A Four-Pulse PRESS Sequence for Correction of the Chemical Shift Misregistration Signal Loss in Lactate Spectroscopy

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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 1.32 ppm. In the visual cortex, detection and quantification of this lactate doublet can be used to investigate metabolic abnormalities in patients with panic disorder [1]. While the standard PRESS sequence is normally used for single-voxel detection of this doublet, the combination of chemical shift misregistration and excitation bandwidth subdivides the single voxel into four sub-volumes, where within each sub-volume the evolution of the doublet due to J-coupling with the quartet of the lactate is unique [2]. For TE=1/J=144ms, certain sub-volumes have signals from the doublet that are 180° out of phase with doublet signals from other sub-volumes, leading to signal loss. Previous methods for correcting this signal loss [3] rephased the doublet components along the positive axis. We have developed a method for rephasing the components along the negative axis, enabling spectral editing with a J-modulation corrected upright spectrum and a J-modulation corrected inverted spectrum.

Methods: The sequence shown in Fig. 1 was originally developed for the inverted acquisition of a J-coupling based GABA editing sequence [4]. The two outer peaks of the edited GABA triplet behave similarly to the lactate doublet, except that the frequency of precession is J rather than J/2. For GABA, a TE=68ms sequence appropriate for 1/2J coupling rate, set up for editing the GABA triplet, will be the correct sequence for 1/J coupling rate of the lactate by setting TE =144 ms.

Detailed analysis of the doublet evolution in the four sub-volumes of the voxel show that the doublet signals are all along the –y-axis for the region where the coupled quartets are hit by both PRESS 180°s (red), 16.64° dephased in regions where the coupled quartets are hit by only one of the PRESS 180°s (light and dark blue) and 33.28° dephased in the region where neither of the PRESS 180°s hit the coupled quartet (teal) (Fig. 3, right). In the standard PRESS sequence, signal from the teal region cancels signal from the red, and signal from the dark blue region cancels signal from the light blue (Fig. 3, left). The detailed dephasing angle calculations are made using Δt = 6700μs and J = 6.9Hz, and computing a relative size of each sub-volumes based on a 1kHz excitation BW. Theoretical lactate doublet signal loss with idealized RF pulse transitions is 3.68% with the modified PRESS sequence and 66.67% with the standard PRESS sequence.

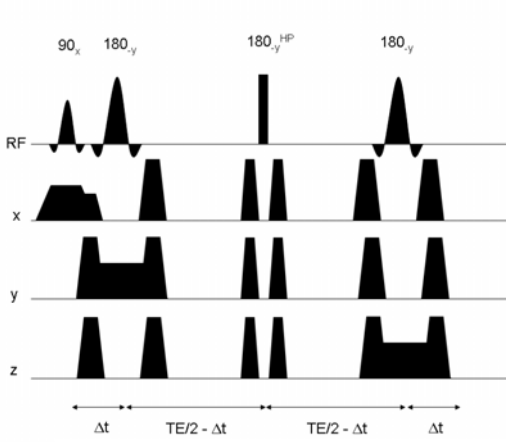

Figure 1. Pulse Sequence Diagram

This modified PRESS sequence was implemented on a Siemens Trio 3T whole body MRI system (Siemens Medical Solutions, Erlangen, Germany). Experiments used a standard GE MRS Brain phantom (containing physiological concentrations of Creatine, Choline, NAA, and lactate) and a Nova Medical, Inc. Bitemporal Lobe Array (Wilmington, MA) surface coil for signal reception. Scan parameters were TE=144ms, TR=1500ms, 128 averages, 2048 points, 2kHz receiver BW, 20mmx20mmx20mm voxel and CHESS water suppression. The standard PRESS sequence used 16 Step EXOR phase cycling and modified PRESS used a novel 16 step phase cycling scheme for four pulses and a 500μs duration hard pulse. Post-processing was done in jMRUI v2.2 with zero filling from 2048 to 4096, hard phase referencing to water, and apodization with a 6Hz Lorentzian filter.

Results: Fig. 2 shows the 3T results using the standard MRS phantom containing physiological concentrations of Choline, Creatine, NAA and Lactate. The top line is the acquisitions with standard PRESS and the bottom line is with the modified PRESS sequence. The lactate doublet signal gain, arising from the elimination of signal cancellation from the different sub-volumes of the selected single voxel, is clearly visible in the modified PRESS spectrum. A slight decrease in the NAA peak is observed. This decrease could be due to incomplete rephasing caused by the additional hard refocusing pulse. The cause and remedy of this decrease is under investigation.

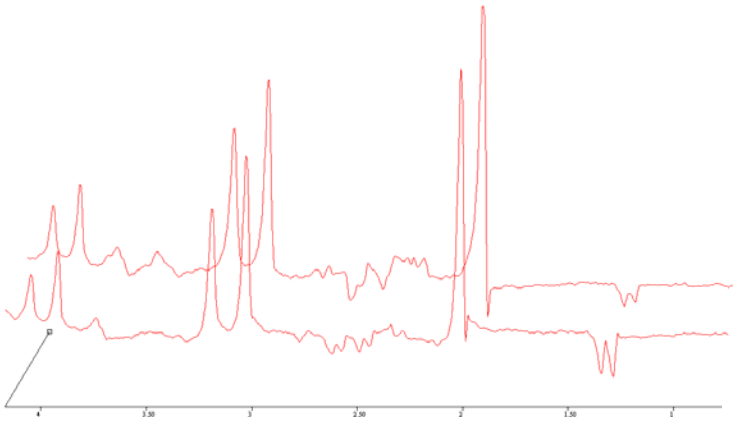

Figure 2. PRESS (top) and Modified PRESS (bottom) MRS Phantom Spectra

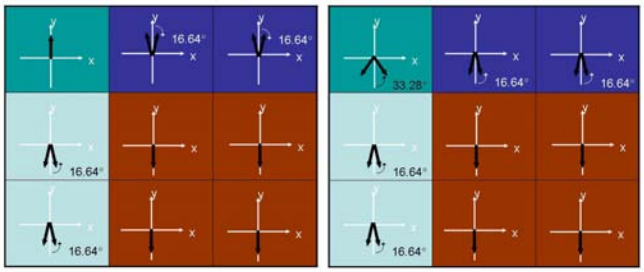

Figure 3. Lactate Doublet Signal Contributions at Echo for PRESS (left) and Modified PRESS (right)

References: 1) Maddock *ISMRM* Poster 2084, 2006 2) Yablonskiy *MRM* 39:169-178, 1998 3) Kelley *JMRI* 9:732-739, 1999. 4) Keltner *MRM* 36:458-461, 1996.

Acknowledgements: Work was partially supported by a scholarship from Northern California ARCS Foundation, Inc. and a UC Davis Imaging Research Center Graduate Fellowship