GABA detection with MEGA-PRESS at 3 Tesla; Improved Sensitivity using Inner Volume Saturation

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Introduction

The MEGA-PRESS method[1] is widely used for the edited detection of coupled metabolites such as GABA. Because the concentration of GABA in the human brain is relatively low, it is important to maximize the efficiency of the editing sequence for optimal SNR. While much work[2,3] has discussed signal losses in the PRESS detection of lactate due to spatial variations in the modulation pattern, less attention has been paid to the spatial evolution of coupling during the MEGA-PRESS experiment. In this abstract, a four-compartment model is used to predict the form of the coupling evolution, and it is shown that significant GABA signal losses occur in MEGA-PRESS measurements under typical measurement conditions at 3 Tesla. It is demonstrated in phantoms and the brain that the inner-volume saturation (IVS) method[4] can be used to overcome the signal losses and restore efficiency of detection.

Theory

The PRESS volume of the detected resonance contains four compartments, in which the coupled, passive spins experience neither, one, or both of the *slice-selective refocusing pulses* respectively. In regions in which the passive spins do not undergo both refocusing pulses, coupling will evolve in a manner other than the full evolution or refocusing required by the two acquisitions of the MEGA-PRESS experiment. It is possible to characterize the behavior of each compartment by an effective coupling evolution time (Table 1), which allows the multiplet form to be calculated in each case (Figure 1b,d,f).

Passive spins undergo	Editing Pulse Off	Editing Pulse On
Both	TE	0
First Only	TE1	0
Second Only	TE2	-TE1
Neither	0	TE1

Table 1. Effective coupling evolution times in the four-compartment model of both halves of the MEGA-PRESS experiment.

Material and Methods

MEGA-PRESS experiments were performed on a phantom (140 mM GABA) and on a healthy human volunteer, using a Philips Intera 3T system with a six channel SENSE receive head coil. RF pulses were transmitted on the body coil which has a maximum RF field of 14 μT (≈ 600 Hz). Phantom measurements of a 3x3x3 cm^3 voxel in 2 minutes and *in vivo* measurements were performed of a 3x3x3 cm^3 voxel located in the posterior white matter in a total experiment time of 17 minutes (TR = 2s, TE = 68 ms, TE1 = 15 ms, TE2 = 53 ms). Measurements were performed using 5-lobe sinc-Gauss slice-selective refocusing pulses of bandwidth 600 Hz. 2D MEGA-PRESS-MRSI was performed to demonstrate the spatial dependence of the evolution of the coupling (matrix size 20x20; FOV 80x80 mm^2; voxel 55x55x10 mm^3). MEGA-PRESS-IVS was performed by enlarging the voxel 50% in the two refocusing dimensions, and saturating signal in the regions of unwanted modulation to trim the voxel back down to the required volume. All MEGA editing pulses had a duration of 14 ms and were applied to the GABA spins at 1.9 ppm.

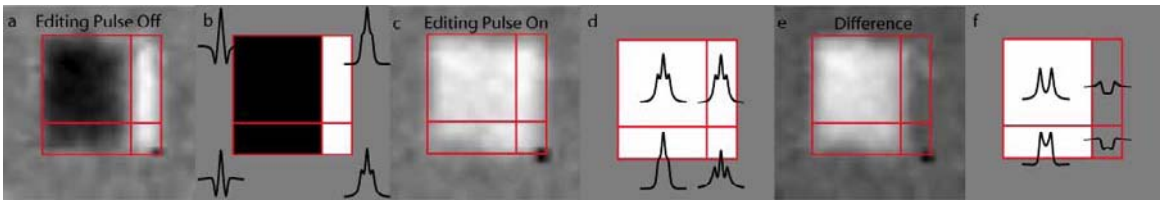

Figure 1. Comparison of MEGA-PRESS-MRSI (a,c,e) with four-compartment model predictions (b,d,f). MRSI plots the integral of the left-hand peak of the GABA triplet at 3.0 ppm.

Results

MRSI, plotting the integral of the outer peaks of the GABA triplet at 3.0 ppm, demonstrates good qualitative agreement with the four-compartment model (Figure 1a-f). IVS results in a 25% improvement in signal intensity in phantom measurements (Figure 2a), in agreement with the simulations (Figure 1f). MEGA-PRESS-IVS of a healthy volunteer results in a similar increase (28%) in the GABA signal detected, as well as an increase in the co-edited Glx signals (Figure 2b).

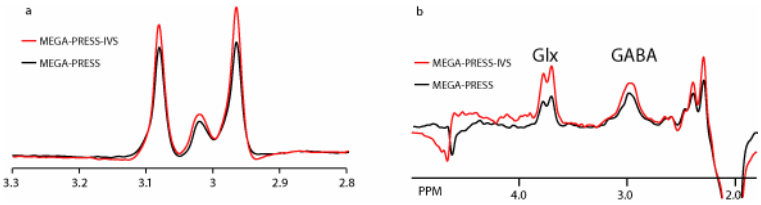

Figure 2. Comparison of MEGA-PRESS-IVS (red) with traditional MEGA-PRESS (black). Both phantom measurements (a) and in vivo measurements (b) show a similar increase in signal intensity with MEGA-PRESS-IVS.

Discussion

Spatial variation of coupling evolution due to the finite bandwidth of slice-selective refocusing pulses leads to significant loss in signal in PRESS-based methods. This is also true for editing methods based on MEGA-PRESS. The IVS method suppresses this variation, so that the desired modulation pattern is generated throughout the volume of interest. IVS has previously been applied to the PRESS detection of lactate[4]; in this abstract, the method is applied to the MEGA-PRESS detection of GABA. Although the increase in signal intensity achieved is moderate (~25%) under the current conditions, any increase in MEGA-PRESS sensitivity will benefit the detection of low-concentration coupled metabolites. Furthermore, it is expected that larger gains will be seen at higher field strengths, due to the increase in chemical shift dispersion and/or the use of weaker transmit B_1 fields. MEGA-PRESS-IVS is also expected to be useful for editing of other coupled spin systems at high fields.

References

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