Assessment of Biexponential T1 decay in prostate tissue.

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Introduction

Prostate tissue exhibit a bi-exponential decay in T2 [1, 2] and ADC [3]. Shutter speed models describing the relation between proton exchange and multi-exponential decay have been developed for both relaxation [4] and diffusion [5] analysis. These models predict that tissues may be in the fast exchange regime characterized by a mono-exponential decay with regard to one parameter although they are in the slow exchange regime and hence multi-exponential with regard to other parameters.

A multi-exponential T1-decay would imply that experimental parameters related to T1 weighting (e.g. repetition time (TR) , flip angle, inversion time (TI), etc.) may influence measurements of T2 and ADC.

In this paper we present results based on a multi spin echo acquisition with and without inversion recovery preparation. We report T1 and T2 values of a bi-exponential model fitting both T1 and T2 simultaneously to the combined data set.

Material and Methods

Nine healthy volunteers median age 56, range 44 – 63 years were included in the study. All acquisitions were performed on 1.5 T Philips Achieva system. An interleaved IR and SE sequence was used with the following parameters: FOV 408 mm, slice thickness 5 mm, scanmatrix 192x192, echo spacing 25 ms, number of echoes 32, repetition time (TR) 8000 ms, inversion time (TI) 800 ms. SENSE factor 2.

Image analysis was performed using nordicICE (Nordic Imaging Lab AS, Bergen Norway) and IDL (ITT Visual Information Solutions, Boulder, Colorado, USA). Single voxels were interactively picked in central gland, peripheral zone and muscle. In the central gland and peripheral zone one voxel was placed in a low intensity area, one in an intermediate intensity area and one in a high intensity area as apparent by visual inspection on the TE = 125 ms images.

Decay curves were fitted to the equation:

$$\hat{S} = \sum_{i=1}^{n} A_i \left(1 - 2K\left(e^{-TI/T1_i} - e^{-TR/T1_i}\right) - e^{-TR/T1_i}\right) e^{-TE/T2_i} + \varepsilon ,$$

where n is the number of exponentials, limited to two in this study, A_i is the relative amplitude of component i, $T1_i$ and $T2_i$ are the corresponding relaxation times and ε denotes the noise floor and is estimated from the late echoes in the muscle signal. K takes the value zero for spin echo data and one for inversion recovery data and facilitates simultaneous fitting of the combined data.

Results

A scatterplot showing individual T1 and T2 estimates is presented in Figure 1. Mean T1 of the fast and slowly decaying components were 1176 ±152 ms and 2944±765 ms respectively. Corresponding T2 were 86±15 ms and 844±288 ms. On closer examination, outliers were found to be measurements with signal fractions less than 10% or larger than 90%. These were not excluded in these analysis.

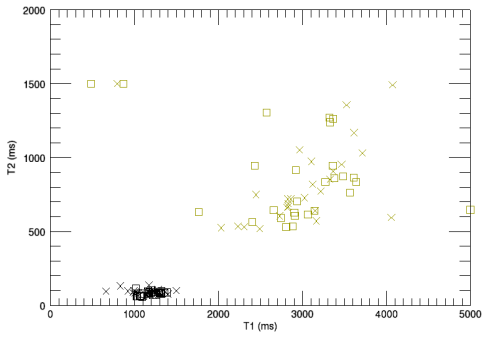

Figure 1: Scatterplot showing regression results for a two compartment model. Black and green symbols show the fast and slowly decaying components respectively. Squares show central gland, and crosses show peripheral zone measurements.

Discussion

In this preliminary analysis we found evidence for a liquid-like T1 component in the prostate MR-signal. Such a slowly decaying component is easily saturated in image acquisitions as noted by Kjaer et al [1]. Hence, care should be taken when comparing results acquired at different TR or with inversion recovery techniques. A two compartment model provided a good fit to data. A more stringent analysis of multiple models will be performed.

In conclusion, we found that MR-signal from prostate tissue is multiexponential also in T1 and that the longer T1 is in the order of 3s making it prone to saturation in many ordinary acquisition protocols.

References

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