T_1 relaxation times of ^{31}P metabolites in human liver at 7T

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Purpose/Introduction

^{31}P-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 ^{31}P-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 ^{31}P-MRS is feasible at 7T in clinically acceptable measurement time [2]. The purpose of this study was to measure T_1 relaxation times of hepatic ^{31}P 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 (^{1}H/^{31}P) (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.

T_1 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 CSDEs 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, T_1 relaxation times for all ATP resonances and Pi were expected to be significantly shorter than for the remaining ^{31}P 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=34min] 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).

$$S(TI) = S_0 + S_1 \cdot e^{-\frac{TI}{T1}} \qquad (1)$$

Results

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

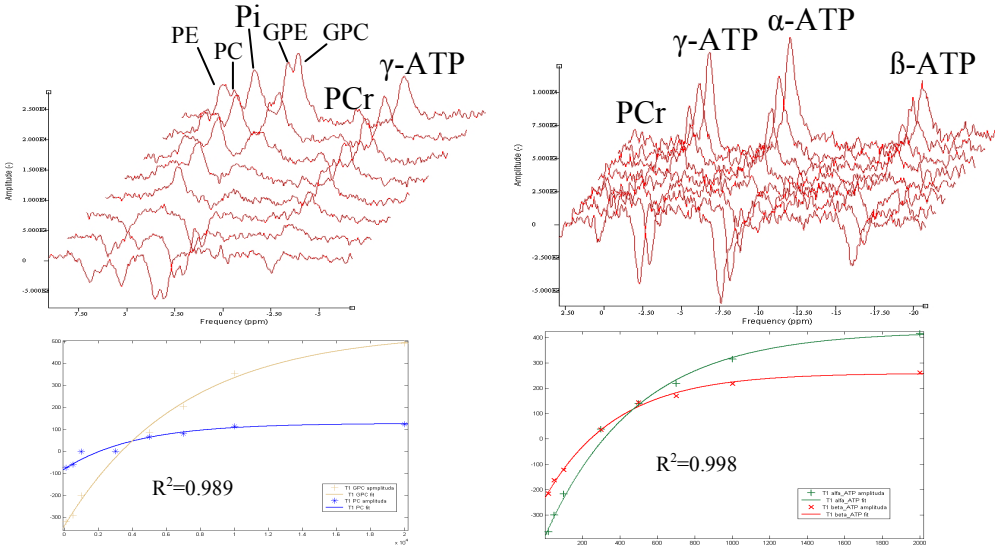

Fig.1 Sample spectra obtained for the "long TR" inversion recovery experiment (a) and the "short TR" inversion recovery experiment (b). Measurement parameters in (b) were optimized for detection of ATP signals with expected short T_1. Mono-exponential fitting is illustrated using the example of GPC, PC (c), α-ATP and β-ATP (d).

Table 1 lists the *in vivo* T_1 relaxation times for all investigated ^{31}P metabolites. To allow an easier comparison, Table 1 lists previously published T_1 relaxation times (i.e.2T and 3T) in addition to our results. No significant differences in T_1 were observed for hepatic ^{31}P metabolites at 7 T compared to lower field strength [3,4].

Table 1. T_1 relaxation times (s) of phosphorus metabolites in the liver.

	Pi	PC	PE	GPC	GPE	γ-ATP	α-ATP	β-ATP
2T [3]	0.77	1.17		4.01		0.42	0.55	0.43
3T [4] n=6	0.73 ± 0.22	2.24 ± 0.83	1.81 ± 1.07	4.26 ± 1.15	6.98 ± 2.30	0.43 ± 0.12	0.58 ± 0.10	0.55 ± 0.19
7T (this study) n=9	0.70 ± 0.33	3.74 ± 1.31	4.41 ± 1.55	5.94 ±1.73	6.19 ± 0.91	0.50 ± 0.08	0.46 ± 0.07	0.56 ± 0.07

Discussion/Conclusion

Due to an overall higher spectral quality at 7 T, T_1 values of eight hepatic ^{31}P metabolite resonances could be determined in our study. Our T_1 values were consistent with previously published results. No significant difference in T_1 between 7 T and previously published T_1 values at 2 T and 3 T were found [3,4]. Since all of these T_1 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 T_1 with increasing B_0 is consistent with previous observations in rat liver [5] where nearly identical T_1 relaxation times were reported for 4.7 T and 8.5 T.

References

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