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Three-dimensional Dixon fat-water separated breath-held imaging of myocardial delayed enhancement

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Introduction

Myocardial delayed enhancement (MDE) imaging of infarction is commonly performed using an inversion-recovery (IR) two-dimensional (2D) breath-held fast gradient recalled echo (FGRE) pulse sequence. Three-dimensional (3D) imaging can improve scanning efficiency by acquiring the desired volume in a single breath-hold. Fat suppression could greatly improve visualization of epicardial enhancement (which occurs in transmural myocardial infarction and myocarditis) as well as pericardial enhancement.

Purpose

To investigate a novel Dixon fat-water separated 3D breath-hold technique for fat suppressed imaging of MDE.

Methods

An ECG-gated dual-echo bipolar-readout 3DFGRE pulse sequence was developed. High receiver bandwidths enabled placement of opposed- and in-phase echoes at 2.4/ 4.8 ms, achieving compact TRs. Elimination of explicit fat suppression enabled use of a novel k-space segmentation scheme that is efficient and has desirable motion insensitivity properties. Radial fanbeam k-space segmentation of an elliptical k_y-k_z region (corners skipped) was employed for efficient coverage of k-space, enabling 3D data acquisition in a single breath-hold. Within each fanbeam, k-space points were acquired in the order of increasing kr. In each R-R interval, a non-selective 180° pulse followed by an inversion time (TI) delay of 200-250 ms preceded data acquisition at ~300 ms (32-36 points). A self-calibrated parallel imaging scheme with acceleration factor of 2.5 in the phase encoding direction yielded an overall breath-holding time of 22-25 s. A robust region-growing based phase-corrected 2-point Dixon reconstruction algorithm of Ma et al. was used. Patients with known or suspected myocardial infarction, myocarditis, pericarditis, or non-ischemic cardiomyopathy were imaged after informed consent on a 1.5 T GE SIGNA scanner using an 8-channel phased array coil. Imaging was performed approximately 10-15 minutes after bolus injection of 0.2 mmol/kg of Gadolinium DTPA contrast agent. The 3D Dixon FGRE scan immediately followed the IR prepared 2D FGRE acquisition.

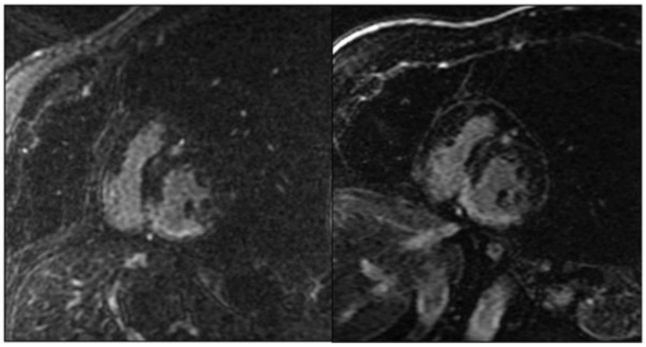

Figure 1
Short axis 2D MDE (left) and 3D Medal MDE (right) images in patient with inferior/inferoseptal infarct demonstrate transmural delayed enhancement.

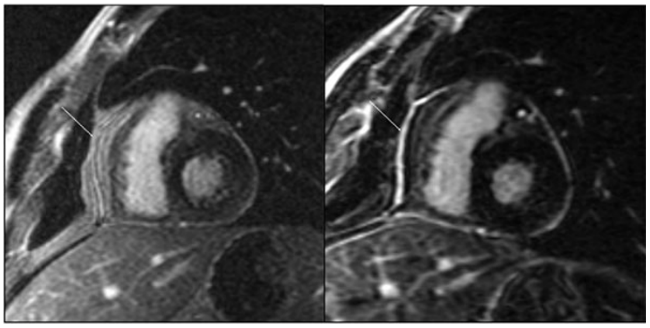

Figure 2
Short axis 2D MDE (left) and 3D Medal MDE images (right) in a patient with pericarditis. Pericardial enhancement is more clearly deomnstrated in the fat-suppressed Medal MDE image (right).

Results

Figure 1 compares conventional 2D MDE with 3D Dixon MDE in a patient with an inferior infarct demonstrating better SNR and spatial resolution of the 3D sequence. Figure 2 compares conventional 2D MDE and 3D Dixon MDE in a patient with pericarditis clearly showing improved visualization of pericardial enhancement in the 3D Dixon sequence.

Conclusion

A technique capable of providing full heart coverage in a single 3D breath-held acquisition was validated. The use of Dixon based fat-water separation makes the technique immune to Bo inhomogeneities, improving SNR as well as fat suppression. The novel radial fan-beam k-space segmentation enabled acquisition of a 3D slab in a short breath-hold.