Transverse relaxation times of strongly *J*-coupled metabolites with LASER and CP-LASER in the rat brain.

D. K. Deelchand[1], P-G. Henry[1], K. Ugurbil[1], and M. Marjanska[1]
[1]Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, MN, United States

Introduction

Carr-Purcell (CP) methods have been commonly used to measure transverse relaxation times. The use of CP pulse trains greatly reduces *J*-modulation for *J*-coupled resonances and lengthens the apparent T_2. For instance, previous studies using localized NMR spectroscopy with CP-type pulse sequences have shown that the pattern of *J*-coupled resonances of metabolites in the human brain can be preserved even at relatively long echo time [1, 2]. Another study has reported that the T_2 times of water and of singlet resonances (NAA and tCr) were increased with CP-LASER compared to PRESS when measured in the human brain at 4 and 7 T [3]. However, so far no T_2 relaxation times of strongly *J*-coupled metabolites have been reported when using the CP method. Therefore, the aim of this study was to measure and compare the T_2 transverse times of metabolites (both singlet and *J*-coupled) in the rat brain when using LASER and CP-LASER sequences.

Methods

Male Sprague-Dawley rats (*n*=5) were studied on a 9.4 T horizontal-bore magnet. The animals were anesthetized with 1.5% isoflurane in a mixture of 50% oxygen: 50% nitrous oxide. Localized *in vivo* ^{1}H NMR spectra from the brain (VOI of 63 µl positioned on the midline 2 mm posterior to bregma and 3 mm to ventral) were measured using LASER and CP-LASER sequences [3]. Spectra were acquired using 4 s repetition time at different echo-times: T_E = 18, 25, 32, 46, 60, 100, 200 and 400 ms for LASER and T_E = 18, 30, 42, 66, 114, 210 and 402 ms for CP-LASER. In CP-LASER, non-selective AFP pulses (HS1, R25) were inserted after the first AHP pulse in LASER and the length of the CP train was increased by additional AFP pulses while fixing the delay (τ_{cp}) between the pulses at 3 ms. The CP pulses were phase cycled according to the MLEV scheme. The acquired spectra were analyzed using LCModel with simulated basis set where the singlet and multiplet of NAA and Cho compounds and the CH_2 and CH_3 groups of total creatine (tCr = Cr + PCr) were separated [4]. The data were then fitted using a mono-exponential decaying function to determine the T_2 relaxation values.

Results and Discussion

Figure 1 shows a comparison of *in vivo* ^{1}H NMR spectra acquired with LASER and CP-LASER in the rat brain. The most noticeable difference was in the 2.1 to 2.5 ppm region where glutamate and glutamine resonances were preserved at long echo time with CP-LASER while with LASER these metabolites underwent fast *J*-evolution.

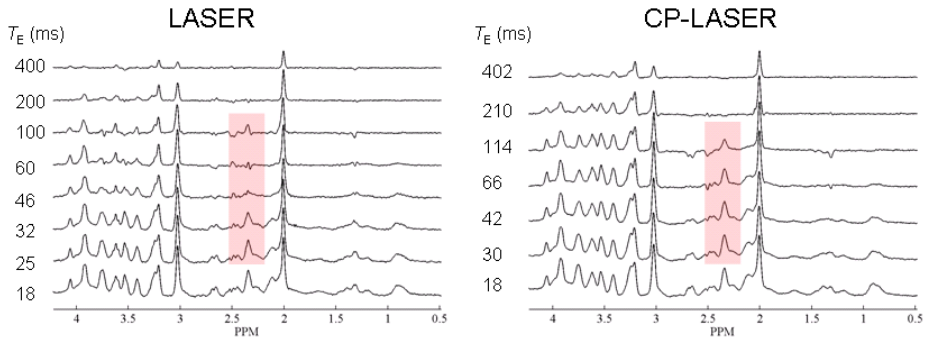

Figure 1: ^{1}H spectra measured with LASER and CP-LASER sequences from one animal.

T_2 relaxation times of metabolites were longer with CP-LASER than with LASER (Table 1). T_2 of NAA singlet was increased from 347 ms to 509 ms when incorporating the CP pulse train in LASER. A similar gain in relaxation time of about 1.3 times (=$T_{2,\text{CP-LASER}}/T_{2,\text{LASER}}$) was observed for other singlets (Table 1) and weakly coupled metabolites (not shown). This ratio was close to that published for water at 7 T in the human brain using similar pulse sequence [5].

In contrast, T_2 of glutamate and glutamine were approximately 2.5 times higher with CP-LASER compared to LASER. Similarly, for another strongly coupled metabolite, taurine, T_2 was approximately 2.5 times higher with CP-LASER compared to LASER. These results are consistent with the density-matrix analysis of Allerhand [6] which suggested that the amplitude and time evolution of the modulation are inhibited by the CP pulses for strongly coupled metabolites compared to weakly coupled and non coupled metabolites.

In conclusion, as T_2 relaxation of metabolites becomes shorter at higher fields [7], one of the ways to increase signal intensity and minimize *J*-modulation is to use CP-methods in localized MRS sequence. Additionally, in LASER sequence with τ_{cp} = 3 ms, the metabolites undergo relaxation with the relaxation times measured with CP-LASER and in order to determine the absolute concentrations of metabolites those T_2 values should be used.

Metabolites	LASER	CP-LASER	Ratio
Singlet			
NAA	347 ± 25	509 ± 25	1.5
tCr CH_3	176 ± 12	239 ± 7	1.4
tCr CH_2	129 ± 10	162 ± 5	1.3
***J*-coupled**			
Glutamate	83 ± 21	212 ± 15	2.6
Glutamine	94 ± 21	218 ± 67	2.3
Taurine	153 ± 31	402 ± 31	2.6

Table 1: T_2 (mean ± SD) of some metabolites using LASER and CP -LASER at 9.4 tesla in the rat brain. Ratio represents $T_{2,\text{CP-LASER}}/T_{2,\text{LASER}}$.

References

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