Magnetic field strength dependence of S-PRESS signal modulation in glutathione

G. Gambarota[1], V. Mlynárik[1], L. Xin[1], and R. Gruetter[1,2]

[1]Laboratory for functional and metabolic imaging (LIFMET), Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [2]Departments of Radiology, Universities of Lausanne and Geneva, Switzerland

Introduction

It has been recently shown that AB and ABX coupled spin systems display significant signal modulations, at a fixed echo time, in the PRESS sequence (90° – [t_1/2] – 180° – [t_1/2] – [t_2/2] – 180° – [t_2/2] – Acq) as the first interpulse delay t_1/2 is varied (S-PRESS [1-3]). Such phenomenon has been verified in vivo for the coupled protons (AB) of citrate at 1.5 T [1, 2] and in vitro for the coupled protons (ABX) of the glutathione cysteine moiety at 7 T [3]. In the present study, we investigated the magnetic field strength dependence of the signal oscillations of the ABX protons. The goal was to determine the optimal echo time and interpulse delay t_1/2 for this novel method of difference spectroscopy editing for the glutathione cysteine moiety.

FIGURE 1

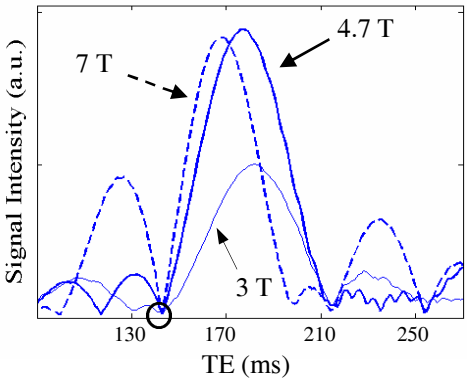

Figure 1. Simulated signal amplitude, as a function of TE, at 3, 4.7 and 7 T.

Methods

Density matrix simulations were developed to assess the J-modulation of the proton signal of the glutathione cysteine moiety (ABX spin system [3]) under PRESS excitation at 3, 4, 4.7, 7 and 9.4 Tesla. In vitro spectra were acquired at 7 T on a phantom containing glutathione, pH-balanced at 7.1, at the temperature of 37°.

Results and Discussion

The amplitude of the signal oscillation varies with the magnetic field strength B_0. At 4 T and 9.4 T, the amplitude is between the 3 T and the 4.7 T line (data not shown). For all field strengths, the signal displays the highest modulation at TE ~ 170 ms. The amplitude is maximal 4.7 T (**Figure 1**). At certain echo times (for example, at TE =143 ms, indicated by the symbol **O** in **Figure 1**), the amplitude of the signal oscillation is zero, that is, changing the first interpulse has virtually no effect on the signal intensity. The optimal parameters to achieve the highest difference in spectral area are TE = 176 ms, t_1/2 = 15, 44 ms at 4.7 T and TE = 168 ms, t_1/2 = 18, 42 ms, at 7 T (**Figure 2**). The frequency of the oscillation slightly increases with B_0 field strength. For reference, the signal intensity for TE = 143 ms, at 7 T, is shown (**Figure 2**). In vitro proton MR spectra of glutathione, acquired at 7 T, with the fixed TE (TE = 168 ms) and different t_1/2 (18, 42 ms) display a remarkable modulation (**Figure 3**), from positive to negative phase, in agreement with the spin simulations. The experimental difference spectrum is shown in C.

FIGURE 2

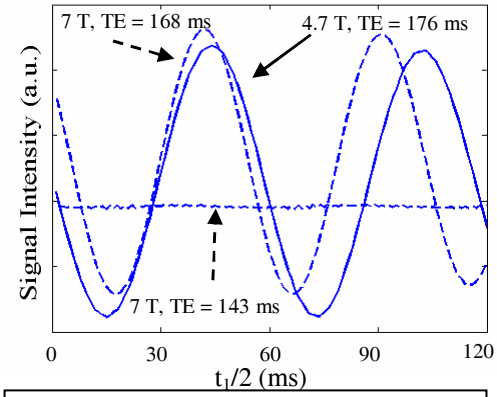

Figure 2. Simulated signal amplitude, as a function of t_1/2, at 4.7 ad 7 T.

Conclusions

At 4.7 T and 7 T, a large signal oscillation of the AB resonances for the ABX spin system of the glutathione cysteine moiety was predicted with density matrix simulations, and verified in vitro at 7 T. Since the singlet resonances are not affected by the changes in the first interpulse delay, the S-PRESS represents a new avenue for editing the glutathione resonances at 2.9 ppm which are underneath the singlet resonance of creatine.

FIGURE 3

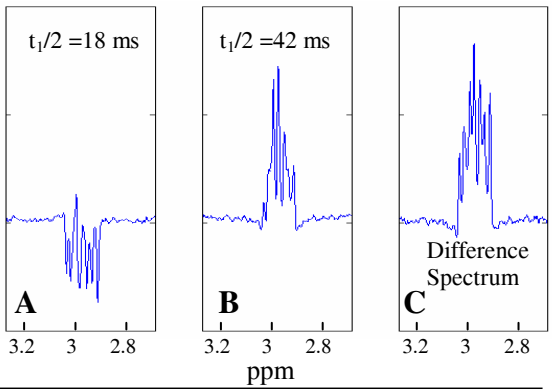

Figure 3. Experimental proton MR spectra of glutathione at 7 T.

References

[1] Gambarota G et al., *Echo-time independent signal modulations using PRESS sequences: a new approach to spectral editing of strongly coupled AB spin systems*. J Magn Reson. 2005;177:299-306. **[2]** Lange T et al., *Prostate Spectroscopy at 3 Tesla Using Two-Dimensional S-PRESS*, in: 'Proceedings of the 14th Annual Meeting, ISMRM', Seattle, Washington, USA, 2006. **[3]** Gambarota G et al., *A Novel Approach to Spectral Editing of Glutathione at 7 Tesla Using Echo-Time Independent Signal Modulations in PRESS Sequence*, in: 'Proceedings of the 14th Annual Meeting, ISMRM', Seattle, Washington, USA, 2006.

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