In vivo Quantitative MR Spectroscopy Using Relaxation Enhancement: Unassigned Downfield Brain Metabolite Resonances at 21.1 T under Ischemic Conditions

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Introduction

The effective T_1 of macromolecular resonances may be shortened significantly using spectrally selective excitations [1]. By exciting only specific resonances, a large reservoir of magnetization remains unperturbed and can enhance MRS sensitivity by magnetization and chemical exchange [2]. Relaxation Enhanced (RE) ^{1}H MRS exploits these benefits for *in vivo* studies, revealing apparent T_1 reductions even for methyl resonances [3,4]. This work presents spatially localized RE spin-echo sequences to investigate *in vivo* quantitative MRS of metabolic resonating downfield from the water peak at 21.1 T, a spectral region studied previously but still lacking full assignment [5]. We quantified ATP, Gln, GSH, NAA and PCr, and estimated concentration changes with ischemia.

Experimental

All experiments were performed at the National High Magnetic Field Laboratory using the 21.1-T, 900-MHz ultra-widebore magnet equipped. Sprague-Dawley rats were scanned 12-h post ischemia. ^{1}H MRS were acquired from a 4.8x4.8x5.2-mm voxel placed in the contra- and ipsilateral (ischemic) sides of the brain using a RE spin-echo sequence, which targeted the 6-10 ppm spectral region by means of 90° sinc pulse and SLR-designed11 180° pulses, respectively 5 and 4 ms (TR=1.5s, NA=1024). Spatial localization was achieved using 3D LASER (Fig.1). Metabolites were quantified using an algorithm based on GAMMA [6]. The metabolite basis set contained only ATP, Gln, GSH, NAA and PCr, present at ≥ 1mM concentrations, plus four broad Gaussian resonances to model the baseline.

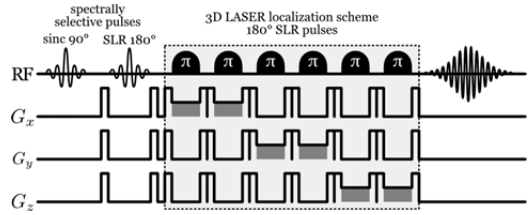

Fig. 1: Spatially localized RE spin-echo using 3D LASER and spectrally selective pulses.

Results and Discussion

Downfield spectra acquired on the ipsi- and contralateral hemispheres of stroked brains show rich *in vivo* metabolic information (Fig.2). The estimated spectra fit the acquired data, showing intense macromolecular contributions, especially around 8 ppm. Resonances show substantial linewidths, presumably due to water chemical exchange, leading to spectral overlapping even at 900 MHz. All metabolites exhibit lower concentrations in the ipsi- than in the contralateral side (Fig.3) with NAA affected by a 5-fold difference (also observed upfield).

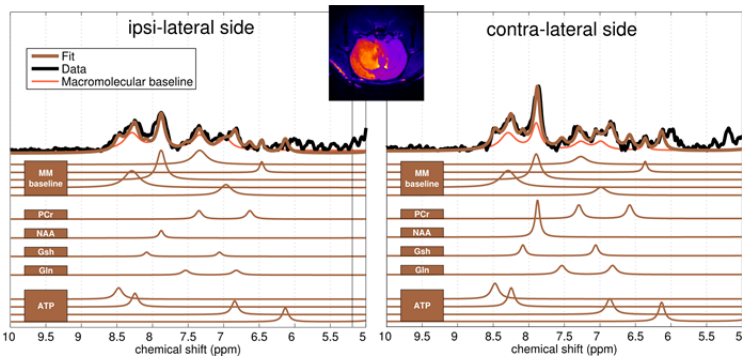

Fig. 2: Acquired and estimated spectra from the ipsilateral and the contralateral side of the rat brain (water image on top).

Conclusions

For the first time, *in vivo* quantitative MRS of the downfield spectral region was performed successfully at 21.1 T. RE significantly enhanced the global spectral quality while providing a commensurate increase in SNR per unit time, allowing for the characterization of hitherto poorly assigned resonances. This technique provides an alternative to conventional *in vivo* ^{1}H MRS by exploring downfield biomarkers.

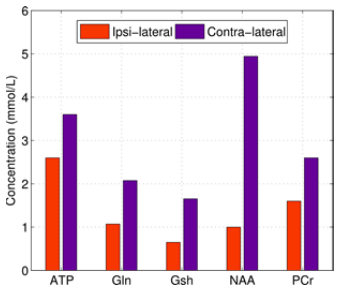

Fig. 3: Estimated concentrations for each metabolite.

Acknowledgements

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