Cardiac Imaging with Chemical Shift Based Water-Fat Separation at 3T

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Introduction

Chemical shift based water-fat separation techniques have been demonstrated for 1.5T cardiac imaging of several pathologies, including fatty infiltration of chronic infarction; arrhythmogenic right ventricular cardiomyopathy (ARVC); fatty tumors; and conditions such as myocarditis and pericarditis [1-4]. Higher field strengths (3T) are now often used in cardiac MRI due to improved image contrast, SNR, and tagging efficiency [5]. However, chemical shift-based separation methods at 3T can be challenging due to the short required echo spacing. Here we demonstrate the use of a chemical-shift based water-fat decomposition method (IDEAL) [6,7] for 3T cardiac imaging.

Methods

A multi-echo gradient echo sequence with 2 fractional (partial-k_x) echoes acquired with positive (fly-back) readouts was implemented at 3T (Discovery MR750, GE Healthcare, Waukesha, WI). An 8-channel cardiac coil or a 32-channel torso coil with the most superior 20 elements activated (NeoCoil, Pewaukee, WI) was used. Two interleaved echo trains with 2 echoes per TR were acquired for each *k*-space line (Fig. 1), providing an effective echo spacing within the optimal range that maximizes SNR performance. Normally, it is extremely challenging to achieve such echo spacing at 3T while maintaining high spatial resolution. Acquisition parameters included: TR/TE_1/ΔTE/BW = 6.3/1.7-1.9/0.8-0.9/±125kHz; FOV/Matrix/Slice Thickness = 35cm/256x192/6-8mm; 24 views per segment; and imaging in every second cardiac cycle, with 17 cardiac cycles per slice. For delayed enhancement imaging, inversion recovery (IR) was used, with TI=250-300ms adjusted as needed to null normal myocardium. The technique was used in a variety of clinical imaging situations, and informed consent was obtained in all patients. Water-fat decomposition was performed with an investigational reconstruction software package, with an advanced region-growing field estimation method [8].

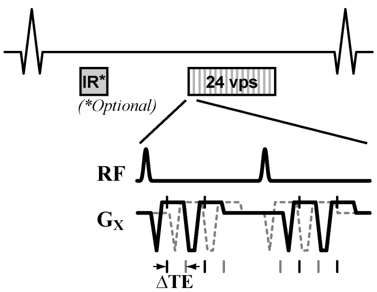

Fig 1 Interleaved multi-echo sequence.

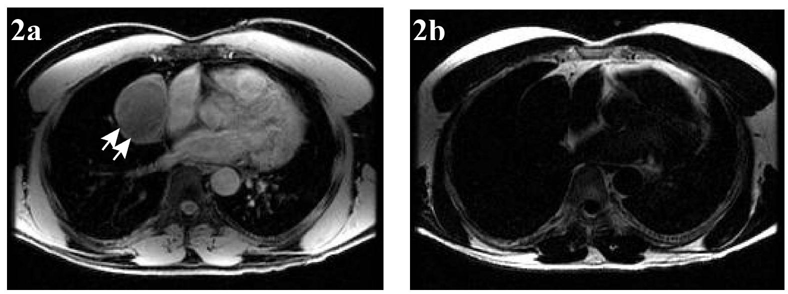

Fig 2 Pericardial cyst with enhancing rim post-contrast, no fatty component.

Results

An example of the evaluation of a large pericardial mass is shown in Figure 2. Post-contrast axial images demonstrated an enhancing rim (Fig. 2a), but no fatty component (Fig. 2b), compatible with a simple pericardial cyst. In Figure 3, good separation of water (3b) and fat (3c) was achieved, unambiguously depicting a thickened pericardium in this patient with pericarditis. Excellent water-fat separation was also achieved in a patient with cardiac sarcoidosis and a transmural inferolateral wall infarct (Fig. 4).

Fig 3 Unsuppressed fat (arrows) in conventional delayed enhancement images (3a); IDEAL water (3b) and fat (3c) images delineate pericarditis and the epicardial fat layer.

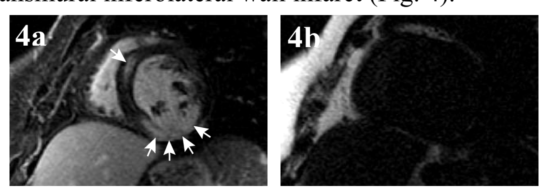

Fig 4 Transmural inferolateral wall infarct and enhancing granuloma in anteroseptal wall in a patient with cardiac sarcoidosis; water (4a) and fat (4b) images.

Discussion

Cardiac imaging at 3T with chemical-shift based water-fat separation provided clear separation of fat and water signals in several clinical imaging situations. Scan time per slice was slightly increased compared to a similar 1.5T method [3]; two interleaved echo trains were required for optimal echo spacing, although this was partially offset by shorter TRs. Water and fat pixel swapping was not observed due to the combination of an advanced region growing field estimation method [8] and near-optimal echo spacing at 3T.

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