A New Spectral Editing MRS Sequence for Lactate and GABA Using a Unique Basing Pulse Combination for Coupled-Spin Inversion at long TE

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Introduction: Magnetic resonance spectroscopy can be used for *in vivo* detection of the faint and often lipid-corrupted lactate doublet centered at 1.33 ppm. In the visual cortex, detection and quantification of the lactate doublet can be used to investigate metabolic abnormalities in patients with panic disorder [1]. A previous spectral editing method used frequency-selective Shinnar Le-Roux (SLR) inversion pulses [2], referred to as BASING pulses, which, by effectively implementing a spin-echo with respect to the second-order magnetization states induced by J-coupling modulation, rendered positive the normally-inverted lactate doublet at TE 144ms. An additional benefit of using the basing pulses was that the positive doublet was not reduced in intensity by chemical shift misregistration, as normally occurs with the inverted lactate doublet. In the single-voxel PRESS sequence outlined in [2], one BASING pulse was applied both before and after the second 180 degree refocusing pulse. When interleaved with the standard PRESS sequence to provide two spectra, one with upright and one with inverted lactate doublet, overlapping lipid signal could be eliminated (edited) by subtracting the spectra with the inverted lactate from the spectra with the upright doublet obtained using the BASING pulse. One disadvantage of this TE=144ms based editing scheme is that the inverted doublets are reduced in size because of signal cancellation associated with chemical shift misregistration of lactate. However, it was reported that no chemical shift misregistration signal loss occurs using TE=288ms [3]. This report prompted our development of a new spectral editing scheme using BASING pulses in which both inverted and upright doublets are acquired at TE=288ms.

Methods: When TE=288ms the lactate doublet is normally upright. An inverted doublet for lactate at TE=288ms is achieved using a PRESS sequence with two frequency selective BASING pulses placed in between the two PRESS 180 degree refocusing pulses, and separated by an interval of TE/4 (Fig. 1). In the figure, the RF pulses labeled Inv_{-y} represent the 21.6ms maximum phase SLR inversion pulses which have a 180Hz inversion band centered on the lactate quartet at 4.1ppm and 0.5% ripple in both the stop and pass bands [4].

The GABA triplet at 3.0 ppm was also spectrally edited using the same sequence with the appropriate TE and frequency offset of the Basing pulse for inverting the protons of GABA located at 1.9 ppm which are coupled to the triplet at 3.0 ppm. The two outer peaks of the GABA triplet interact effectively as a doublet with a difference in the frequency of precession between the two subpopulations of the triplet of 2J rather than J. Consequently, since the editing sequence for the lactate doublet requires TE=288ms, the sequence for the GABA triplet requires TE=144ms. For GABA, the SLR inversion pulse was modified to have 18ms duration, 111Hz inversion BW, 0.83% ripple in stop band and 1.5% ripple in pass band, and to improve signal the crushers surrounding the SLRs were turned off for the GABA experiments.

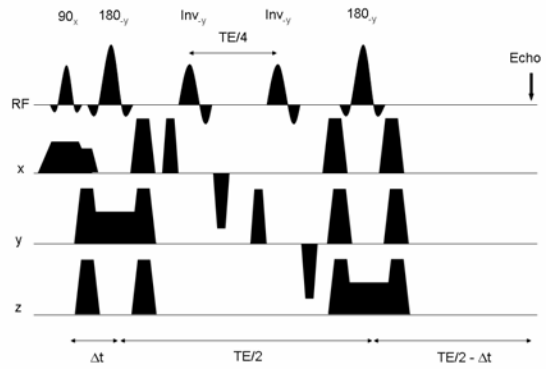

Figure 1. Pulse Sequence Diagram

The sequence was implemented on a Siemens Trio 3T whole body MRI system (Siemens Medical Solutions, Erlangen). The lactate experiment was performed on a human volunteer with IRB signed consent using a Nova Medical Bitemporal Array (Wilmington, MA) surface coil for signal reception, with TE=288ms, TR=1550ms, 256 averages for each acquisition, 16 step EXOR phase cycling, 2048 points, 2kHz receiver BW for the PRESS refocusing pulses, 25mmx30mmx20mm voxel placed in visual cortex, SLR frequency offset from water = -77Hz. The GABA experiment was performed on a phantom containing 10mM GABA in water with the same surface coil, TE=144ms, TR=1500ms, 128 averages for each acquisition, 16 step EXOR phase cycling, 2048 points, 2kHz receiver BW, 40mmx40mmx40 voxel and SLR frequency offset from water = -375Hz. Post-processing was done in jMRUI v2.2 and consisted of zero filling from 2048 to 4096, hard phase alignment to the residual water signal and apodization with 4Hz Gaussian filter.

Results and Discussion: Fig. 2 shows the TE=288ms lactate editing results. The top line shows the inverted lactate doublet from the acquisition with the SLR inversion pulses on, the middle line shows the upright doublet from the acquisition with standard PRESS sequence, and the bottom line is the edited spectra obtained by subtracting the inverted from the upright spectra. The arrow points to the edited lactate doublet centered at 1.32ppm. The inverted doublet does not show chemical shift misregistration signal loss when compared to the upright acquisition. Fig. 3 shows the TE=144ms GABA 3.0ppm outer triplet peak editing results, the top line shows the upright peaks from the acquisition with no SLR inversion pulses, the middle line shows the inverted peaks from the acquisition with the SLR inversion on, and the bottom is the edited spectra. The spectral editing sequence will be most effective at higher field, where chemical shift misregistration is likely to cause greater signal loss than the additional T2 decay of the longer TE.

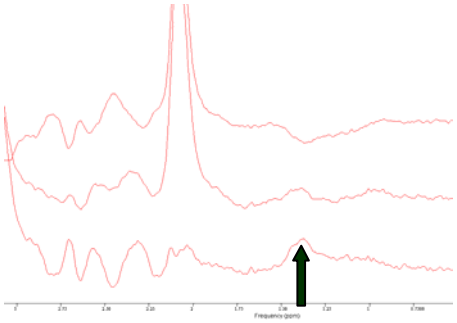

Figure 2. In Vivo Lactate Editing with TE=288

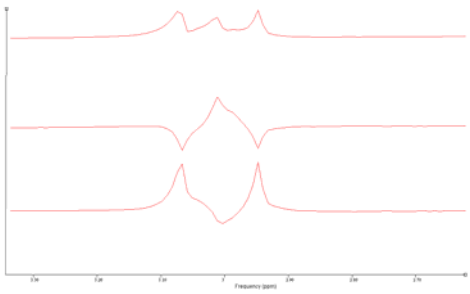

Figure 3. Phantom GABA Editing with TE=144

References: 1) Maddock *ISMRM* Poster 2084, 2006. 2) Star-Lack *JMR* 133:243-254, 1998. 3) Lange *AJNR* 27:895-901, 2006. 4) Kelley *JMRI* 9:732-737, 1999.

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