Systolic-Phase Black-Blood Imaging for Fatty Tissue Detection in Arrhythmogenic Right Ventricular Dysplasia

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Introduction

Arrhythmogenic right ventricular dysplasia (ARVD), one of the leading causes of sudden death [1], is a disease where right ventricular (RV) myocardium is replaced by fatty or fibrotic tissue. It is currently diagnosed with MRI utilizing a variety of imaging sequences to evaluate wall-motion abnormalities, the presence of scar tissue, and the presence of fatty regions in the right ventricular wall. A breath-held, black-blood fast spin echo (FSE) sequence, timed for the systolic cardiac phase, is presented. Data acquisition occurs at the cardiac phase where the RV is thick and relatively motionless, allowing for easier detection of small fat layers. Preliminary clinical experience suggests that this breath-held sequence is as effective in detecting fatty layers as the current gold standard, a 10-15 minute respiratory-gated fat-suppressed spin-echo sequence [2].

Purpose

Detection of fatty tissue layers in the RV wall is currently difficult, due to the small extent of the fatty layers and the great degree of motion that occurs in the RV. The required high in-plane spatial resolution (~0.7x 0.7 mm) is difficult to achieve with current breath-held, black-blood, double-inversion-recovery (DIR) FSE sequences. This is complicated by the fact that data acquisition occurs in late diastole when the RV wall is thin, making detection of fat more difficult. This study evaluated the clinical efficacy of DIR FSE with systolic-phase acquisition for detecting fat regions in the RV wall.

Methods

With conventional black-blood imaging, the DIR preparation is performed immediately after the ECG trigger. This is followed by a time TI, which is dependent on the TR, to null the signal from blood. The TR is typically measured as a multiple of the cardiac cycle; e.g., 1xRR or 2xRR. When TR=2xRR, the required TI causes the readout period to be in diastole, which is often desirable to minimize cardiac motion; it is also the time when the myocardium is the thinnest. The pulse sequence used in this work is shown in Figure 1. The imaging structure is shifted such that data acquisition occurs in systole. To achieve the required TI, the DIR preparation must be placed in the previous cardiac cycle. Short-axis images of the heart were acquired on a 1.5T scanner (GE Healthcare) with the following parameters: TE/TR 4.6/2xRR msec; TI ~500-650 msec (heart rate-dependent); 256x224 matrix; ETL 20; 26 cm FOV; 6 mm slice thickness. Imaging was performed with and without fat suppression. Two patients with suspected ARVD were imaged.

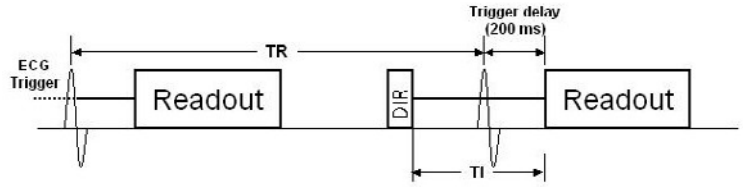

Figure 1. Pulse sequence timing diagram for systolic-phase DIR FSE with TR=1xRR. Regardless of the TR, the DIR preparation occurs in the cardiac cycle prior to data acquisition.

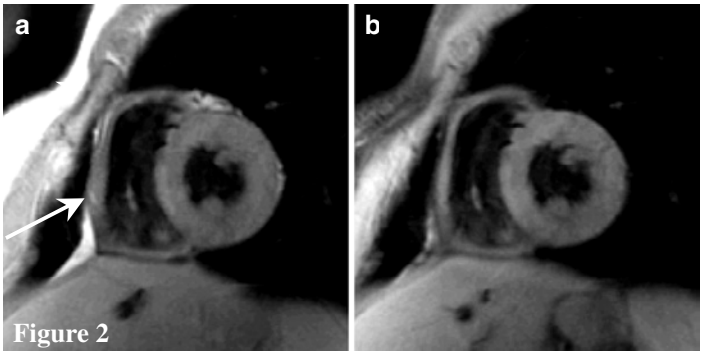

Figure 2

Results

Figure 2 shows images of a single slice acquired without fat suppression (Fig. 2a) and with fat suppression (Fig. 2b) using systolic-phase DIR FSE. The thickened RV myocardium in systole affords easier identification of small fatty infiltrations (arrow).

Discussion and Conclusions

This work has demonstrated that performing black-blood DIR FSE imaging with data acquisition in systole may improve the diagnosis of fatty tissue associated with ARVD. Because of the limited resolution achievable with breath-held scans, imaging the thickened RV myocardium in systole can allow better visualization of the tissue. In the two patients studied, all fatty tissue detected with a 10-15 minute respiratory-gated, fat-suppressed, spin-echo sequence [2] was also detected with this breath-held sequence. Unlike conventional DIR FSE, the preparation and acquisition periods do not occur in the same cardiac cycle when imaging in systole. This can cause the nominal TI to vary if the heart rate changes. Furthermore, imaging in systole may not allow complete wash-in of nulled blood. Nevertheless, even in cases with incomplete blood suppression, delineation of fat from normal RV myocardium should not be affected. Systolic-phase, black-blood imaging appears to be a beneficial technique for imaging fatty infiltration in ARVD.

References 1. Van der Wall E et al., Herz 25:356 (2000). 2. Abbara S et al., AJR 182;587 (2004)