Implementation and Validation of Localized Constant-Time PRESS on a 7T MRI/MRS scanner

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Introduction: Ongoing effort is directed to developing methods for improving spectral resolution and quantification of brain metabolites at pre-clinical and clinical field strengths. Recently, a constant-time approach has been applied in conjunction with localized MRS techniques towards this goal (1-3). In order to improve the detection of overlapping brain metabolites without inducing coherence transfer we have implemented and validated a localized constant-time (CT) spectroscopic method based on PRESS.

Methods: Localized constant-time PRESS (LCT-PRESS) was implemented on a 7T Cliniscan MRI/MRS scanner equipped with a 72mm volume resonator for RF transmit in combination with a four channel phased array receive coil. The sequence utilizes three slice-selective RF pulses [90° – $(T_{CT} + t_1)/2$ – 180°- $(T_{CT} - t_1)/2$ – 180° – acquisition] to achieve volume localization. The interval between the first 90° pulse and the following 180° pulse was incremented by $t_1/2$, while the interval between the 180° pulse and the final 90° pulse was correspondingly decremented by $t_1/2$. The evolution interval, $(T_{CT} + t_1)/2$, was placed after the first slice selection pulse while the second evolution interval, $(T_{CT} - t_1)/2$, was placed after the crusher gradients surrounding the 180° pulse. The position of the 180° refocusing pulse was, in effect, stepped through the fixed delay of T_{CT}. By design, the sequence exhibits spin-spin decoupling along the F1 dimension with improved spectral separation for all overlapping resonances. The method was validated in a brain phantom containing GABA 2.5mM, L-aspartate (Asp) 1 mM, creatine (Cr) 4mM, ethanolamine (Et) 2.5mM, glucose (Glc) 2mM, glutamate (Glu) 7mM, glutamine (Gln) 3mM, glutathione (GSH) 1.5mM, glycerophosphorylcholine (GPC) 1mM, myo-Inositol (mI) 4mM, lactate (Lac) 5mM, phosphocreatine (PCr) 3.3 mM, phosphorylcholine (PCh) 1 mM, taurine (Tau) 13mM, N-acetyl aspartate (NAA) 6.5mM and NAAG 0.5mM. The metabolites were prepared in a buffer containing 1 mM DSS, 72mM K_2HPO_4, 28mM KH_2PO4, 200mM Na formate, 1g/L NaN_3. at a pH of 7.2. The in vivo experiments were performed on healthy rats using a voxel size of 0.4 x 0.4 x 0.4 cm3 (64 µl) predominantly from the striatum of the brain. The experiments were performed with TR/T_{CT} of 2s / 26ms, 50 t_1 increments, and 16 averages for each experiment, resulting in a total acquisition time of ~ 26 minutes. For in vivo studies the animals were anesthetized under isoflurane and rectal temperature and respiration rate were monitored throughout the experiment and maintained in physiological range. All the protocols were approved by the local ethics committee.

Results: Figure 1 shows the coronal slice image of the rat brain obtained by a turbo spin echo sequence and the MRS voxel location is shown for all the measurements. Fig 2 shows the LCT – PRESS spectrum obtained from the rat brain. The LCT-PRESS spectrum clearly demonstrates the well resolved resonances of several metabolites at 7T. The table shows the assignment of various metabolites. The LCT-PRESS sequence performs this separation due to its incorporation of constant-time evolution, resulting in spin-spin decoupling along the F1 dimension. LCT-PRESS is also seen to be effective in separating the resonances of Glc, Glu which cannot be achieved by conventional approaches.

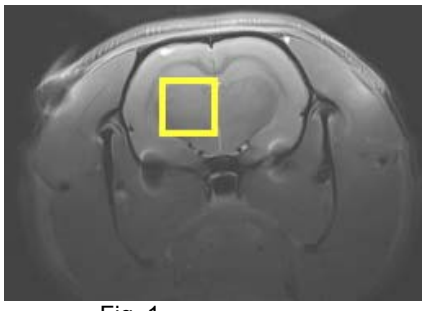

Fig. 1

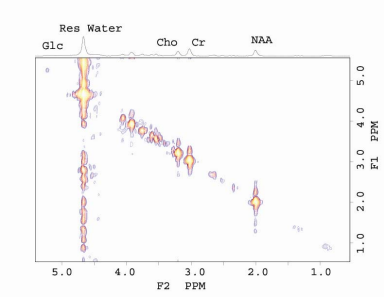

Fig. 2

PPM	Assignment
0.9	Macromolecules, Valine
1.31	Lac
2.0	NAA (Acetyl moiety)
2.34	Glu + GABA
2.5	Glutathione
2.66	Asp
3.03	Creatine
3.2	Choline + GPC+PC
3.61	GPC+ mI
3.74	Glu + Gln
3.9	Cr + GPC
4.05	Ch+mI
5.2	Glucose

Discussion: Several brain metabolites overlap with each other due to the limited spectral separation at both pre-clinical and clinical field strengths. The LCT-PRESS sequence performs this separation due to its incorporation of constant-time evolution, resulting in spin-spin decoupling along the F1 dimension. LCT-PRESS is also seen to be effective in separating the resonances of Glu and Glc which cannot be achieved by conventional approaches.

Conclusion: We have implemented and validated the LCT-PRESS technique in healthy rat brain. This sequence clearly demonstrates superior resolution and permits reliable detection of several brain metabolites that overlap in conventional techniques.

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