Fat Imaging and Suppression Techniques and Applications for Cardiac MRI

Karl K. Vigen[1], Christopher J. Francois[1], Scott K. Nagle[1,2], Mark L. Schiebler[1], and Scott B. Reeder[1,3]
[1]*Radiology, University of Wisconsin-Madison, Madison, WI, United States,* [2]*Medical Physics, University of Wisconsin-Madison, Madison, WI, United States,* [3]*Medical Physics, Biomedical Engineering, and Medicine, University of Wisconsin-Madison, Madison, WI, United States*

Purpose Suppression and imaging of fat in and near the heart are potentially useful for imaging cardiac and para-cardiac pathology. This work will review methods for fat suppression, describe newer methods to robustly separate fat and water signals with chemical-shift based decomposition, and outline potential applications for cardiac fat suppression and imaging.

Outline of Contents Fat suppression in cardiac imaging can be performed with methods similar to those used in other regions of the body. Typically, ECG-triggering and breath holding are used, although other respiratory and cardiac motion-compensating methods are possible. Techniques such as chemical-shift based fat suppression and short-tau inversion recovery (STIR) can be used. Fat can also be imaged indirectly, for example, by imaging with and without fat suppression.

A common method for performing fat suppression in cardiac imaging is triple inversion recovery (Triple-IR) imaging, which often follows Double-IR imaging. With Double-IR, a non-selective inversion and a slice-selective inversion pulse are played in succession following the cardiac trigger, timed to suppress signal from blood flowing into the slice (Fig. 1a). Triple IR adds an additional IR pulse timed to suppress fat, allowing the distinction of fat and, for example, slow-flowing blood (Fig. 1b).

Coronary artery imaging is often challenging in MRI, and fat suppression is commonly used. With 3D-bSSFP imaging using navigator echoes, an intermittent fat-suppression pulse can be used to help increase visibility (Fig. 2).

More recently, direct fat visualization has been demonstrated with chemical shift based water-fat separation methods in cardiac imaging [1-4]. By acquiring multiple echoes in a single TR, water and fat images can be decomposed and displayed separately (Fig. 3). Combinations forming in-phase, out-of-phase images, and fat signal fraction images can also be displayed. If R2* is included in the signal model, R2* maps can also be generated.

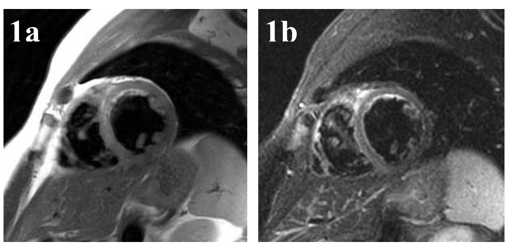

Fig 1 Double-IR (1a) and Triple-IR (1b) in a normal volunteer at 1.5T.

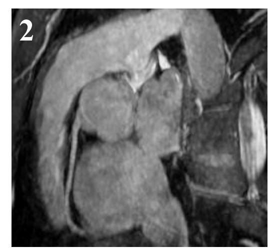

Fig 2 Curved reformat of 3D-bSSFP 1.5T coronary imaging with intermittent fat-sat.

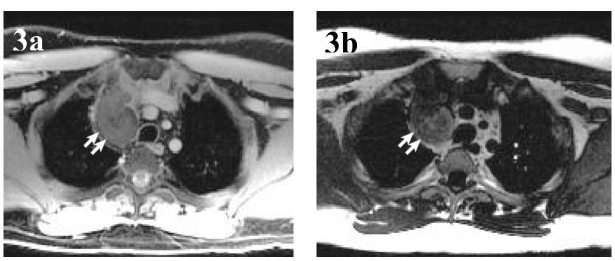

Fig 3 Mediastinal mass with water (3a) and fat (3b) tissue components after chemical-shift based water-fat 3T imaging.

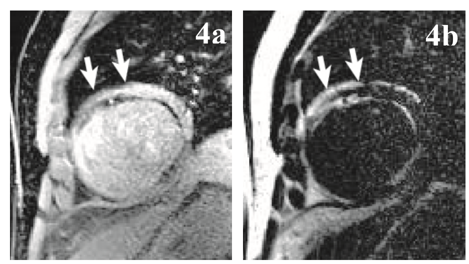

Fig 4 Water(4a)- and fat(4b)-separated 1.5T images demonstrating pericarditis.

Possible cardiothoracic imaging applications include: identifying the presence of fat in chronic myocardial infarct; determining the composition of unknown masses in and near the heart (Fig. 3); and visualizing structures surrounded by fat, such as the coronary arteries and the pericardium. In addition, pericardial fat is associated with cardiac diseases including coronary artery disease [5] and atrial fibrillation [6], suggesting that the quantification of the volume of pericardial fat is a possible biomarker for the risk of future heart disease.

Summary Several methods are available for fat suppression when cardiac motion is present. Recently developed methods using chemical shift based water-fat imaging have been shown to provide visualization of both water- and fat- containing cardiac structures. A variety of imaging applications may possibly benefit from the suppression or direct imaging of fat.

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, Magn Reson Med* **61:** 215-21 (2009). [4] Vigen KK *et al, Proc. 17th ISMRM,* 2775 (2009). [5] Miao C, *et al, Radiology* **261:**109-15 (2011). [6] Wong CX, *et al, JACC* **57:**1745–51 (2011).