Implementation of Metabolite Cycling ^{1}H MR Spectroscopy on a 7T Parallel Transmit System: First Application in Skeletal Muscle

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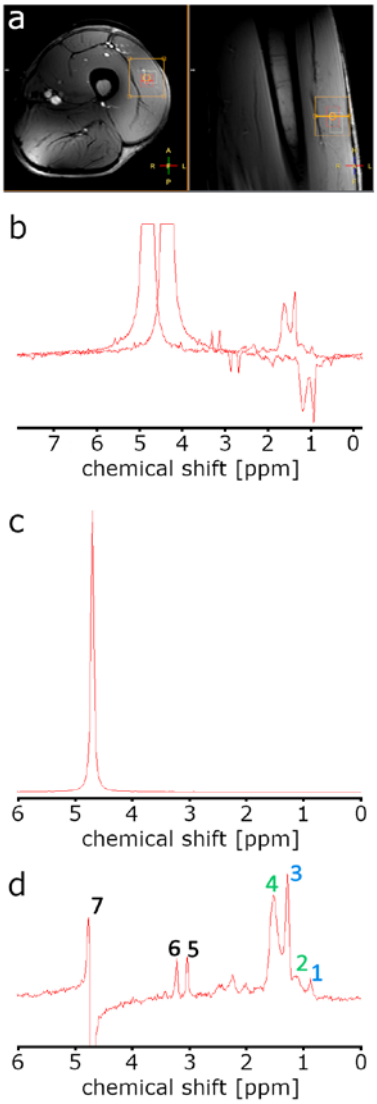
Introduction: Single voxel (SV) magnetic resonance spectroscopy (MRS) in body applications often suffers from either a lack of spatial specificity, due to large voxel sizes, or from low signal-to-noise ratios. Additionally, respiratory and other motion, induces phase and frequency shifts, which then leads to incoherent averaging, and hence to suboptimal results. Metabolite cycling[1] (MC), has been proven beneficial, especially for small voxel volumes which are influenced by motion[2-4]. However, especially at ultra-high fields, SV applications in the body suffer from large B_0 and B_1 inhomogeneities as well.

This work demonstrates the first implementation of MC spectroscopy on a 7T system with parallel transmit capability, in order to overcome B_1 issues and increase spatial specificity in SV body MRS.

Methods: All measurements were performed at a 7T whole body system (Philips, Best, The Netherlands) using eight parallel transmit channels, each connected to a transmit-receive fractionated dipole antenna[5] (MR Coils BV, Drunen, The Netherlands) and 16 additional receive loops integrated with the antennas (2 per antenna). The volunteer gave written informed consent according to local ethics regulations.

First, a T1 weighted image of the legs of the volunteer was recorded. The voxel (15×15×20 mm^3) was then placed in the vastus lateralis (see Fig. 1a). B_0 shimming and B_1 shimming was performed using the MRCode software (MR Code BV, Zaltbommel, The Netherlands). A spectrum was acquired using non-water-suppressed STEAM (N_{avg} = 64; TE/TM/TR = 12.5/37/2000 ms) with the MC pulse applied during the mixing time (TM). The spectra were then phase and frequency corrected before averaging.



Results & Discussion: Figure 1b displays the summed upfield and downfield inverted spectra. After correcting the frequency shift between those, a water spectrum (Fig. 1c) and a metabolite spectrum (Fig. 1d) were calculated. In the metabolite spectrum the IMCL and EMCL signals are clearly separated. Such clear separation can only be achieved at the high spectral resolution attained by the ultra-high field strength of 7T and high quality B_0 shimming.

While SV MRS in the leg certainly does not suffer from respiratory motion, these initial results demonstrate that the suggested technique, namely non-water-suppressed MC-STEAM at a 7T system capable of parallel transmit, is a promising approach to separately detect IMCL and EMCL in the heart.

References

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Figure 1: *MC-STEAM localized spectra in the vastus lateralis muscle. (a) depicts the voxel position (15×15×20 mm^3) in the vastus lateralis. (b) displays the sum of the upfield inverted spectra and the sum of the downfield inverted spectra acquired. (c) shows the pure water signal, calculated by summing all acquired spectra after frequency correction, while (d) displays the metabolite spectrum calculated by subtracting the upfield inverted spectra from the downfield inverted spectra after frequency correction. Peaks annotations in the spectrum (green: IMCL; blue: EMCL): 1,2: methyl; 3,4: methylene; 5: total creatine; 6: TMA; and 7: residual water.*