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

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**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 \(\mu\)l 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 (\(\tau_{cp}\)) 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.

\(T_2\) relaxation times of metabolites were longer with CP-LASER than with LASER (Table 1).

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

<table>
<thead>
<tr>
<th>Metabolites</th>
<th>LASER</th>
<th>CP-LASER</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singlet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAA</td>
<td>347 ± 25</td>
<td>509 ± 25</td>
<td>1.5</td>
</tr>
<tr>
<td>tCr CH(_3)</td>
<td>176 ± 12</td>
<td>239 ± 7</td>
<td>1.4</td>
</tr>
<tr>
<td>tCr CH(_2)</td>
<td>129 ± 10</td>
<td>162 ± 5</td>
<td>1.3</td>
</tr>
<tr>
<td>J-coupled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glutamate</td>
<td>83 ± 21</td>
<td>212 ± 15</td>
<td>2.6</td>
</tr>
<tr>
<td>Glutamine</td>
<td>94 ± 21</td>
<td>218 ± 67</td>
<td>2.3</td>
</tr>
<tr>
<td>Taurine</td>
<td>153 ± 31</td>
<td>402 ± 31</td>
<td>2.6</td>
</tr>
</tbody>
</table>

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 \(\tau_{cp}\) = 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.

**References**

[1] Soher et al. MRM 2005;

**Acknowledgement**

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