A Magnetic Resonance Technique for Simplified and Simultaneous Imaging of Myocardial Viability and Function using Undersampled Projection Reconstruction

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INTRODUCTION

Myocardial viability assessment in patients with coronary artery disease and left ventricular dysfunction can be critical to determine which patients might benefit from revascularization [1]. T1-weighted inversion recovery post-contrast MR imaging has shown promise in distinguishing infarcted from normal myocardium since infarcted myocardium exhibits higher signal than normal myocardium [2-3]. However, the selection of right inversion time (TI), which depends on contrast dosage and also varies from patient to patient, to null normal myocardium signal greatly affects the diagnostic value. Typically, images at several different TI values are acquired until an image with optimized normal myocardium signal suppression is achieved. This process is obviously time-consuming and not robust.

This work presents a fast TrueFISP MR imaging technique that allows retrospective selection of the TI time required to null normal myocardium effectively and easily by taking advantage of the intrinsic oversampling of the center of the k-space in projection reconstruction (PR) acquisition technique and a sliding-window reconstruction technique with a temporally varying aperture with radial distance [4].

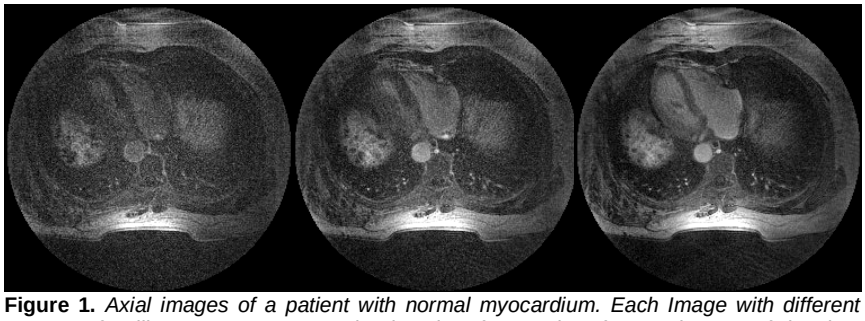

Figure 1. *Axial images of a patient with normal myocardium. Each Image with different amount of nulling was reconstructed using data from 3 time frames (100 % of the data obtained at the time of interest, 50 % of the high spatial frequency data from the left and right neighboring frames. 16 cardiac phases were acquired in a scan time of 12 seconds.*

MATERIALS AND METHODS

A 2D cardiac-gated, angularly undersampled PR-based, segmented TrueFISP inversion-recovery MR technique for post-contrast myocardium viability imaging was developed. All experiments were performed on a 1.5 T cardiac scanner (GE Medical Systems, Milwaukee, WI). Projections were acquired in an interleaved fashion [5] with typical scan parameters of TR/TE/Flip = 3.9 ms/1.4 ms/40°, 64-128 projections, 4-8 projections per interleave, 16 interleaves, FOV = 350 mm x 350 mm, slice thickness = 5 mm, and RBW = ±125 kHz. Scan time varied between 8-18 heart beats. During each heart beat, 3-7 distinct sets of interleaved projections were repeatedly acquired until an ECG trigger was detected, at which point the projection angle was incremented and new distinct sets of interleaved projections were acquired. Projection data were first gridded onto a Cartesian grid and then fast-Fourier transformed along both directions. A sliding-window reconstruction scheme with a temporal aperture varying with radial distance (or Tornado filter) was utilized to combine data from several time frames (3-7) in k-space to form images. For example, to reconstruct an image at time frame t using 5 time frames, 100 % of the data obtained at t, 75 % of the data (high spatial frequency) obtained at time frames (t – 1) and (t + 1), and 25 % of the data (high spatial frequency) obtained at time frames (t – 2) and (t + 2) are combined to form a final image.

RESULTS AND DISCUSSION

Figure 1 shows axial snapshot images of a patient with normal myocardium with different amount of signal nulling. Each image was reconstructed using data from 3 time frames (100 % of the data obtained at the time frame of interest, 50 % of the high spatial frequency data from the immediate left and right neighboring time frames. Sixteen cardiac phases were acquired in a scan time of 12 s and the temporal aperture is 31.2 ms wide. This reconstruction technique decreases streak artifacts and increases signal-to-noise ratio. Note that this method also provides dynamic cine images of myocardial function because of high temporal resolution achieved. In addition, T1 maps can be generated from the same images to assess wall motion abnormalities or contractility. Short scan time achieved with this method also makes breath-holding more tolerable to elderly patients. This TrueFISP PR-based inversion recovery technique offers higher signal-to-noise ratio compared to our previous RF-spoiled gradient-recalled technique [5].

CONCLUSIONS

Our initial results suggest that a 2D cardiac-gated PR-based segmented TrueFISP inversion-recovery technique allows retrospective selection of inversion time (TI) for nulling normal myocardial signal. The technique exploits the oversampling of the center of the k-space in PR to provide several different tissue null points and allows retrospective adjustment of TI. These advantages and our preliminary results suggest that a PR-based segmented inversion-recovery technique may be a viable alternative for the imaging of myocardial viability as well as wall motion abnormalities.

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