Multiple-refocusing for Suppression of Myo-Inositol for Glycine Measure at 1.5T: Simulation Study

C. Choi[1]

[1]Advanced Imaging Research Center, University of Texas Southwestern Medical Center, Dallas, Texas, United States

INTRODUCTION

Glycine (Gly) in healthy human brain is difficult to measure using conventional short-TE ^{1}H-MRS, because of its low concentration (~0.5 mM) and the abundant overlapping multiplet of myo-inositol (mI). The suppression of the mI multiplet at the 3.55-ppm Gly resonance, primarily arising from strongly-coupled resonances, requires rigorous investigation of the signal dependence on the sequence parameters. Following a report of PRESS (point-resolved spectroscopy) TE-averaging at 4.0 T [1], triple refocusing has been proposed for 3.0 T recently [2], in which degradation of the mI multiplet over multiple refocusing was utilized. To date, a strategy for 1.5 T, which is a field strength used in a vast majority of clinical studies, has not been reported. Here, we report a density-matrix simulation study of multiple refocusing for elimination of the mI signal for Gly measure at 1.5 T. Results of searching for an optimal multi-refocusing sequence and spectra at optimal echo times are presented.

METHODS

Suppression of the strongly-coupled resonances of mI for detection of the Gly singlet at 1.5 T was investigated with numerical solution of the Liouville–von Neumann equation for multiple refocusing sequences. The time evolution of the density operator over the sequence was calculated for the Hamiltonian that includes the Zeeman, chemical shift and scalar coupling terms, and the shaped RF pulses and gradient waveforms. For single-voxel localization, the spatial resolution was set to 1%, with two hundred pixels within a sample-size length set at double the slice thickness, along each of the three orthogonal directions. A 90° RF pulse (9 lobes; 3.0 ms; BW = 3.8 kHz) and two 180° RF pulses (9 lobes; 7.6 ms; BW = 1.0 kHz) were used for 3D space localization. For sequences with more than two 180° pulses, non-slice selective 180° pulses with the same envelop and duration were applied between the two slice selective 180° pulses. The published chemical shift and coupling constants [3] were used. Relaxation effects (T_1 and T_2) were not included in the simulation. The simulation was programmed with Matlab (The MathWorks, Inc.).

RESULTS and DISCUSSION

Fig. 1 displays the TE dependence of the mI signal intensity following multi-180° RF pulses preceded by a 90° excitation pulse, i.e., $90°[-180°-]_N$, where N is the number of 180° pulses and the individual echo time for each 180° pulse is TE/N. The mI signal between 3.5 and 3.6 ppm degrades markedly as TE increases. The pattern of signal degradation is not the same for all types of sequence investigated. Signal degradation with TE retards with increasing number of 180° pulses. The mI signal maintains positive polarity at most TEs, as opposed to the case at 3.0 T [2]. For N = 2, which is a widely-used PRESS design, peak amplitude and area do not become null up to TE = 300 ms. The total TE has to be long (≥ 300 ms) for the mI signal to attenuate sufficiently for Gly detection. For triple-refocusing (N = 3), which was chosen for Gly measure at 3.0 T [2], the mI signal is minimal at TE = 108 ms, but the mI peak amplitude is ~35% with respect to the Gly signal for [mI]/[Gly] = 8. Enhanced selectivity for Gly detection is predicted with additional 180° pulses, the appropriate TE increasing with the number of 180° pulses; i.e., TE = 146, 176, 239, and 298 for N = 4, 5, 6 and 7, respectively.

Fig. 2 presents calculated spectra of mI and Gly following multiple refocusing for echo times at which the mI peak amplitude is small, for N = 3, 4, 5, 6, and 7. It is predicted that mI suppression capability enhances with increasing number of 180° pulses markedly. The mI-to-Gly peak amplitude ratios are 39%, 35%, 31%, 12% and 4% at TE = 108, 146, 176, 239, and 298 ms, for N = 3, 4, 5, 6, and 7, respectively. Suppression of the mI strongly-coupled resonances can be further enhanced by changing sub-echo times slightly. The optimal sub-echo times and the residual mI multiplet will depend on the type and duration of RF pulses, as discussed in the prior study at 3.0 T [2]. The proposed echo times are relatively long, and consequently the Gly signal will be attenuated substantially. However, Gly measurement by the proposed method should be feasible with the long apparent T_2 at this low field.

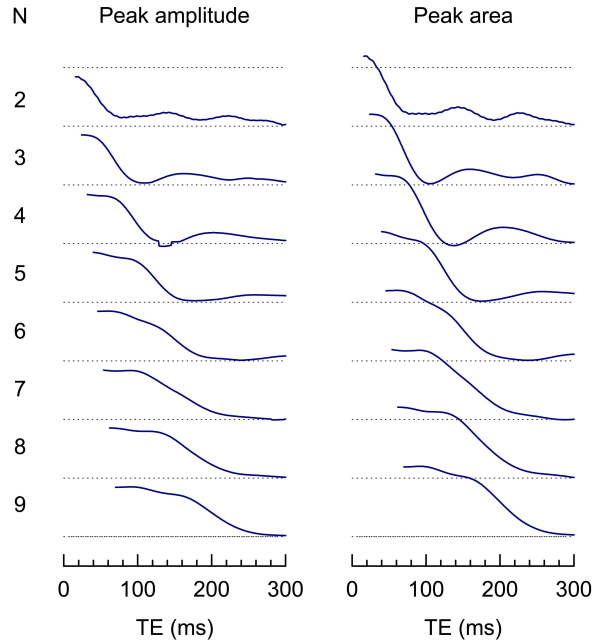

FIG. 1. Numerically-calculated TE dependence of the mI signal, at 1.5 T, for multi-refocusing sequences that consist of a 90° RF pulse followed by several numbers of 180° RF pulses, indicated by N. Echo time was changed with 1-ms increment, and the sub echo times were equal for each 180° pulse (i.e., TE/N). The peak amplitude and area were obtained between 3.5 and 3.6 ppm, after line broadening to 0.04 ppm. The horizontal dotted lines represent zero for each N. For both peak amplitude and area, the distance between the dotted lines is equivalent to 10 times the Gly signal for [mI]/[Gly] = 8.

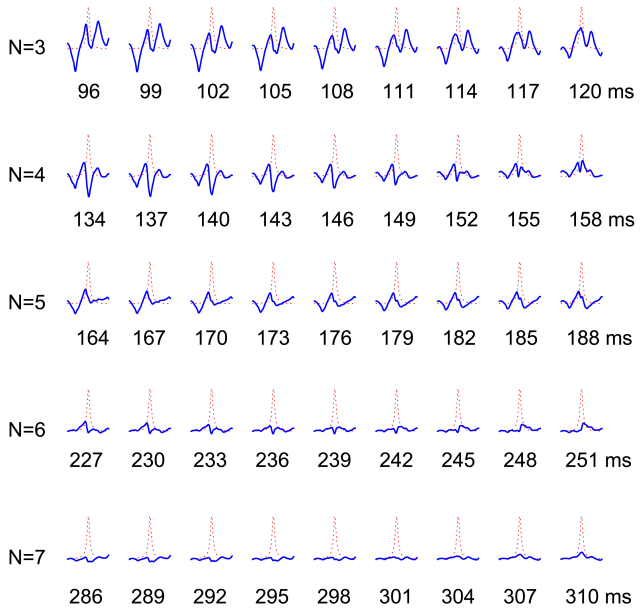

FIG. 2. Calculated spectra of mI (solid) and Gly (dotted) following multi-refocusing sequences (N = 3, 4, 5, 6, 7) for nine TEs for each N are plotted between 3.3 - 3.8 ppm, for [mI]/[Gly] = 8. For each N, the mI peak amplitude is the least between 3.5 - 3.6 ppm at the echo time in the middle of each row. Spectra are broadened to 0.04 ppm.

REFERENCES

1. Prescot AP *et. al.* Magn Reson Med 2006;55:681-686.
2. Choi C *et. al.* Magn Reson Med (in press; Article # MRM 07-9270).
2. Govindaraju V *et. al.* NMR Biomed 2000;13:129-153.

This research was supported by Canadian Institutes for Health Research.