Cardiac Fat -Water Imaging: Early experience and clinical utility

M. L. Schiebler[1], K. K. Vigen[1], C. J. Francois[1], S. K. Nagle[1], A. Shimikawa[2], H. Yu[2], J. H. Brittain[3], and S. B. Reeder[1]
[1]Radiology, UW Madison, Madison, WI, United States, [2]Applied Science Lab, General Electric, Menlo Park, CA, United States, [3]Applied Science Lab, General Electric, Madison, WI, United States

Introduction: There are multiple pulse sequences available for myocardial imaging that take advantage of fat and water spectral separation for the determination of the presence of fat. These include conventional fat saturated (spectral saturation of the fat peak) sequences, and chemical shift-based water-fat separation methods. The purpose of this study was to explore the clinical utility of a cardiac-gated chemical shift-based method (IDEAL) for cardiothoracic imaging [1, 2].

Methods: After obtaining IRB approval and informed consent, a total of 52 patients (32 for suspected myocardial infarction and 20 patients referred for non-myocardial thoracic pathology) were imaged. 42 patients were imaged at 1.5T (Signa HDx, GE Healthcare, Waukesha, WI), and 10 patients were imaged at 3T (Discovery MR750, GE Healthcare, Waukesha, WI). An 8-channel cardiac coil (1.5T) or a 32-channel torso coil (3T) with the most superior 20 elements activated (NeoCoil, Pewaukee, WI) was used. IDEAL imaging was performed with an investigational cardiac-gated multi-echo gradient echo sequence, with 3 echoes in a single echo train at 1.5T [3] or 4-echo (2 echoes/TR) interleaved acquisition at 3T. In both cases the achieved echo spacings provided the range for optimal SNR performance [4]. Specific acquisition parameters were (1.5T): TR/TE1/ΔTE/BW = 7.0-7.8/1.5-1.7/1.6-2.0/±100kHz; (3T): $TR/TE_1/\Delta TE/BW$ = 6.3/1.7-1.9/0.8-0.9/±125kHz; matrix = 192x192 (full echo) or 256x192 (fractional echo); FOV/Slice Thickness = 35cm/6-8mm; 16-32 views per segment; and imaging in each or every second cardiac cycle, for 13-25 cardiac cycles per slice. For delayed enhancement imaging, inversion recovery (IR) was used, with TI=180-300ms. A T2Prep sequence [5] with TE_{eff} = 10-50ms was also available to produce T2 contrast. Water-fat decomposition was performed with an investigational on-line reconstruction package, with an advanced region-growing field estimation method [6].

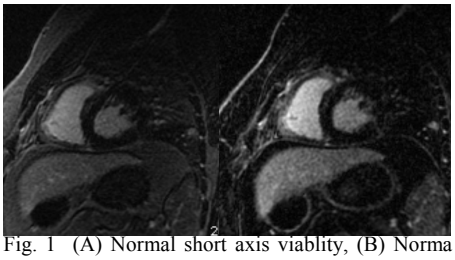

Fig. 1 (A) Normal short axis viablity, (B) Norma water-only IDEAL viability image.

Results: Viability imaging using the water image from IDEAL was found to be of similar quality to the routine viability images with improved conspicuity of abnormally enhancing tissue using IDEAL, in many cases. (Figures 1, 2 and 3). In general the apparent CNR of enhancing scar was larger on the IDEAL water-only images, possible related to small differences in spatial resolution and timing of acquisition relative to contrast administration.

There was consistent separation of water and fat signals within the paracardial fat, epicardial fat and retrosternal fat using IDEAL. (Figures1 and 4). Double IR images had higher spatial resolution than IDEAL, however, IDEAL offers additional tissue characterization through robust separation of water and fat signals..

Pericardial disease was particularly well suited to imaging with IDEAL because the epicardial fat is effectively separated from thickened and enhancing pericardium, improving its conspicuity

Direct visualization of fatty infiltration within the ventricle seen in arrhythmogenic right ventricular cardiomyopathy (ARVC) and in normal individuals is nicely demonstrated with this approach (Figure 5).

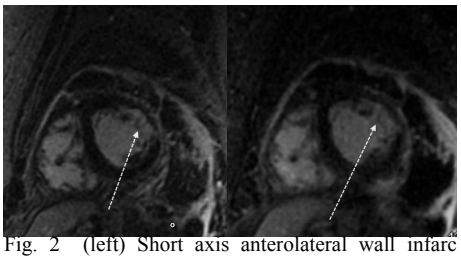

Fig. 2 (left) Short axis anterolateral wall infarc viability scan, (right) Short axis anterolateral infarc water-only IDEAL viability image.

Discussion: Our early clinical experience in cardiovascular imaging with IDEAL before or after gadolinium enhancement, with or without viability imaging shows that this technique provides robust separation of water and fat and direct visualization of fat-containing pathologies in the heart or mediastinum. Direct visualization of fat within pathological structures in fat-only images simplifies interpretation and improves the certainty of diagnosis.

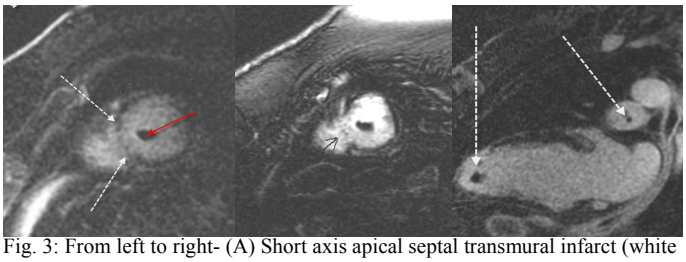

Fig. 3: From left to right- (A) Short axis apical septal transmural infarct (white arrows) viability scan with apical thrombus (red arrow), (B) Short axis septal transmural infarct IDEAL water viability scan, (C) Long axis IDEAL water viability image showing transmural apical infarction with apical thrombus (long arrow) and an incidental left pulmonary artery embolus (shorter arrow).

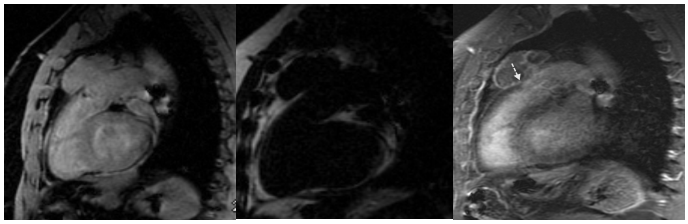

Fig. 4: From Left to right- (A) Sagittal IDEAL water image, (B) Sagittal IDEAL fat image of anterior mediastinal mass (thymoma). Mass demonstrates no fat, and (C) Sagittal gradient echo fat sat post gadolinium images shows peripheral enhancement of the cystic mass which abuts the pericardium without invasion.

References:
1. Reeder SB et al, MRM 2005 54:636-44
2. Reeder SB et al, ISMRM 2006, pg 2444
3. Vigen KK et al, ISMRM 2009, pg 2775
4. Pineda et al MRM 54(3):625-35 (2005)
5. Brittain JH et al, MRM 33:689-696 (1995)
6. Yu H et al, Magn Reson Med 54:1032-9 (2005)

Acknowledgements: We gratefully acknowledge support from GE Healthcare.

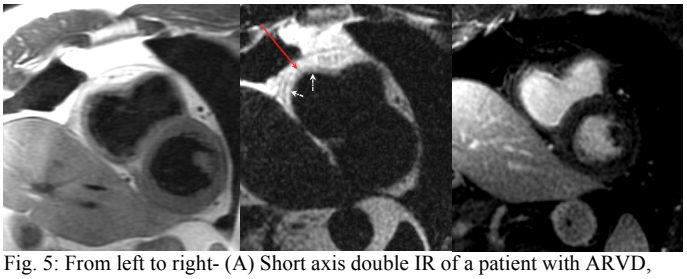

Fig. 5: From left to right- (A) Short axis double IR of a patient with ARVD, (B) Short axis of post Gd Viability IDEAL fat image showing fat in the right ventricular free wall, (C) Short axis of post Gd viability water image showing no delayed enhancement.