A longitudinal study on age-related changes of T1rho relaxation in rat brain

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Introduction: A new mechanism for MR tissue contrast, T1rho (T1ρ) relaxation, has been investigated in biomedical applications. T1rho represents 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" radiofrequency (RF) field. T1rho relaxation has been suggested as a sensitive biomarker to detect early stage of intervertebral disk degeneration [1], cartilage degeneration in osteoarthritis [2], and liver fibrosis (3,4). In neuroimaging, T1rho imaging has been used to study the mouse model of Alzheimer' disease [5], as well as the patients with Alzheimer' disease, mild cognitive impairment and Parkinson's disease [6, 7]. However, whether normal brain aging is associated with brain T1rho relaxation change remains unknown. In this study, we measured the T1rho relaxation in the thalamus, hippocampus and cortices of rat brain during the normal aging process.

Material and Methods: 18 male Sprague-Dawley rats were used in the study with the animal ethics approval. The rats were scanned longitudinally at the age of 5 months, 8 months, 10 months and 15 months respectively. Two rats died at the age of 14 months, leaving 16 rats examined at 15 months. MRI was performed on a 3 T clinical scanner (Achieva, Philips Healthcare, Best, The Netherlands). Under anesthesia, animals were positioned prone and a custom made quadrature volume RF coil of 7cm internal diameter was used as signal transmitter and receiver. 16 axial slices were used to cover the whole rat brain. For T1rho measurement, a rotary echo spin-lock pulse was implemented in a 3D fast field echo (FFE) sequence. Spin-lock frequency was set as 500 Hz and images were acquired at spin-lock times (TSLs) of 1 ms, 20 ms, and 50 ms, TE and TR were 3.6 ms and 7.3 ms respectively. TI (delay time) after acquisition was set as 5500 ms to restore equilibrium magnetization prior to the next T1rho preparation. The voxel size was 0.3×0.35×1.50 mm3. The flip angle was 40 degree and the number of signal average was 3. T1rho maps were computed on a pixel-by-pixel basis using a mono-exponential decay model of M(TSL)=M0*exp(-TSL/T1rho) with a home-made Matlab program (Mathworks, Natick, MA, USA). T1rho values were measured in user-defined regions of interest (ROIs) in the bilateral thalamus, hippocampus, and frontal cortices from T1rho map of rat brains (Fig.1).

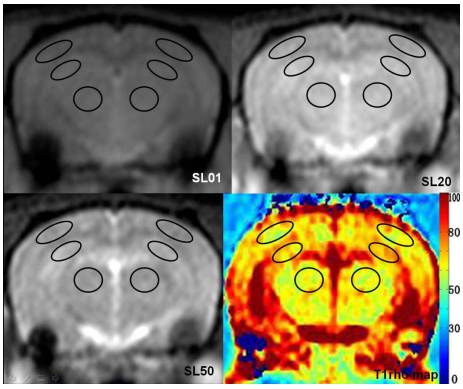

Fig. 1. Regions of interest in the bilateral thalamus, hippocampus, and frontal cortices of T1rho weighted image with spin-lock time of 1 ms (SL01), 20 ms (SL20), and 50 ms (SL50), and T1rho map.

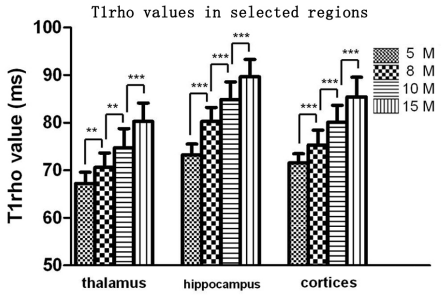

Fig.2.T1rho values (mean+SD) in selected brain regions (thalamus, hippocampus and cortices) of rats at the age from 5-month to 15-month.

Results: A trend of T1rho value increase during the aging progress was noted in thalamus, hippocampus and cortices (Fig. 2). At the age of 5-month, T1rho values were 67.2 ± 2.4 ms, 73.2 ± 2.3 ms and 71.6 ± 1.9 ms in the thalamus, hippocampus and cortices, respectively. At month 8, on average T1rho value in the thalamus, hippocampus and cortices increased by 5.1%, 9.7% and 5.2% compared with the value at month 5. At month 10, T1rho value in the thalamus, hippocampus and cortices increased on average by 5.8%, 5.7% and 6.4% respectively compared with the value at month 8. At month 15, T1rho value in the thalamus, hippocampus and cortices was 80.3 ± 3.9 ms, 89.7 ± 3.7 ms and 85.4 ± 4.1 ms respectively, increased on average by 7.5%, 5.7% and 6.6% compared with the value at month 10 (Fig. 2).

Discussion: In the current study, we found T1rho value increased in the thalamus, hippocampus and cortices regions during the normal aging process. Age is a major risk factor for most common neurodegenerative diseases, including Alzheimer's disease, and Parkinson's disease. T1rho imaging has been used to evaluate the plaque burden in mice model of Alzheimer' disease [5]. Borthakur and colleagues suggested that T1rho relaxation rate increases progressively with Alzheimer' disease related pathology (plaque burden) in the mouse brain. Recently, increased T1rho values in the hippocampus of mild cognitive impairment patients, Alzheimer' disease patients, Parkinson's disease patients with dementia have been reported [6, 7]. A longitudinal study of brain volume change in human subjects during normal aging found a significant decrease in whole brain with increasing age [8]. We expect the trend of T1rho value increase in rat brain from month 5 to month 15 in this study might be contributed to age-related changes of brain tissue composition.

References: *[1] Nguyen AM, et al. J Bone Joint Surg Am.2008; 90(4):796-802. [2] Burstein D, et al. Radiol Clin North Am. 2009; 47(4):675-86. [3]Wang YX, et al. Radiology. 2011;259(3):712-9. [4] Sirlin CB. Radiology.2011;259(3):619-20. [5] Borthakur A, et al, J Mag Res Imaging. 2006;24(5):1011-7. [6] Haris M, et al, JMRI. 2009;29(5):1008-12. [7] Haris M, et al, J Neurol. 2011; 258(3):380-5. [8]Scahill RI, et al. Arch Neurol. 2003; 60(7):989-94.*