Mono-exponential T_2-analysis of a two-pool system – *Does echo-spacing matter?*

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Target audience

The presented work will be beneficial to anyone using the spin-echo T_2 quantification approach.

Purpose

It is generally well accepted that tissue exists of multiple relaxation components, such as for example the free water protons and myelin-bound water protons in brain tissue[1]. However, the spin-echo based quantification of a single T_2 on such tissues is commonly considered to be the gold standard. Therefore, we have investigated whether the echo-spacing (ΔTE) matters when performing a mono-exponential analysis of a two-pool system.

Methods

We have performed Bloch simulations for a spin-echo sequence of a two-pool system. Pool fractions were varied from 10% to 90% with $T_{2,1}$ = 50ms and $T_{2,2} = T_{2,1}/10$ (5ms). The relaxation curve was sampled every ms up to $3xT_{2,1}$ (150ms), Gaussian noise was added with an SNR ~50 for the initial signal at TE = 0, creating 100 measurements per TE (simulating an average ROI size). Subsets were taken with constant echo-spacing (ΔTE) ranging from 1ms up to 30ms. The subsets were mono-exponentially fitted, omitting sample points where S < 3x standard deviation of the added noise.

Results

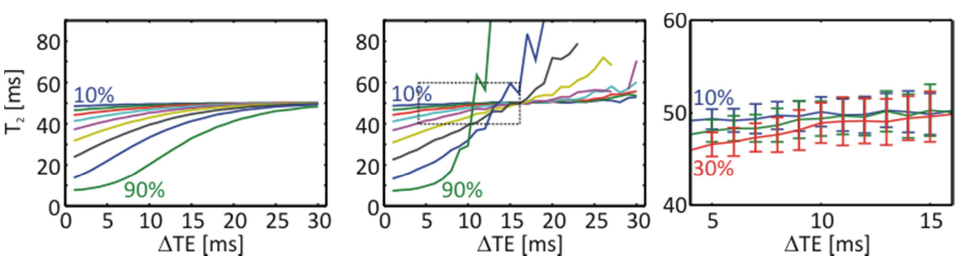

Figure 1 T_2 as a function of the echo-spacing, without noise (left), mean values after analysis of signal with noise addition (middle) and a zoomed in view of this graph with additional error bars indicating the standard deviation for $T_{2,2}$-pool size of 10%, 20% and 30% (right).

The shorter the echo-spacing, the larger the influence of the fast relaxing pool, the larger the fast-relaxing pool the larger its influence on the obtained T_2 (Figure 1). Noise influences the observation of T_2 (Figure 1) and might lead to a reduced number of sample points to fit as a result of a fast decay due to a large $T_{2,2}$-pool. Figure 2 shows box-plots of the simulations with 10%, 20% and 30% $T_{2,2}$-pool fractions, comparing 5, 8, 10, 12 and 15ms echo-spacing. The largest difference between the mean as well as median observed T_2-values is obtained in a sample with 30% $T_{2,2}$-pool size and is approximately 3ms (ΔTE = 5ms versus ΔTE = 15ms).

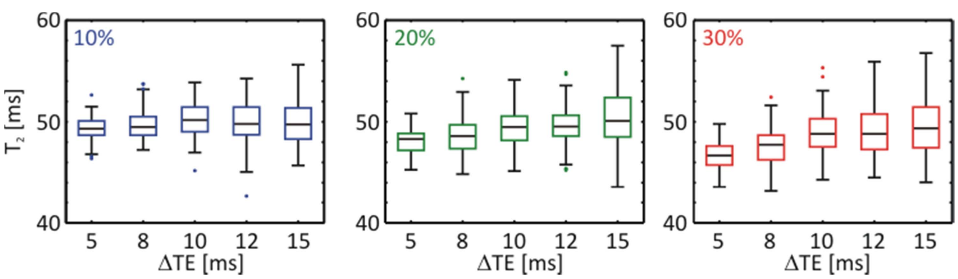

Figure 2 Box-plots for T_2-analysis with ΔTE = 5, 8, 10 and 12ms for samples with 10%, 20% and 30% $T_{2,2}$-pool size (f.l.t.r.).

Discussion

Simulation results illustrate the independency of the T_2-quantification on ΔTE and pool fraction (fraction ≤30%) in a no-noise situation as well as the situation with noise (Figure 1). The observed differences between the means and medians (best visible in Figure 2) does not exceed 3ms when $T_{2,2}$-pool fractions ≤ 30% and 5ms ≤ ΔTE ≤ 15ms. In practice, this difference will not be considered to be an observation of different T_2, since the typical standard deviation obtained in an ROI of in vivo white matter is 6ms for a 10ms spaced T_2-quantification (single-echo spin-echo with TR = 2.5s; 30 echoes, TE_{max} = 300ms; voxelsize 1.3x1.3x4mm^3).

Conclusion

We have shown that the echo-spacing in a spin-echo acquisition for T_2-quantification does not matter when performing a mono-exponential analysis of a two-pool system.

References

1. MacKay AL, Whittall KP, Adler J, Li DKB, Paty DW, Graeb DA. In vivo visualization of myelin water in brain by magnetic resonance. *Magn Reson Imaging*. 1994; 31: 673-677.