Multi-contrast Delayed Enhancement (MCODE) Provides Improved Imaging of Sub-Endocardial Myocardial Infarction

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Introduction

Delayed enhancement imaged using an inversion-recovery sequence exhibits excellent contrast between infarcted and normal myocardium. However, the contrast between the MI and the blood pool is frequently suboptimal. Since a large fraction of infarctions caused by coronary artery disease are subendocardial, it is often difficult to assess the precise size of the infarct or to detect small infarcts. The T2 of blood is significantly longer than either acute or chronic MI. The proposed Multi-COntrast Delayed Enhancement (MCODE) imaging method produces a series of images with both T1 and T2 weightings which provides both excellent contrast between normal and infarcted myocardium, and between blood and MI.

Methods

The MCODE imaging method produces separate images with T1 and T2-weighting. Both images are acquired during the same breath-hold at the same cardiac phase and are therefore registered, which is critical to discriminate subendocardial MI. Both single-shot TrueFISP and TurboFLASH sequences were implemented. For the single-shot trueFISP sequence, T2 weighting is achieved using a large flip angle readout after magnetization recovery, whereas the segmented TurboFLASH sequence uses a T2 preparation [1].

The sequences were implemented on the Siemens Sonata and Avanto 1.5T scanners. For the single-shot phase-sensitive inversion-recovery (PSIR) TrueFISP sequence, the multi-contrast sequence required a single 3 heartbeat acquisition to acquire T1-weighted (IR image), PSIR reference, and T2-weighted images at the same cardiac phase in mid-diastole. The matrix size was typically 192x96 or 256x128, with or without parallel imaging, respectively. Similarly for the segmented PSIR TurboFLASH sequence, 3 heartbeats were used per segment, with a typical matrix size of 256x125. A B1-weighted phased-array combined phase-sensitive reconstruction method was used [2]. N=11 patients with chronic MI were imaged approximately 20 minutes after administering a double dose of Gd-DTPA. CNR between MI and blood were measured for both T1 and T2 weighted images.
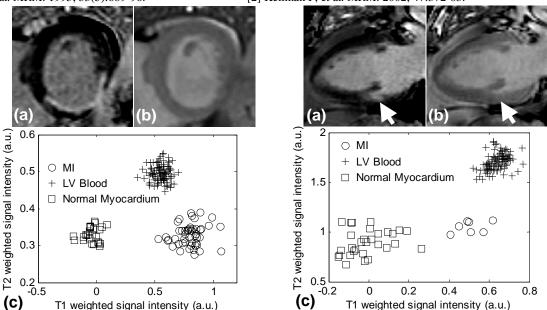
Results

Images and corresponding scatter plots of signal intensities for MI, blood, and normal myocardium regions are shown in Figures 1 and 2 for two patients (using TrueFISP). The scatter plots show how the T2 image may be used to distinguish between blood and MI despite similarity in T1 weighted intensities. The measured MI-to-blood CNR (m±sd) was better in the T2-weighted image than T1-weighted image (22.5±8.7 vs. 2.9±3.1, N=11, P<0.001, for TrueFISP, and 19.4±10.8 vs. 3.9±2.3, N=11, P<0.001, for TurboFLASH). Short axis images for a patient with subendocardial MI are shown in Fig. 1. The MI and normal myocardium are easily discerned in (a) while the MI and blood are easily discerned in (b). In this case, with good MI-to-blood contrast in the T1-weighted image, the T2 image still provides improved discrimination between MI and LV blood pool. The endo and epi contours may be traced on (b) and copied to (a) (not shown) as an effective means of visualization and detection. Long axis images from a second patient are shown in Fig. 2 illustrating enhanced detection of a small sub-endocardial MI. The MI indicated by arrow might easily be missed in the T1-weighted image (a) but is easily distinguished from the blood pool by comparison with T2-weighted image (b).

Discussion

Multi-COntrast Delayed Enhancement (MCODE) imaging provides a significant improvement in the ability to detect subendocardial MI by providing a T2 weighted image with high contrast between blood and MI. MCODE should improve both the detection and sizing of MI, as well as improve detection of fibrosis exhibiting a more diffuse enhancement pattern.

References

[1] Brittain JH, et al. MRM. 1995; 33(5):689-96.   [2] Kellman P, et al. MRM. 2002; 47:372-83.

Figures. 1 & 2. (a) T1-weighted and (b) T2-weighted delayed enhancement images, and (c) scatter plots of signal intensities in MI, blood, and normal myocardium regions illustrating the discrimination of the MCODE method.