Purpose/Introduction

31P-MRS provides unique information on hepatic energy metabolism in vivo. Alternations in hepatic energy metabolism are indicative for inflammatory and neoplastic liver diseases and were demonstrated in T2DM patients [1]. The major limitation of hepatic 31P-MRS was low signal sensitivity at clinical scanners and from that resulting long acquisition times. Nowadays, several fold higher SNR is available at human whole body 7T MR scanners and hepatic in vivo localized 31P-MRS is feasible at 7T in clinically acceptable measurement time [2]. The purpose of this study was to measure T1 relaxation times of hepatic 31P metabolites at 7T, which are necessary for further method optimizations and corrections during data quantifications.

Subjects and Methods

Data were acquired on a 7T MR system (Siemens) using double-tuned surface coil (1H/31P) (RAPID Biomedical, Columbus, OH), with a diameter of 10 cm. During in vivo measurements volunteers (n=9) were lying in the lateral position with the lateral lobe of the liver on the surface coil.

T1 relaxation times were measured by a 1D-ISIS localized IR sequence. An adiabatic inversion pulse (WURST, 3 ms duration) and a square excitation pulse (300 µs duration) were used. To minimize CSDE GOIA pulses were used to select an 30 mm thick slab. Data were acquired interleaved, i.e., every eight acquisition was performed with the same TI, to account for possible subject movement. Since, T1 relaxation times for all ATP resonances and Pi were expected to be significantly shorter than for the remaining 31P metabolites, two separate inversion recovery (IR) experiments were performed with optimized measurement protocols (i.e. “long TR” IR experiment [TI:100-20000ms, TR=20s, TA=3min] and “short TR” IR experiment [TI:20-2000ms, TR=3s, TA=7min36s]) in each subject. Data were quantified with AMARES algorithm and fitted with non-linear, least-squares fitting routine with a trust-region algorithm in MATLAB 2008a (MathWorks, Natick, MA, USA) using single exponential non-linear regression (Eq.1). $S(TI) = S_0 + S_1 \cdot e^{-\frac{TI}{T1}}$ (1)

Results

Representative spectra and fits of both the “short TR” IR experiment and the “long TR” IR experiment are presented in Figure 1.

Table 1. T1 relaxation times (s) of phosphorus metabolites in the liver.

<table>
<thead>
<tr>
<th></th>
<th>Pi</th>
<th>PC</th>
<th>PE</th>
<th>GPC</th>
<th>GPE</th>
<th>γ-ATP</th>
<th>α-ATP</th>
<th>β-ATP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2T [3]</td>
<td>0.77</td>
<td>1.17</td>
<td>1.17</td>
<td>4.01</td>
<td></td>
<td>0.42</td>
<td>0.55</td>
<td>0.43</td>
</tr>
<tr>
<td>3T [4]</td>
<td>0.73 ± 0.22</td>
<td>2.24 ± 0.83</td>
<td>1.81 ± 1.07</td>
<td>4.26 ± 1.15</td>
<td>6.98 ± 2.30</td>
<td>0.43 ± 0.12</td>
<td>0.58 ± 0.10</td>
<td>0.55 ± 0.19</td>
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<tr>
<td>7T (this study) n=9</td>
<td>0.70 ± 0.33</td>
<td>3.74 ± 1.31</td>
<td>4.41 ± 1.55</td>
<td>5.94 ± 1.73</td>
<td>6.19 ± 0.91</td>
<td>0.50 ± 0.08</td>
<td>0.46 ± 0.07</td>
<td>0.56 ± 0.07</td>
</tr>
</tbody>
</table>

Discussion/Conclusion

Due to an overall higher spectral quality at 7 T, T1 values of eight hepatic 31P metabolite resonances could be determined in our study. Our T1 values were consistent with previously published results. No significant difference in T1 between 7 T and previously published T1 values at 2 T and 3 T were found [3,4]. Since all of these T1 relaxation time studies were performed with the same method (i.e. IR experiments) possible methodical bias is negligible. This absence of any significant changes in T1 with increasing B0 is consistent with previous observations in rat liver [5] where nearly identical T1 relaxation times were reported for 4.7 T and 8.5 T.

References