Novel Radial MRI Technique for Obtaining High Resolution Black Blood Images of the Heart with and without Fat Suppression from a Single k-space Data Set

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Abstract: A double inversion radial MRI method has been designed to acquire data with and without fat suppression within a single k-space data set. Data is then post-processed to produce high resolution images of the heart with and without fat suppression. The method produces these two images from data acquired in a breath hold. With this novel technique the imaging time is reduced and there is no misregistration between the fat-suppressed and non fat-suppressed images.

Introduction: Arrythmogenic right ventricular dysplasia (ARVD) is a condition characterized by progressive lipid infiltration in the right ventricular free wall leading to ventricular malfunction and death. Black blood MRI techniques are often used for the non-invasive detection of lipid infiltration in ARVD. The detection of lipid infiltration in the right ventricular free wall, however, is a challenging problem. Techniques require high resolution because the right ventricular free wall is only 3-4 mm thick. Ideally data with and without fat suppression need to be obtained in a single breath hold to avoid misregistration between the fat-suppressed and non fat-suppressed images. In this work, we introduce a novel radial MRI method for obtaining high resolution images of the heart with and without fat suppression from a single k-space data set. The technique produces high-resolution images without misregistration between the fat-suppressed and non fat-suppressed images.

Methods: The method presented here consists of a double inversion (DBIR) preparatory period, for suppressing signal from flow[1], followed by a radial fast spin echo (RAD-FSE) pulse sequence to minimize artifacts due to residual flow and motion[2]. DBIR RADFSE was implemented on a 1.5T GE Signa NV-CV/i MRI scanner equipped with 40 mT/m gradients. A four-element phase-array torso coil was used for signal detection. Data were acquired with cardiac gating in a breath hold, using an echo-train length of 16, 160 radial views, a TR=2R-R, and NEX=1. A chemical shift fat suppression pulse was used on the acquisition of every other radial view such that half of the data (80 radial views) were acquired with fat suppression and the other half were acquired without fat suppression. On each set the 80 views were distributed uniformly over the 2π radians. Also within each set, the angular ordering of views was chosen to minimize image artifacts due to T2 decay during the acquisition of the echo train[3].

Images with and without fat suppression were generated by using 80 views with and without fat suppression, respectively, in the central part of k-space up to a radius corresponding to the Nyquist condition. All 160 radial views were used beyond the Nyquist point, as shown in Fig. 1. An interpolation function was used to calculate the remaining lines of data in the central part of k-space. A filtered back-projection complex reconstruction was used to obtain the final images.

Results and Discussion: With the post-processing method outlined in Fig. 1 we can obtain high-resolution images with and without fat suppression from a single k-space data set (Fig. 2a). Since all the data is used beyond the Nyquist point, artifacts caused by angular undersampling are reduced. Despite the mixing of k-space data in the high spatial frequencies (data with and without fat suppression), the images obtained from a single k-space data set have comparable fat/water contrast to the images obtained from two full k-space data sets (Fig. 2b) where all the views were acquired with and without fat suppression, respectively.

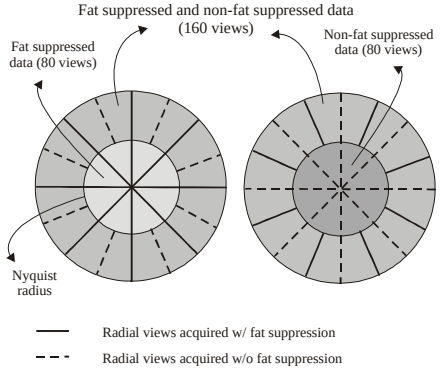

Fig. 1. Post-processing scheme of radial k-space data for obtaining high resolution fat suppressed and non-fat suppressed data.

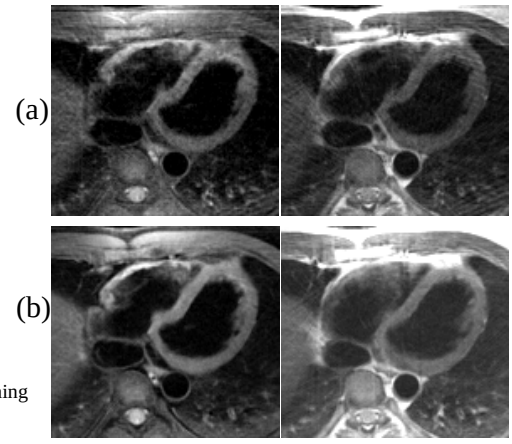

Fig. 2. (a) Fat suppressed (*left*) and non fat-suppressed (*right*) images obtained from data acquired in a single breath hold. One half of the radial views (80 out of 160 views) were acquired with fat suppression. Images were obtained after post-processing k-space data as shown in Fig. 1. (b) Images acquired with (*left*) and without (*right*) fat suppression. Each image was acquired in a separate breath hold with all 160 radial views acquired with and without fat suppression, respectively.

The major advantage of the method presented here is that data are acquired in half the time compared to existing methodologies. Thus high-resolution data with and without fat suppression can be obtained in the same breath hold. This minimizes misregistration between the fat-suppressed and non fat-suppressed images, thus allowing comparison of data on a pixel by pixel bases which should yield a better characterization of tissue type.

Conclusion: A DBIR RAD-FSE method has been developed to obtain high-resolution images with and without fat-suppression from a k-space data set acquired in one breath hold. The methodology has been demonstrated in the heart and has the potential to be used as an improved technique for detecting lipid infiltration in pathologies such as ARVD.

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References: (1) Simonetti OP, Cardiac Radiology, 199, 49 (1996); (2) Altbach MI, ISMRM, 10, 1723 (2002); (3) Theilmann RJ, MRM (in press).