High Resolution Water/Fat Imaging in Animal Models

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Target Audience: This work targets researchers interested in water/fat imaging of animal models

Introduction: Animal models are utilized in obesity research to quantify and visualize the distribution of adipose tissue (AT). Applications include volumetric segmentation and quantification of the subcutaneous (SAT), intra-abdominal (IAAT) and total adipose tissue (TAT) [1, 2]. Due to the small scales of animal models, partial volume effects can cause significant segmentation errors [1]. Therefore, high resolution water/fat images are required to distinguish different adipose tissue depots in the animal model; this requires extended acquisition times. Water and fat images are often acquired using multi-gradient-echo unipolar sequences, where the echoes are acquired over multiple TR to achieve optimal echo-spacing. This further prolongs the scan time. Recently, a new bipolar sequence that can provide accurate fat measurement in shorter acquisition time compared to the unipolar sequence, has been proposed[3]. In this work, we demonstrate the ability of this sequence to double the spatial resolution within the same acquisition time of the unipolar sequence, allowing clearer identification of adipose tissue structures without further increase in scan time.

Materials and Methods: The experiments were carried out under approval granted by the Animal Use Subcommittee of our institution's Office of Research Ethics. Two guinea pigs were scanned on a 3T MR (Discovery MR 750, GE Healthcare, Waukesha, WI) using 32-ch coil array. The unipolar sequence was adapted from a previous study [4]. Unipolar and bipolar sequences were performed on each animal within ~20 mins of acquisition time per sequence. Six echoes were acquired as recommended for fat quantification. Coronal acquisition of the whole animal was performed with FOV=26 cm x 15.6 cm, flip angle=3 °, BW=± 142.86 KHz, NEX=3 for both sequences. The unipolar acquisition was obtained with ETL=3, TR/TE1/ΔTE = ~13.0/1.22/1.02 ms, slice thickness=0.9 mm and acquisition matrix = 276 x 182 x 88. Voxel dimensions = 0.94 x 0.86 x 0.9 mm^3 (= 0.728 mm^3). The high resolution bipolar acquisition was obtained using the sequence proposed in Soliman *et al.* [3], where half the voxel size of the unipolar acquisition was achieved without further increase in scan time. ETL=6, TR/TE1/ΔTE = ~13.0/1.25/1.29 ms, slice thickness=0.7 and acquisition matrix = 276 x 278 x 112. Voxel dimensions = 0.94 x 0.56 x 0.7 mm^3 (= 0.368 mm^3). Conjugate-gradient SENSE [5] and Max-IDEAL [6] were used in the reconstruction.

Results and Discussion: The spatial resolution was doubled using the bipolar sequence within same acquisition time of the unipolar sequence. Water and fat images were successfully generated from all acquisitions. As shown in the figure, clear structures of SAT and IAAT can be identified using the bipolar sequence, while partial volume effects prevent the clear depiction of the underlying anatomy in the unipolar sequence. It is worth noting that, for comparison, similar echo-timing (TE1/ΔTE) were required to achieve similar noise performance in the 2 sequences [7]. Therefore the resolution was fixed in the readout direction and was increased in the phase- and slice-encode directions.

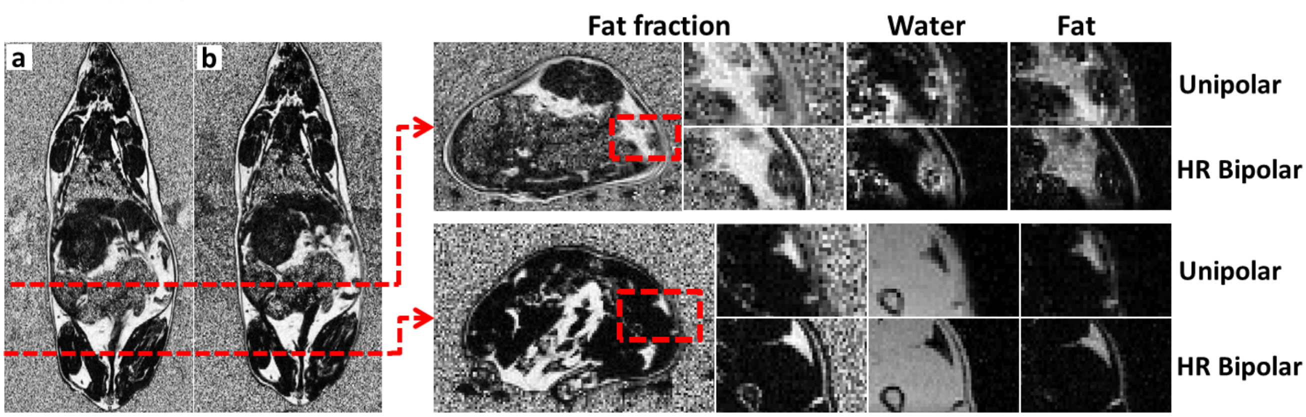

Figure: Fat fraction (fat/[water+fat]) maps from bipolar (a) and unipolar (b) sequences. Two slices are shown from an axial reformat at the locations denoted by the red arrows. In each example, the top row is the unipolar sequence and the bottom row is the high resolution (HR) bipolar sequence. The zoomed views, delineated by the red boxes, demonstrate the ability of the high resolution bipolar sequence to identify water and fat structures, not clearly depicted in the unipolar sequence.

Conclusion: Within the same scan time, the bipolar sequence can achieve double the spatial resolution of the unipolar sequence, allowing clearer depiction of water and fat tissues in animal models.

References: [1] Ranefall JMRI 2009, 30:554; [2] McCurdy ISMRM 2014:969; [3] Soliman ISMRM 2014:1673; [4] Sinclair ISMRM 2014:2143; [5] Pruessmann MRM 2001,46:638; [6] Soliman MRM 2014,72:510; [7] Hernando MRM 2008,67:638.