Measurement of spin-spin relaxation of myocardial lipids and water at 3T by optimized clinical ^{1}H MRS protocol.

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Purpose

Increased myocardial lipid (MYCL) accumulation is one of the features of cardiomyopathy. Over the last decade ^{1}H MR spectroscopy has been introduced, validated and applied for measurement of MYCL [1]. Patients with increased BMI, impaired glucose tolerance and type 2 diabetes mellitus presented with substantial myocardial steatosis [2]. Dynamic experiments aiming to elucidate the mechanism of MYCL accumulation pointed to the dynamic nature of this lipid compartment and revealed the effects of increased plasma free fatty acid concentration, acute or chronic hyperglycemia and systematic hyperinsulinemia [3,4]. Never-the-less direct comparison of the data acquired at different field strength and by different MRS protocol is hampered due to the fact, that none of the studies described relaxation behaviour of methylene -(CH2)- group of fatty acid carbohydrate chains, which resonance is usually taken as the measure of MYCL accumulation. Relaxation times of water signal could have been taken from MRI data [5], but the relaxation times of lipid resonances could have been only assumed from already known skeletal muscle data [6]. Experimental problems of clinical myocardial spectroscopy include suppressing the influence of breathing and heart motion by efficient data acquisition triggering, efficient and stably performing shimming procedure and diminishing or correcting frequency shifts between single spectral transients. Recently several approaches acquiring the MRS data during breath hold have been proposed and validated [7,8]. The aim of this study was to apply optimized ^{1}H MR shimming and spectroscopy protocol for the acquisition of spectra w/o water suppression during multiple breath holds with multiple echo time and thus to assess spin-spin relaxation times of water and lipid methylene $-(CH_2)_n-$ group signal in myocardium of healthy volunteers.

Methods

Up to now six healthy volunteers (6m/2f, age: 31±5years; BMI: 25±5 kg.m^{-2}) underwent the examination on 3T TimTrio/SyngoVB17 MR System (Siemens, Erlangen, Germany). Combination of body-array and spine-multi channel coils was used for signal detection. All scans were performed in the inhale breath-hold position and triggered on the ECG signal in the mid diastole. After scout images, short- and long axes T2 weighted – "black blood" images were acquired and used for the placement of adjustment- and measurement volumes. Measurement volume (volume of interest, VOI) was positioned within the inter-ventricular septum in the midway between base and apex. Even though the size of VOI could differ according to individual anatomy, typical measures were 15(18)mm x 10(8)mm x 30mm. Adjustment volume was avoiding pericardial fat, it was centred on VOI and it was larger than VOI by approximately 1 cm in every direction. Automatic shimming was based on gradient recalled double echo field map acquisition (GRE-SHIM, WIP_452, Siemens Healthcare). This sequence allows adjustment of field of view, resolution and timing acquisition. B0 field map was acquired during single breath hold. Next breath hold was used for frequency adjustment. PRESS sequence was used for MRS signal acquisition. Repetition time was set by heart beat frequency of the volunteer. Data acquisition was repeated twice for every from five different echo times (30, 40, 50, 70, 100 ms) each with 2 dummy scan and 4 averages for water signal or 8 averages for the acquisition of water suppressed signal. Transmitter and reception frequency was centered on the resonance frequency of interest: 4.7 ppm for water or 1.25 ppm for methylene lipid group. Total experiment time did not exceed 60 minutes. Data were processed of line by AMARES algorithm within jMRUI software package. Monoexponential relaxation behaviour was assumed and spin-spin (T2) relaxation times of water and methylene lipid resonance were calculated by linear regression of echo time evolution after the normal logarithm of the respective amplitude was taken. Data are given as mean ± standard error of the mean.

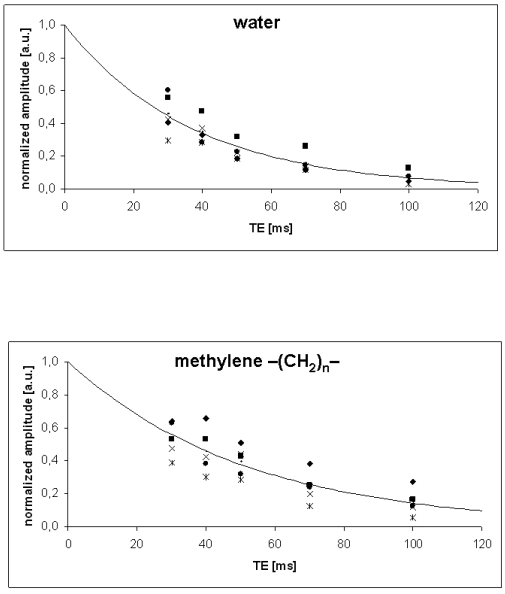

Figure Spin-spin relaxation behaviour of water and methylene lipid group resonances from myocardium at 3T. Amplitudes were retrospectively normalized to magnetization at TE= 0 ms for every individual. Monoexponential lines depicting the behaviour were fitte means of normalized amplitudes at every TE.

Results/Discussion/Conclusion

Optimized MRS protocol yielded spectra with sufficient SNR for both water and methylene signal in the whole applied range of echo times in five of six patients. Pooled relaxation behaviour is given in the figure and individual as well as mean T_2 relaxation times and regression coefficients are given in the table. T_2 time of water assessed here is good agreement with previously published MRI based data[5]. T2 time of lipid methylene group is shorter than those measured in skeletal muscle at 3T [6].

	H_2O		$(CH_2)n$	
Vol.	T_2 [ms]	R^2	T_2 [ms]	R^2
01	32.6	*0.981*	76.3	*0.979*
02	49.3	*0.977*	54.9	*0.967*
03	35.7	*0.989*	47.2	*0.944*
04	29.4	*0.966*	34.8	*0.982*
05	37.3	*0.931*	47.8	*0.961*
Mean	**36.85**		**52.23**	
SEM	3.38		6.84	

References

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