$T_{1\rho}$ MRI of Patients with Alzheimer's Disease

A. Borthakur[1], C. Wang[2], D. Li[1], C. M. Clark[3], J. Q. Trojanowski[4], V. M-Y. Lee[4], E. R. Melhem[1], and R. Reddy[1]

[1]Department of Radiology, University of Pennsylvania, Philadelphia, PA, United States, [2]Department of Bioengineering, University of Pennsylvania, Philadelphia, PA, United States, [3]Department of Neurology, University of Pennsylvania, Philadelphia, PA, United States, [4]Department of Pathology & Lab Medicine, University of Pennsylvania, Philadelphia, PA, United States

Objective

To determine $T_{1\rho}$ in the brain of patients with Alzheimer's Disease (AD).

Background

Early AD is associated with neuronal loss and consequent changes in gray matter, which eventually leads to the atrophy of cortical gyri and widening of sulci. While volume of CSF, gray and white matter change with the progression of AD (1), small, and especially focal changes (1-2% decrease in volume) may not be detectable with enough sensitivity to distinguish between normal age-related volume decrease and AD-related changes. As an alternative, interactions between macromolecules and bulk water and changes in macromolecular content can be indirectly quantified by spatially mapping MR relaxation times. In these relaxometric maps, any change in relaxation times due to the presence of protein aggregates will be reflected over an entire volume-averaged pixel, thereby providing an indirect method of detection without a necessity for very high-resolution images or longitudinal measurements. $T_{1\rho}$ is the spin lattice relaxation time constant in the rotating frame, which determines the decay of the transverse magnetization in the presence of a spin-lock radio-frequency field. While Campeau et al (2) demonstrated that hippocampal T_2 was not significantly different between AD patients and normal subjects, $T_{1\rho}$ measurements performed on healthy volunteers (3), demonstrated that the values were greater than T_2 in the same locations in the brain. This is because the spin-lock RF field reduces contributions from susceptibility and diffusion to signal loss resulting in a greater dynamic range, which translates to greater sensitivity in biological tissues than T_2. Therefore, quantitative $T_{1\rho}$ MRI is an attractive alternative for relaxometric MRI measurements at a clinically-feasible MRI resolution. In this work, we measured $T_{1\rho}$ values in a number of AD patients and compared these to data from age-matched healthy volunteers. The results should provide valuable baseline values of $T_{1\rho}$ in these two cohorts.

Materials and Methods

The university's Institutional Review Board approved all experiments involving human subjects. MRI was performed on a Siemens Sonata 1.5T clinical scanner using the vendor-supplied head coil. A total of six AD patients (mean age: 68±7) and five age-matched controls (mean age: 77±9) were imaged. Imaging parameters were TE/TR= 12/2000ms, FOV=24cm, slice thickness=2mm, matrix= 256x128, turbo factor=5 for a total imaging time of 6 minutes for four images. The duration of spin-lock pulse (TSL) varied four times between 20-80ms. The time of inversion was fixed at 860ms for fluid-suppressed $T_{1\rho}$ images. $T_{1\rho}$ maps were calculated with the IDL programming language by fitting each pixel's intensity as a function of TSL by a linear least-squares algorithm. The plane of the imaged slice was perpendicular to the AC/PC plane and included the head of the hippocampus. A single user manually selected regions of interest and recorded average $T_{1\rho}$ values. A student's t-test was performed to determine the significance of any differences between $T_{1\rho}$ values obtained in both cohorts.

Results and Discussion

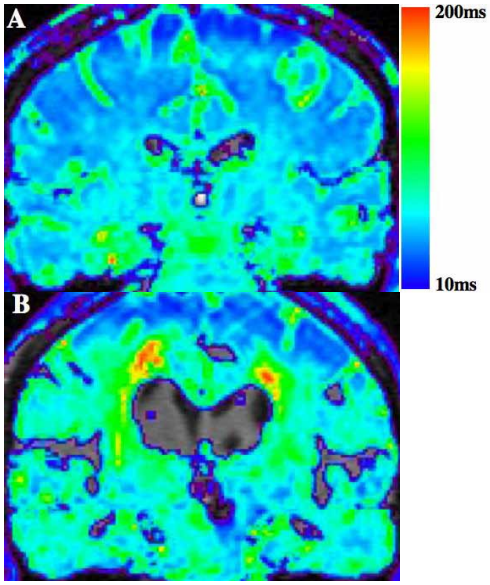

Figure 1: Representative $T_{1\rho}$ maps (in color) overlaid on their respective gray-scale $T_{1\rho}$ MR image of a 57 year-old normal female volunteer (figure A) and a 65 year-old AD patient (figure B) The color bar-scale on the right was windowed from 10ms (blue) to >200ms (red) to better highlight regions of elevated $T_{1\rho}$ in the AD patient's brain. The average $T_{1\rho}$ in the AD patient was 96.9±9ms while the normal control was 84.5±7ms in the temporal lobes.

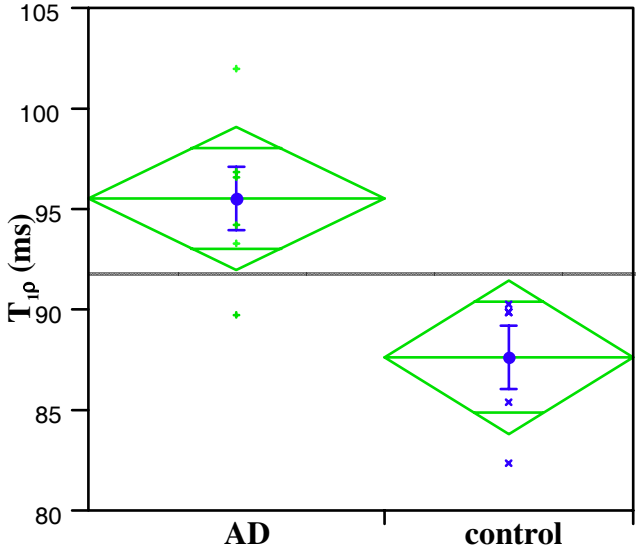

Figure 2: $T_{1\rho}$ values from all subjects in the both AD (+) and control (x) cohorts. The average $T_{1\rho}$ for the AD group was 95.5±2ms (mean ± std. error) and for controls was 87.6±2ms and the difference was statistically significant ($p<0.01$).

Acknowledgements

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References

1. DeCarli, C., *et al. Neurology* **40**: 872-883, 1990.
2. Campeau, N.G., *et al. Radiology* **205**: 197-201, 1997.
3. Borthakur, A., *et al. J Magn Reson Imaging* **19**: 403-409, 2004.