Examining Cell Density: Mono- and Multi-exponential Analysis of Magnetic R
T2 and Diffusion

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Abstract

A simple sample of cells suspended in agarose produced up to three T2 and diffusion components. Each component was fit for T2 and diffusion values. The fraction was positively associated with cell density, which may suggest an association with cells. These findings may lead to tailoring MR sequences for particular tumor characteristics.

Regression

Discussion and Conclusion

Three components were fit overall for both ADC and T2, even in a simple sample of cells in agar. Some multiexponential parameters were related to cell density. Slow ADC and short T2 fractions may have been linked to agar content in the samples. Both the intermediate ADC and long T2 fractions decreased with increasing cell density, however they were of unknown origin and warrant further investigation. T2 and ADC monoeponential decays were affected by underlying individual components in different ways. These findings may lead to tailoring MR sequences for a particular tumor characteristic.

Acknowledgements

NIH Supplement to R01CA116164
John K trậnwicz's lab, UCSF

References


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Methods

Objectives:

1. Investigate Non-Negative Least Squares (NNLS) as a method for identifying multiple ADC and T2 components of water.
2. Relate each ADC and T2 component to cell density.
3. Determine whether certain components are more indicative of intracellular or extracellular environments.

Sampling Strategy:

1. A sample of astrocytes was grown in 4% agarose plugs (NewEra, Vineland, NJ) and transferred to bottomless NMR tubes with susceptibility-matching plugs (NanoN, Norwell, MA).
2. Harvested astrocytoma cells were mixed with 4% agarose plugs (NanoN, Norwell, MA).
3. Performance CPMG with 62 TEs linearly spaced from 50-1270ms; diffusion-weighted sequence with 32 b-values linearly spaced from 10-500MHz Varian Spectrometer.

Data Analysis:

The MR water signal is initially aligned along the z-direction and is perturbed to the transverse plane for recording. In the transverse plane, interacting nuclear spins lose phase coherence (or relax) causing an overall reduction in signal strength.

The apparent diffusion coefficient (ADC) is a measure of water’s random thermal molecular motion. The signal equation is

\[
S(t) = S_0 \sum_{f} \int_{0}^{t} \exp\left(-K_{eff} S_{0} \sum_{b} \int_{0}^{t} \exp\left(-b \cdot T_2 \right) \right) dt
\]

Where A is the predicted data matrix, s is the proportion vector, y is the observed signal vector, and p is the number of measured components.

Significance:

The medium T2 value and signal fraction were inversely related to cell density, which may have indicated an association with agar. The slow fraction was positively associated with cell density, which may suggest an association with cells. The long T2 fraction was not associated with cell density, but the long T2 fraction was correlated with cell density.

Implications:

- The ADC and T2 values significantly correlate in regions of tumor and edema.
- The slow fraction of the medium component was related to cell density, which may suggest an association with cells.
- The 1.00 fraction was related to cell density, but the 0.26 fraction was decreased with increasing cell density, however they were of unknown origin and warrant further investigation.

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