Multi-echo IDEAL Cardiac Water-Fat Imaging

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Introduction

In cardiac magnetic resonance imaging, separation of water and fat signals is important for improved visualization of enhancing myocardium and pericardial disease, as well as direct visualization of fat in pathologies such as arrythmogenic right ventricular cardiomyopathy (ARVC), fatty tumors, and fatty infiltration of chronic myocardial infarctions. Fat can appear similar to slow blood flow with some methods, and fat may obscure enhancing myocardium, particularly epicardial enhancement that can occur in myocarditis, pericarditis, and non-ischemic cardiomyopathies. Chemical shift based water-fat separation methods have been used to provide separate water and fat images in balanced-SSFP CINE imaging [1] and myocardial viability imaging [2,3]. Here, we demonstrate the ability of IDEAL [1,4] to decompose fat and water signals in cardiac imaging with a gated multi-echo segmented gradient-echo sequence. Included are the use of near-optimal TE increments that maximize SNR performance [4] and a modified version of an advanced field-map estimation method with region-growing [5].

Methods

A multi-echo gradient echo sequence with 3 echoes acquired with positive (fly-back) readouts was implemented with and without inversion recovery (IR) at 1.5T (Signa HDx, GE Healthcare, Milwaukee, WI). Parameters included: TR/TE_1/ΔTE/BW = 7.2-7.8/1.5-1.7/1.9-2.0/±100kHz; FOV/Matrix/Slice Thickness = 35cm/192x192/6-8mm; 16-32 views per segment; and one segment in each or every second cardiac cycle, for a duration of 13-25 cardiac cycles per slice. In addition, a T2-preparation sequence (T2-Prep) with or without IR was available [6,7]. The technique was demonstrated in patients and volunteers for several clinical imaging situations.

Results

An example of "rule-out" suspected ARVC is shown in Figure 1, acquired in diastole without IR. A conventional double-IR black-blood sequence (1a) used for comparison showed high signal in the mid RV wall concerning for fat vs. slow flow (arrows). This was easily resolved as blood and not fat using IDEAL (1b,1c) images. Myocardial viability imaging with IR (TI=200ms) for suppression of myocardial signal is shown in Figure 2 (no infarct in this patient), with good separation of water (2a) and fat (2b) signal.

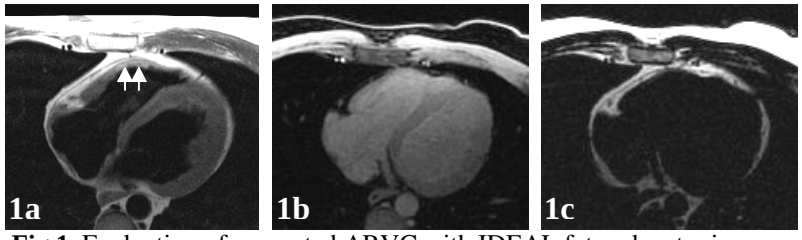

Fig 1 Evaluation of suspected ARVC with IDEAL fat and water images.

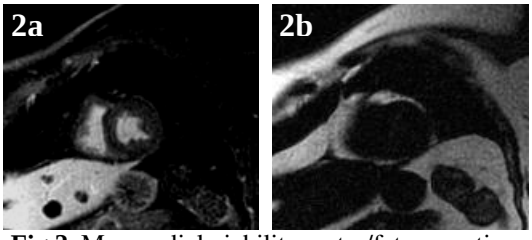

Fig 2 Myocardial viability water/fat separation.

Increased T2 weighting was achieved using T2-Prep with varying effective-TE values (Figure 3). The water image in a normal volunteer without (3a) and with T2-Prep (TE_{eff} = 25ms (3b) and 50ms (3c)) demonstrated consistent fat separation and increasing T2 weighting. Figure 4 shows flow independent black blood imaging in a normal volunteer with T2Prep-IR [7] with TI=400ms and TE_{eff}=70ms combined with the IDEAL acquisition for robust fat suppression. Excellent suppression of blood was achieved with separation of water (4a) and fat (4b) and higher SNR than is normally achieved with triple-IR fat-suppressed black-blood imaging.

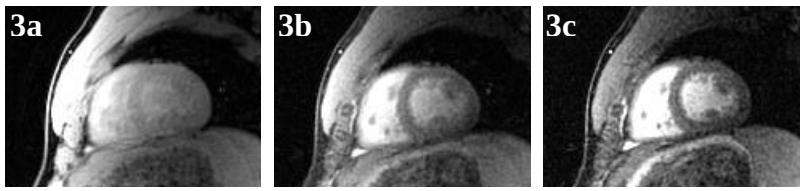

Fig 3 IDEAL without (3a) and with T2-Prep, TE_{eff} = 25ms (3b), 50ms (3c).

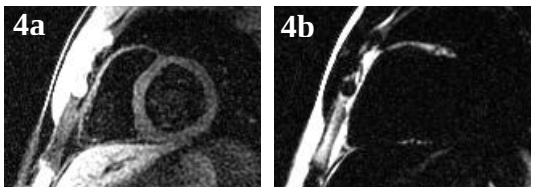

Fig 4 T2-Prep IR IDEAL Black Blood Imaging.

Water-fat swapping, a challenge commonly faced in chemical shift based water-fat imaging methods, was not observed due to the use of a modified version of an advanced region growing field estimation method [5].

Discussion

Cardiac imaging with IDEAL fat-water separation can be applied in several imaging situations. The use of IDEAL for separating fat and water signal provided unambiguous visualization of fat in several clinical situations, with potentially improved performance over conventional fat suppression methods, inherent registration of water and fat images, and no need for separate fat-suppressed and unsuppressed acquisitions. Importantly, the multi-echo readout provided scan times similar to conventional methods.

References [1] Reeder SB *et al, J Magn Reson. Imaging* **22:** 44-52 (2005). [2] Goldfarb JW, *Magn Reson Med* **60:** 503-9 (2008). [3] Kellman P, *et al, 16th ISMRM,* 823 (2008). [4] Reeder SB, *et al, Magn Reson Med* **51:** 35-45 (2004). [5] Yu H, *et al, Magn Reson Med* **54:** 1032-9 (2005). [6] Brittain JH, *et al, Magn. Reson. Med* **38:** 343-54 (1997). [7] Liu CY, *et al, 16th ISMRM*, 2957 (2008).