Using Long Echo Times in Proton Magnetic Resonance Spectroscopy in the Vastus Lateralis Muscle

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Introduction: The majority of Proton Magnetic Resoncance Spectroscopy (^{1}H-MRS) studies engaged in intramyocellular lipid (IMCL) quantification have used short echo time (TE = 10-40 ms) acquisition methods. The short TE spectra are characterized by large, broad and asymmetric resonances from metabolites with short spin-spin (T_2) relaxation times, causing spectral overlap. An optimal separation of IMCL and extramyocellular lipid (EMCL) can be found in the soleus and tibialis anterior muscle, in the lower leg, due to the parallel muscle fiber orientation. However, for physiological studies, investigation of the vastus lateralis muscle is important as biopsies are generally performed on this muscle. Due to a decrease in parallel muscle fiber orientation, the overlap of the IMCL and EMCL peaks increases in the vastus lateralis muscle, making IMCL quantification more challenging. It is reported that acquisition of ^{1}H-MRS spectra with long TE (at 270 ms) improves separation of the lipid peaks in soleus and tibialis anterior muscle [1, 2]. To compensate for the loss of signal with a longer TE, an increase of voxel size can be implemented more easily in the relatively large vastus lateralis muscle as compared to the smaller muscles in the lower leg. Besides an improved separation of the lipid peaks, the use of long TE may reveal metabolites with longer T_2 relaxation times, due to the relative suppression of short T_2 metabolite signals.

Materials and methods: One male and two female lean subjects (age 29 +/- 2 yrs.) were positioned supine in a whole body MRI-scanner (Achieva, 3T, Philips Healthcare) with the left leg positioned parallel to the main magnetic field. A two-element flexible surface coil was positioned on the vastus lateralis muscle. T_2-weighted turbo spin echo images consisting of three transversal slices were acquired (FOV 250 x 210 x 30 mm, slice thickness 0.9 mm, TR/TE 2000/100 ms, turbo factor 20), which enabled precise positioning of the voxel. The ^{1}H-MRS spectra were acquired with a point-resolved spectroscopy sequence (PRESS). Parameters were TR = 2000 ms, TE = 37 ms for short TE and TE = 350 ms for long TE, spectral bandwidth 2kHz, number of points 2048, the number of averages was 32 for short TE and 256 for long TE with 16 phase cycling steps and the voxel volume was between 5.8 and 15 mL. In contrast to the short TE spectra, no water suppression was used for the long TE spectra. Shimming was performed automatically using an iterative procedure.

Results: Figure 1 shows that spectra acquired with long TE are characterized by an increased lipid peak separation when compared to short TE spectra. Besides a better separation between the methylene peaks of IMCL and EMCL, the methyl peaks of both IMCL and EMCL are better resolved. The creatine peak (at 3.03 ppm) is apparent as a relatively broad, asymmetric peak at short TE, but becomes a single, symmetrical resonance at long TE. Remarkable is the appearance of the sharp peak at 2.13 ppm in the long TE spectra, which is hardly visible with short TE. This peak can be attributed to the acetyl group of acetylcarnitine [3].

Discussion: Spectra with excellent separation of the methylene and the methyl peaks of IMCL and EMCL can be acquired in the vastus lateralis muscle at long TE. After correction for T_1 and T_2 relaxation, the ratio between the methylene and methyl peaks of IMCL can be determined as a parameter of average fatty acid chain length. The creatine peak can be used as an internal concentration reference. Contamination of this peak is diminished at long TE, which makes quantification more reliable. In vivo detection of acetylcarnitine, which is facilitated by the relative suppression of broad peaks from short T_2 metabolites, can provide new insights into skeletal muscle cell metabolism, as this metabolite can possibly be seen as a marker for mitochondrial imbalance between acyl-CoA load and tricarboxylic acid cycle activity [4].

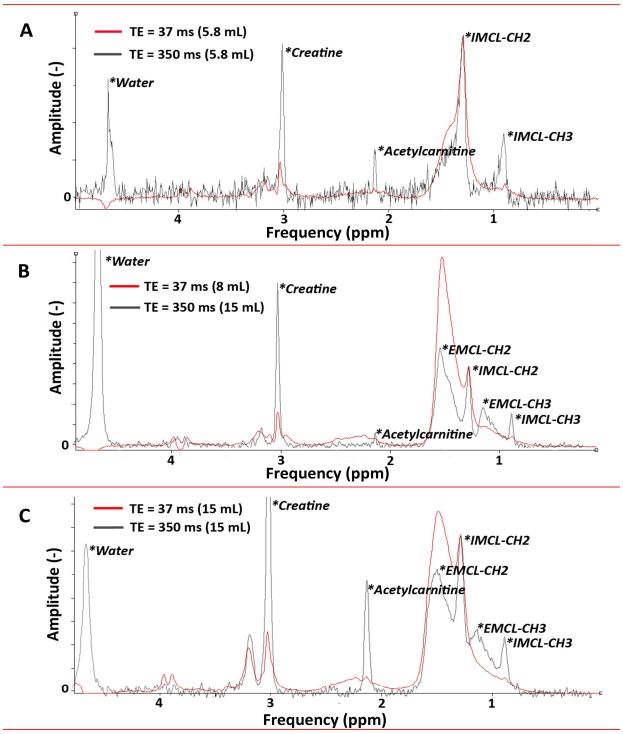

Figure 1. Proton MR spectra of three subjects (A, B and C) in the vastus lateralis muscle. Spectra acquired with TE = 37 ms are shown in red, spectra with TE = 350 ms in green. When using a long TE, the lipid peaks are better separated, the creatine peak is less contaminated and a sharp acetylcarnitine peak at 2.13 ppm appears.

References:

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