Quantitative Mapping of Fatty Acid Composition using Free-Breathing Spectroscopic Imaging with Compressed Sensing

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Introduction: Non-alcoholic fatty liver disease (NAFLD) is a common health concern. Research using single voxel MR spectroscopy has shown that fat composition in the liver may be important in characterizing NAFLD [1]. MR spectroscopic imaging (MRSI) approaches can provide a spatially resolved measure of this composition information with improved spatial coverage, but are limited by slow acquisition times. In this work, a free-breathing MRSI acquisition based on spin echo single point imaging (SE-SPI), accelerated using blind compressed sensing (CS), was used for quantitative mapping of fatty acid composition.

Methods: CS SE-SPI was validated using set of pure oil and oil/water mixture phantoms and evaluated in an *in vivo* mouse study (N=16), with PRESS voxels acquired for comparison in both cases. Mice were split into four groups; fatty livers were induced in half of the mice using a methionine choline deficient (MCD) diet, and iron overload simulated in half of the mice by iron injection. Three fatty acid composition metrics were considered; unsaturation index (UI), a surrogate unsaturation index (UIs), and polyunsaturation index (PUI), as described in [1].

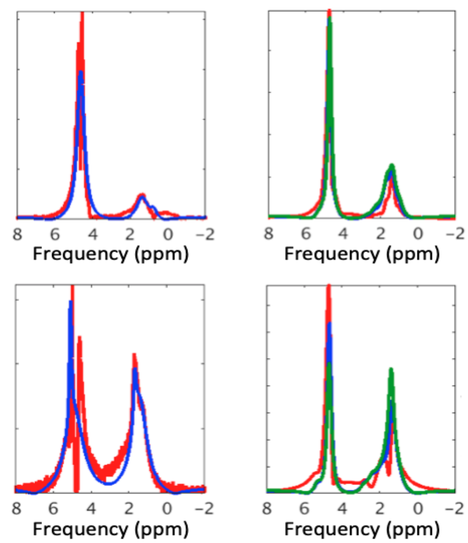

Fig. 1: Typical spectra in MCD mice, with (top row) and without (bottom row) iron injections. Left – spectra acquired with PRESS (shown in red is the raw spectrum, in blue the phased HSVD fit). Right – spectra acquired with CS SE-SPI (shown in red is the raw spectrum of a 3x3x3 sub-volume, in blue the phased HSVD fit of that sub-volume, in green the phased HSVD fits averaged over the entire liver).

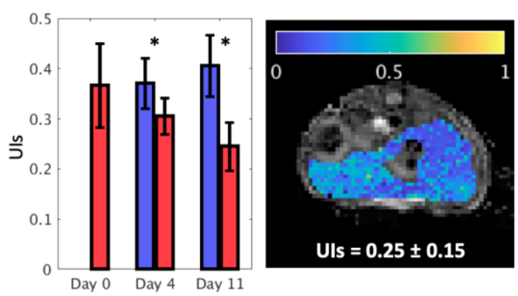

Fig. 2: Left – UIs as measured using CS SE-SPI showed a significant decrease ($p < 0.05$ using Welch's t-test) in the MCD group (red) as compared to the control group (blue) on days 4 and 11 following the start of the diet; error bars indicate 95% confidence intervals. Right – CS SE-SPI and corresponding map of UIs in the liver of one of the mice on day 11 of the MCD diet (value indicated is mean ± sd).

Results and Discussion: Phantom results showed good agreement between PRESS and CS SE-SPI. In the mouse study, PRESS measurements of fat composition were limited by increased line width and peak splitting (see Fig. 1), likely a result of large voxel size and lack of respiratory compensation; as such, no trends were observed. CS SE-SPI showed no significant trends in UI or PUI; however, a significant decrease in UIs was observed in MCD mice (see Fig. 2), in agreement with literature results [2].

Conclusion: This work demonstrates that CS SE-SPI can provide reliable maps of fatty acid composition. If accurate fatty acid profiles could be acquired clinically it would allow researchers to investigate the hypothesized role that differing profiles might play in liver disease.

References: [1] Johnson *et al.*, Hepatology (2008). [2] Li *et al.*, J. Biol. Chem. (2009).