Novel strategy to differentiate water and lipid composition

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Introduction: The prevalence of obesity and diabetes is an increasing world-wide problem. Not only the lipid content but also the distribution of lipid composition is of special importance in the pathogenesis of these diseases (1). A detailed analysis of lipid content and distribution of lipid composition appears indispensable for a better understanding of lipid metabolism and its regulation. Proton magnetic resonance spectroscopy has evolved to be a reliable method for measuring both fat content and composition non-invasively. Adipose tissues and liver are critical for lipid metabolism. Typically, this method measures one region of interest and the refocusing pulses required in the PRESS sequence involve high RF power deposition. The objective of this study was to demonstrate the feasibility of a magnetic resonance imaging based method to assess the lipid distribution in neck fat pad.

Materials and methods: Phantom: 2 standard NMR tubes were used, filled with 100% alcohol and intralipid (<20%) separately. Animals: One ob/+ mouse 38 weeks of age was used. The mouse was anesthetized using isoflurane (1.5%-2.25%) in an oxygen-air mixture (150/400) throughout the experiments with intubation. The body temperature and respiration were monitored. The respiration signal was used for respiration gating during MR acquisition. All animal experiments were performed in strict adherence to the Swiss Law for Animal Protection.

MRI experiment: All MRI measurements were performed on a Bruker BioSpec 94/30 (Bruker BioSpin MRI, Ettlingen, Germany) system using a volume resonator for excitation and a surface coil for signal detection. Gradient Echo sequence was applied with the following parameters: VOI 1.6*2.2 cm² (phantom), 2.5*2.5 cm² (neck), slice thickness = 1 mm; number of slice = 1, matrix size = 128*128, flip angle (NA) = 20.

Results: Anatomical MR images displaying phantom at TE=3.0, 3.2, 3.4 3.6 ms are shown in Fig.1a (from left to right) with single voxel spectra of alcohol and intralipid at TE/TR=12/6000ms (Fig.1b). Typical results processed from MRE data were used to differentiate individual resonances δM.

Discussion and conclusion: The present study demonstrates that in vivo ¹H MRI TE series can reveal the distribution of individual frequency components at high spatial resolution compare to single voxel spectroscopy or chemical shift imaging (CSI). This method is attractive under conditions when few resonances have to be resolved, i.e. the spectral resolution requirement is relatively low. In such case the available measurement time can be invested to increase spatial resolution. Moreover, the method uses relatively low flip angle, hence reducing power deposition. Accurate spectral quantification requires T1 and T2 maps for individual resonances. Also the spectral resolution has to be high enough to accurately reproduce lineshapes. An attractive application of this method is the analysis/monitoring of the distribution of lipid content and composition within various tissue compartments yielding insights into normal and disordered lipid metabolisms.

References:

Fig.1. (A) MR images from phantom, (B) single voxel spectrum from one voxel in alcohol and intralipid separately as indicated in (A), typical MRI derived results from alcohol (C) and intralipid (D).

Fig.2. MR images from neck of ob/+ mouse for a TE series (TE=3 to 4.5ms).

Fig.3. Chemical shift specific MR images obtained following FT of image series shown in Fig.2. Spectra of two voxels are plotted.