Macromolecule Suppressed GABA Editing with Single Spin-Echo and Out-of-voxel Artifact Suppression

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INTRODUCTION: In-vivo measurement of Gamma-aminobutyric-acid (GABA) using magnetic resonance spectroscopy offers valuable information in understanding brain functions. Based on J-difference editing, MEGA PRESS, has been used to detect the GABA resonance at 3ppm [1]. For maximum signal strength, the editing pulse is generally applied at 1.9ppm and 7.5ppm with an echo time of 68ms. However, due to the wide transition bandwidth of the editing pulse, macromolecule resonances are coedited, with the signal at 3ppm mostly contributed from lysine, whose 3ppm resonance is coupled with its 1.7ppm resonance. To suppress macromolecule signals, a symmetric suppression method has been proposed where the editing pulse is applied at 1.9ppm and 1.5ppm with the assumption that the macromolecule 1.7ppm resonances are equally affected from the editing pulses so that the partially edited resonances at 3ppm are cancelled out in the edited spectrum. Unfortunately, this method results in reduced GABA signal because the editing pulse applied at 1.5ppm partially inverts the 1.9ppm resonance even when more selective editing pulses are used at a longer TE of 80ms [2]. Instead of using a double spin-echo MEGA-PRESS sequence, a 1D ISIS based single spin-echo editing sequence, MEGA-SPECIAL, has been developed to allow more selective editing pulses at the optimal TE of 68ms [3]. However, out-of-voxel artifacts can rise from imperfect ISIS subtraction. This issue is worse when there are susceptibility artifacts or motion in the ISIS direction. Here, we propose out-of-voxel artifact suppression in the ISIS direction using a 1D echo planar (EP) version of SIAM[4]. This approach can alternatively be viewed as a 1D implementation of the sensitive point method [5]. The result is a MEGA-SPECIAL sequence for macromolecule suppressed GABA editing with reduced subtraction burden.

METHODS: A MEGA-SPECIAL sequence with EPI readout gradient for out-of-voxel artifact suppression was implemented on a GE MR750 scanner (Waukesha, WI) as shown in Figure 1. A 5000Hz adiabatic hyperbolic secant, HS, pulse was used for the 1D ISIS localization in the Z direction. A 25ms Gaussian pulse with 50Hz transition bandwidth was used for GABA editing. By applying an EPI readout gradient with the corresponding acquisition bandwidth, out-of-voxel signals in the ISIS direction are suppressed. The spectral FID was sampled with1024 data points and a bandwidth of 2500Hz. The acquisition of each data point was set to occur when the K-space trajectory is at zero. The EPI gradient strength was calculated based on the acquisition bandwidth and the prescribed slice thickness. A 50mM GABA phantom and a 50mM lysine phantom were built to evaluate the GABA editing and macromolecule suppression at TE/TR=68ms/2s, 32 averaging with a voxel size of 25x25x25mm. The macromolecule suppression and its effect on GABA editing were investigated by comparing edited GABA/Lysine peaks at 3ppm with the editing pulses applied at 1.9/7.5ppm and 1.9ppm/1.5ppm. The comparison of GABA editing with and without macromolecule suppression and the effect of out-of-voxel artifact suppression was performed on human subjects with the same prescription as the phantom studies except for with 64 averaging at an acquisition time of 8 minutes. The effect of the out-of-voxel suppression was investigated by turning the EPI gradient on and off.

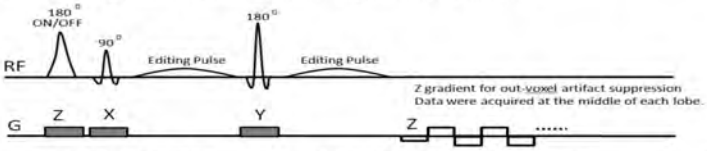

Fig 1. MEGA-SPECIAL sequence with EPI for out-voxel suppression.

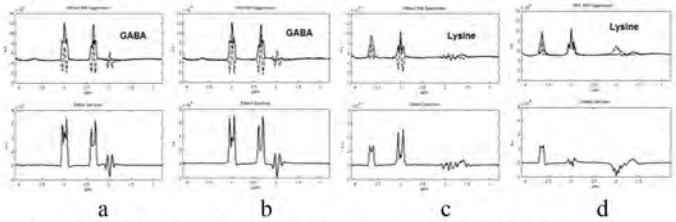

Fig 2. Spectra from GABA/Lysine phantoms without(a/c) and with(b/d) MM suppression.

RESULTS: Spectra from the GABA and lysine phantoms with and without macromolecule suppression are shown in Figure 2. Measured from the phantom experiments, the edited GABA signal with macromolecule suppression is 98% of that without macromolecule suppression. The edited lysine signal with macromolecule suppression is 7% of that without macromolecule suppression. Figure 3 and Figure 4 are representative spectra from occipital lobe and striatum with EPI on and off. For voxels with poor field homogeneity in the ISIS direction such as in striatum, the out-of-voxel suppression significantly improved the baseline of the edited spectra while producing identical edited spectra for voxels in the occipital lobe. As shown in Figure 5, macromolecule suppression reduced the 3ppm peak by 50% in the edited occipital spectrum.

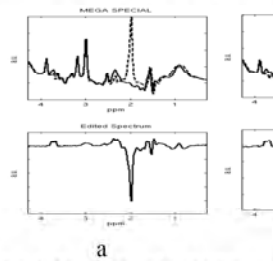

Fig 3. Occipital lobe spectra with EPI on(a)/off(b).

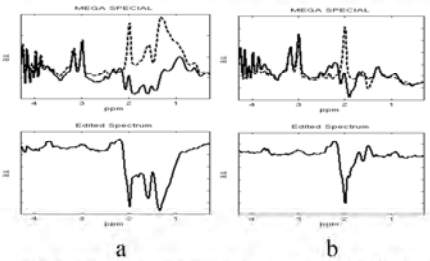

Fig 4. Striatum spectra with EPI on(a)/off(b).

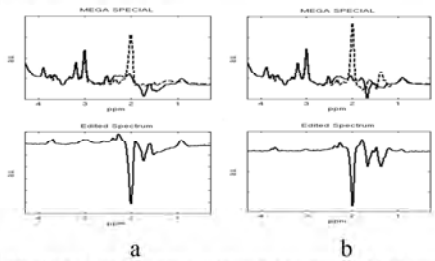

Fig 5. Occipital lobe spectra without(a)/with(b) MM suppression.

CONCLUSIONS: A MEGA-SPECIAL sequence with out-of-voxel artifact suppression using the EP-SIAM was developed for GABA editing and macromolecule suppression. Phantom studies showed 93% macromolecule suppression while maintaining 98% GABA signal. In-vivo studies demonstrated significantly improved baseline using out-of-voxel artifact suppression. With macromolecule suppression, edited peak at 3ppm reduced 50%, indicating significant macromolecule contribution.

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