Measurement of T_1 relaxation times of major metabolites in the mouse brain at 11.7 and 17.6 Tesla using voxel-localized proton magnetic resonance spectroscopy

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Introduction:

Localized proton MR spectroscopy can be used to investigate non-invasively the pathogenesis of several brain disorders in humans [1]. This technique can also be used to phenotype the increasing numbers of animal models of brain disease. Conducting these studies at very high magnetic fields (>9.4 tesla) benefits the signal-to-noise-ratio (SNR) and spectral resolution, and, hence, can make proton MRS in rodents a valuable tool for researchers. At these field strengths, however, a knowledge of relaxation times, especially T_1, is essential in order to conduct optimized experiments and to study changes induced by various pathogenic conditions; these values have not yet been reported. Previously, relaxation times of proton brain metabolites have predominantly been measured in rat models [2,3] at fields up to 9.4 Tesla. Here, we report on the measurement of T_1 relaxation times of the major metabolites in mouse brain *in vivo* at 11.7 and 17.6 tesla.

Methods:

Localized spectroscopic experiments were carried out on a Bruker Avance 500 MR system (Bruker Biospin, Rheinstetten, Germany, 11.7 tesla, super wide bore) using a quadrature birdcage coil with an inner diameter of 28 mm (Rapid Biomedical, Würzburg, Germany), and on a Bruker Avance 750 MR system (17.6 tesla, wide bore) using a 38 mm linear birdcage. For each field strength five female C57BL/6J mice (Harlan) with a body weight of 17 ± 2 g were used. For each measurement a $3 \times 2 \times 3$ mm^3 voxel was positioned just below the hippocampus using a scout RARE image. Manual shimming was performed using a non-water-suppressed PRESS sequence. A metabolite spectrum (TE/TR=13/10000 ms, NA=32) was then acquired from the voxel. Localized T_1 measurements used the same PRESS sequence, which followed a frequency-selective (5 ppm bandwidth) adiabatic pulse applied between the NAA (2.00 ppm) and the creatine (3.03 ppm) resonances to achieve optimal inversion of the entire spectral range of interest. A CHESS water suppression module was optionally applied between the inversion module and the PRESS sequence. Eight values of the variable inversion delay were used ranging from 100 ms to 10 s. The data were analysed in the time domain using AMARES in jMRUI [4]. The localized spectroscopic sequence was validated prior to *in vivo* experiments by comparing T_1 values obtained with localized and standard, non-localized inversion-recovery sequences on phantoms.

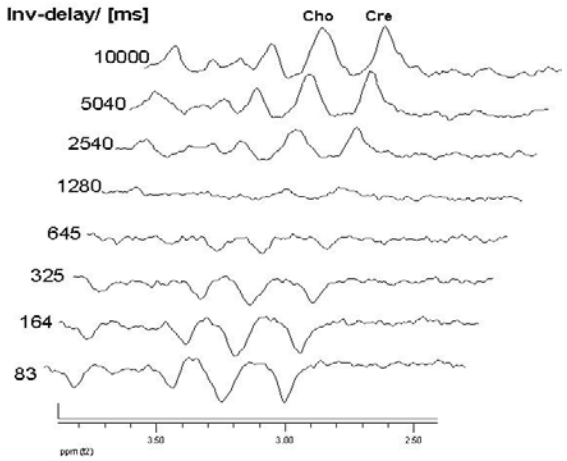

Figure 1: Spectra from an inversion recovery experiment of ar 18 μl voxel placed in a mouse brain. Shown data was acquirec at 750 MHz.

Results:

Example spectra for each time point on the T_1 metabolite curve are shown in Figure 1. The measured T_1 values for the water and metabolite resonances *in vivo* are shown in Table 1. Although the differences between the T_1 values at the two field-strengths are not statistically significant at the $p<0.01$ level, due to the small sample size, the values at 17.6 tesla appear to be systematically higher. However, values measured at 11.7 tesla are significantly higher than those reported previously at 9.4 tesla [2] in the rat brain.

Discussion:

Although there is some variation in the reported field strength dependence of metabolite T_1 relaxation times, mainly caused by limited SNR, the data obtained here show that there are small increases in T_1 from 11.7 to 17.6 tesla. These results suggest that metabolite correlation times are on the order of 10^{-9} to 10^{-10} seconds in the mouse brain *in vivo*.

	T_1 @ 11.7 T	SD	T_1 @ 17.6 T	SD
Cr	1.508	0.251	1.577	0.351
Cho	1.553	0.210	1.641	0.149
H_2O	1.468	0.248	1.826	0.176

Table 1: *In vivo* mouse brain T_1 values of water and th main brain metabolites, creatine and choline.

References:

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