Fat Water Separation in mice

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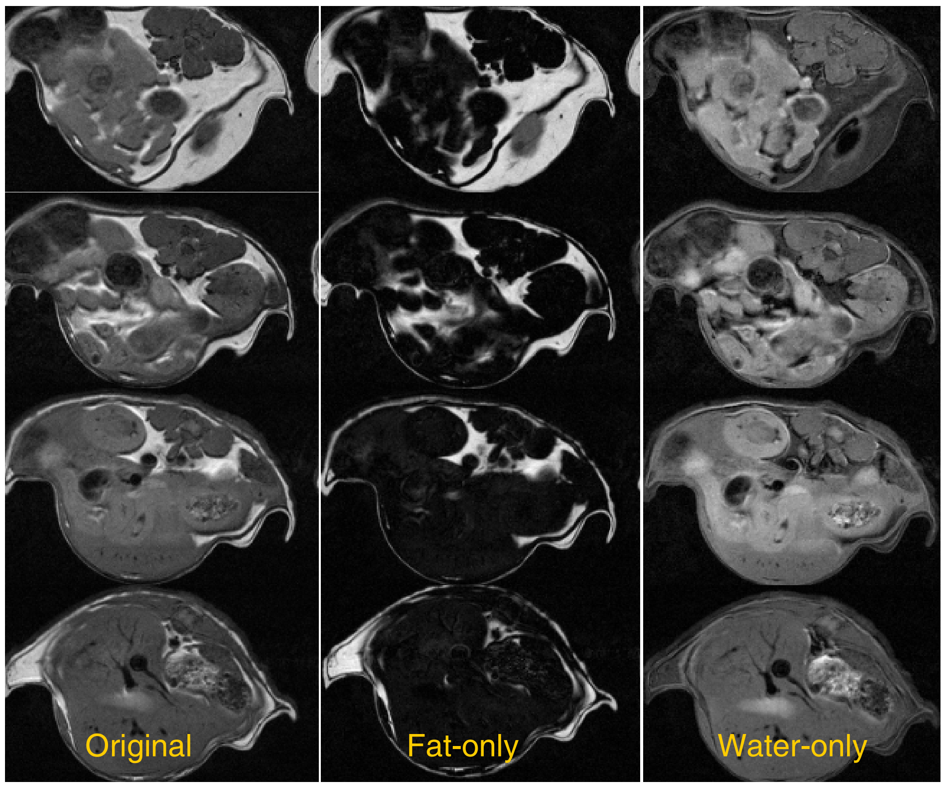
Introduction: The wide use of transgenic mice in obesity studies [1] has increased the demand for MRI techniques that can be used to investigate lipid distribution and its long term accumulation in mice. Conventional signal intensity based fat-water separation techniques suffer from partial volume effects where a pixel is designated either as water or as fat regardless of the partial contributions from fat and water. Phase sensitive reconstruction of Dixon images [2] alleviates this problem albeit with long scan time, usually requiring 3 images. In this study, we used a spin echo Dixon technique that requires only two images [3] to separate fat and water from high resolution images in mice on a 7T MR scanner.

Method: A spin echo sequence with two excitations was used. In the first excitation a standard spin echo is acquired with a minimum echo time with fat (F) and water (W) magnetization in-phase (phase shift, $\psi = 0$). In the second excitation, the fat and water phase is made opposite ($\psi = \pi$) by shifting the refocusing pulse but keeping the echo time fixed. The shift τ is calculated from $\psi = 4\pi\sigma f_0\tau = \pi$, where σ =3.5 ppm is the fat-water chemical shift, and f_0=300 MHz is the resonance frequency of the scanner; resulting τ =239µs. After the static phase is removed from both images, the complex images can be written as $I_{in}=W+F$ and $I_{out}=(W-F)e^{-i\varphi}$ for the first and second excitations respectively. The residual phase vector $e^{-i\varphi}$ is either parallel (+) or anti parallel (-) to $I_{out}/|I_{out}|$ depending on the dominant signal in I_{out}. The correct sign of $e^{-i\varphi}$ is determined by the region growing method introduced by Ma [3]. Once the residual phase is removed (by multiplying by its conjugate), the water-only image and the fat-only image are calculated as $I_{in}+ I_{out}$ and $I_{in}+ I_{out}$, respectively.



The method was implemented on a 7 T (Bruker, Biospin, GmbH, Germany) scanner. A 72mm ID RF coil was used. Mice were anesthetized with 2% (vol) Isoflurane. A pneumatic pillow (SA Instruments, Inc. NY, USA) was used for respiratory gating. Imaging parameters were as follows: TE/TR=9/4000ms, FOV=3.6cmx3.6cm, matrix=128x128, slice thickness=1.2mm, NEX=4. Twenty interleaved axial slices were obtained in the abdomen in a total scan time of about 20 min. Post processing was performed off-line with in-house developed software written in IDL (ITT Visual Information Solutions, CO, USA)

Results and Discussion: Samples of original and fat-water separated images of an obese Cre/Flox mouse (Figure) demonstrate excellent fat-water separation. The low signal-to-noise (SNR) regions near the fat-water boundaries are very well handled by the post processing technique. The resolution requirements on the gradients limit the minimum TE to about 9ms. Acquisition of multiple echoes would have further lengthened the effective TE, thus compromising the SNR. Therefore a multi echo (fast) spin echo acquisition was not considered. The trigger window of the respiratory gating must be narrow (~200-300ms) enough to ensure that no misregistration of slices occur due to motion artifacts. The SNR efficiency of the two point Dixon spin echo sequence is ideally suited for fat water separation in high resolution in vivo studies.

References: 1) Giridharan NV, Indian J Med Res, 108:225, 1998. 2) Dixon WT, Radiology 153:189, (1984). 3) Ma J, Magn Reson Med 52:415, 2004.