI*. 9:81, 1999. [3] Cieszanowski A *Eur Radiol*. 12:2273, 2002. [4] Kim YH *J Comput Assist Tomogr*. 29:571, 2005. [5] Altbach MI *JMRI*. 16:179, 2002. [6] Altbach MI, *MRM* 54:549, 2005. [7] Song HK *MRM*, 44:825, 2000.