A comparative study of brain regional T1rho values of spontaneously hypertensive rat and Wistar Kyoto rat

Feng Zhao[1], Li-Hong Zhang[2], Jing Yuan[1], Queenie Chan[3], David Yew[2], and Yi-Xiang Wang[1]

[1]Department of Imaging and Interventional Radiology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, [2]Department of Anatomy, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, [3]Philips Healthcare, Hong Kong

Introduction: T1rho (T1ρ) tissue contrast 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 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 MR has been used to study Alzheimer' disease in mouse model [5], as well as Alzheimer' disease, mild cognitive impairment and Parkinson's disease in patients [6,7]. Spontaneously hypertensive rats (SHR), which are normotensive at birth and develop sustained hypertension between 3 and 6 months of age, are the model most extensively investigated for evaluating hypertensive brain damage and its treatment [8]. In this study, we measured the T1rho relaxation in the thalamus, hippocampus and cortices of SHR rats and Wistar Kyoto (WKY) control rats at the age of 6-month.

Material and Methods: Eleven male Spontaneously hypertensive rats (SHR) and ten male Wistar Kyoto (WKY) control rats were used in the study with the animal ethics approval. The rats were MR scanned at the age of 6-month. MRI was performed on a 3 T clinical scanner (Achieva, Philips Healthcare, Best, The Netherlands). After anesthesia, animals were positioned prone and a custom made quadrature volume RF coil of 7cm internal diameter was used as signal transmitter and receiver. 14 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, 50ms, and 80 ms, TE and TR were 3.6 ms and 7.4 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 4. 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 maps (Fig.1).

Results: At the age of 6-month, T1rho values in thalamus, hippocampus and cortices were 63.4±1.4 ms, 71.0±2.4 ms, and 79.3±2.7 ms respectively in WKY rats, and 66.4±2.8 ms, 76.2±3.6 ms, and 84.6±3.8 ms respectively in SHR rats, being 4.8% higher (P=0.01), 7.4% higher (P=0.001), and 6.7% higher (P=0.003) for SHR rats than WKY rats (Fig. 2).

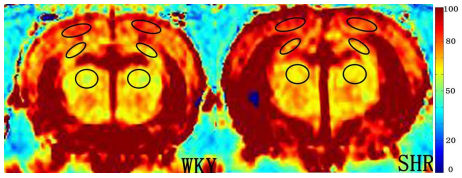

Fig. 1. T1rho maps for one WKY (left) and one SHR (right) rats. ROIs were placed on bilateral thalamus, hippocampus and cortices.

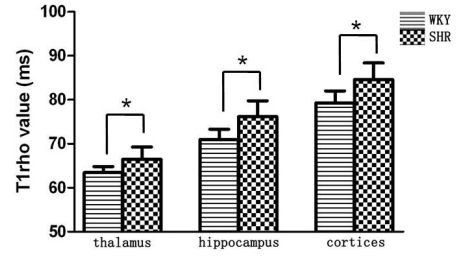

*Fig. 2. T1rho values in thalamus, hippocampus and cortices of WKY and SHR rats. *: P<0.05.*

Discussion: In this study, it was found that T1rho values in the thalamus, hippocampus and cortices of SHR rats were significantly higher than those of WKY control rats at the age of 6-month. It has been documented that chronic hypertension may induce blood brain barrier dysfunction in cerebral cortex, deep gray matter and hippocampus of adult spontaneously hypertensive rats (SHR) [9]. The time-dependent rise of arterial blood pressure, the occurrence of brain atrophy, loss of nerve cells, and glial reaction are phenomena shared to some extent with hypertensive brain damage in humans [8]. Borthakur et al suggested that T1rho relaxation increases progressively with Alzheimer' disease-related pathology (plaque burden) in the mouse brain [5]. Haris et al suggested that the increased T1rho in Parkinson's disease patients with dementia may be associated with the increased atrophy and high Alzheimer' disease related changes [7]. In this study, the higher T1rho values in thalamus, hippocampus and cortices of SHR rats compared with WKY control rats, might be caused by hypertensive-related brain changes, such as brain atrophy, loss of nerve cells and glial reaction. T1rho MR imaging might be a potential technique to monitor brain changes due to chronic hypertension. T1rho MR imaging for SHR and WKY rats at the age of 9-month will be further studied in our lab.

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