Macromolecule Suppressed GABA Editing using Spectral Spatial RF Pulses

Meng Gu[1], Adam B. Kerr[2], Ralf E. Hurd[3], and Daniel M. Spielman[1]

[1]Radiology, Stanford University, Stanford, California, United States, [2]Electrical Engineering, Stanford University, Stanford, California, United States, [3]GE Healthcare, Menlo Park, California, United States

INTRODUCTION: Gamma-aminobutyric-acid (GABA) is the major inhibitory neurotransmitter in the human brain and in-vivo measurement of GABA using magnetic resonance spectroscopy offers valuable information in understanding brain functions. Based on J-difference editing, MEGA PRESS [1], has been used to detect the GABA resonance at 3ppm. In order to achieve the 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. The assumption of this method is 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 longer and more selective editing pulses are used at a longer TE of 80ms [2].

Here, we present a new editing method by incorporating spatial and spectral selectivity into the PRESS refocusing RF pulses to achieve both GABA editing and macromolecule suppression. As shown in Figure 1, by using spectral-spatial refocusing RF pulses with narrow transition bandwidths, GABA resonance at 3ppm can be edited by refocusing ("ON" case)/not refocusing ("OFF" case) the 1.9ppm resonance. As the lysine 1.7ppm resonance is not refocused in either case, its resonance at 3ppm is suppressed in the edited spectrum.

METHODS: A spectral-spatial 180° pulse with a minimum-phase spectral filter was designed with a 2D inverse SLR approach to achieve refocusing with narrow transition bandwidth [3-5]. The variable-rate selective excitation (VERSE) algorithm was applied to reduce the peak B1 for each subpulse [6]. The final pulse used had a 31ms duration, 440Hz spectral bandwidth, 33Hz transition bandwidth and a 27μT peak B1. Pulse and gradient waveforms are shown in Figure 2. A pair of the spectral-spatial refocusing pulses were incorporated into a PRESS sequence and implemented on a GE 3T MR scanner. The corresponding frequency profile at the spin echo is shown in Figure 3.

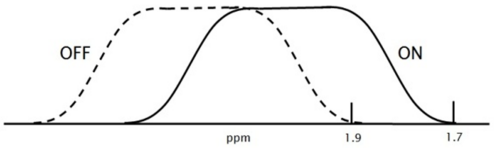

Fig. 1 GABA editing scheme using spectral-spatial pulses.

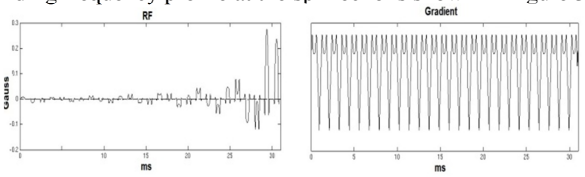

Fig 2. Pulse and gradient waveforms of the spectral-spatial pulse.

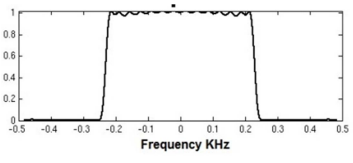

Fig 3. Frequency profile at spin echo.

RESULTS: A 50mM GABA phantom and a 50mM lysine phantom were built to test the GABA editing and macromolecule suppression. The spectral-spatial based editing sequence was compared with the MEGA PRESS with symmetrical suppression at TE/TR=80ms/2s, 16 averaging with a voxel size of 4x4x2cm. The MEGA PRESS editing pulses were applied at 1.9ppm and 1.5ppm while the spectral-spatial pulse frequencies were shifted by 35Hz. Spectra of the "ON" and "OFF" cases and the edited spectrum for the MEGA PRESS and spectral-spatial PRESS are shown in Figure 4 and Figure 5. Measured from the phantom experiments, the edited GABA signal using spectral-spatial PRESS is 15% higher than that using MEGA PRESS with symmetrical suppression. The MEGA PRESS achieved 95% lysine suppression while the spectral-spatial PRESS achieved 90% lysine suppression. The comparison of MEGA PRESS and spectral-spatial PRESS was performed on several human subjects with the same prescription as the phantom studies except for with 64 averaging at an acquisition time of 4:30 minutes. Shown in Figure 6 are the results from a representative 42-year-old healthy male subject. The measured GABA signal with spectral-spatial PRESS is 24% higher than with MEGA PRESS.

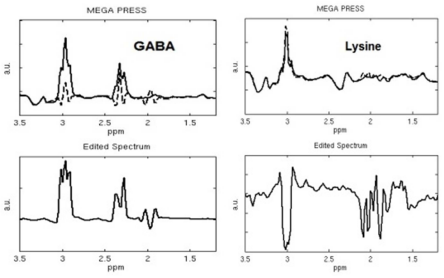

Fig 4. GABA/lysine spectra using MEGA PRESS.

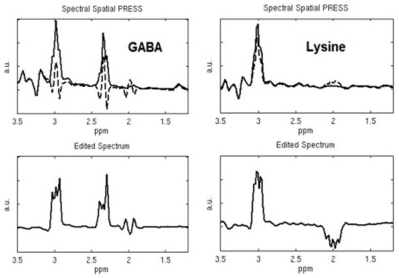

Fig 5. GABA/lysine spectra using spectral-spatial PRESS.

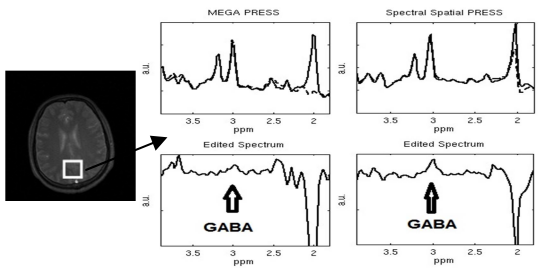

Fig 6. In-vivo spectra using MEGA PRESS and spectral-spatial PRESS.

CONCLUSIONS: A new editing method based on spectral-spatial RF pulses was developed for GABA editing and macromolecule suppression. Phantom studies showed higher edited GABA signal compared with MEGA PRESS with symmetrical suppression and 90% lysine suppression. In-vivo studies demonstrated significantly higher edited GABA signal compared with MEGA PRESS with symmetrical suppression. In addition to more efficient editing of the GABA signal, the use of spectral-spatial RF pulses offers other valuable benefits of lipid suppression and improved spatial selectivity compared with MEGA PRESS.

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