A Sodium Imaging Study of Huntington's Disease at 4T

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Introduction

Sodium MR imaging has been shown to be sensitive to cell viability and death [1, 2]. Changes of Tissue Sodium Concentration (TSC) have been observed due to neurodegenerative, inflammation and tumorous pathologies [3-5]. Using this non-standard innovative MRI approach, we aimed to investigate cellular and metabolic integrity of brain tissue in pre-symptomatic and symptomatic brains affected by Huntington's Disease (HD). The neuropathological hallmark of HD is progressive striatal loss starting several years prior to symptom manifestation, therefore an imaging method able to monitor early neuronal physiological disturbances in brain tissue appears to be most desirable.

Methods

Twenty-six informed subjects participated in this study. Comparison between structural and sodium MR imaging profiles of thirteen HD brains (6 female, 7 male, 44 ± 9.6 years of age; mean ± SD) and thirteen normal brains (6 female, 7 male, 44.9 ± 9.9 years of age, mean ± SD) with no history of neurological or psychiatric disorder and no medication were performed. All measurements were conducted on a home-assembled 4T whole-body scanner equipped with a Siemens (Erlangen, Germany) console using a dual 1H/23Na head coil (Rapid Biomed, Germany). Sodium measurements were performed using a centric SPRITE sequence [6]. To minimize signal biases due to the bi-exponential behavior of sodium in the brain, the sodium signal was acquired at an ultra-short echo time of 300us. The final image resolution was 7.0 mm isotropic. Acquisition time for each sodium image was 36 minutes. A B1 map of a homogeneous phantom was used to normalise signal variations across the field-of-view. Quantitative maps of the TSC were obtained using a two-point calibration curve from the signals of two phantoms of known sodium concentration (100 and 150 mmol/l) placed near the head. Anatomical scans of each subject were acquired with an MP-RAGE sequence at the end of each sodium measurement. The T1-weighted images were then analyzed with voxel-based morphometry (VBM).

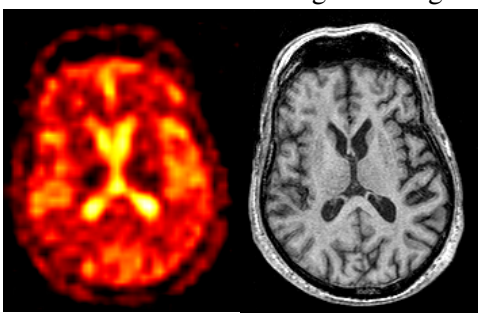

Figure 1. Coregistered sodium (left) and T1-weighted (right) images.

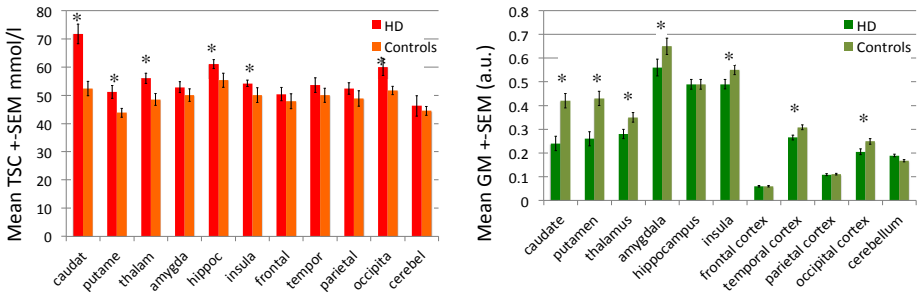

Figure 2. TSC analysis based on specific ROIs (left) showed significant increase of sodium concentration in the HD group (indicated by an asterisk) where VBM (right) indicated a marked decrease of gray matter values .

Results

Comparing the TSC of the entire brain in HD subjects and healthy controls, a significant increase (p=0.001) of sodium concentration in HD was observed (HD = 54±3 mmol/l; Controls 49±3 mmol/l). Using ROI-based analyses the highest TSC values were found in the bilateral caudate, but also in the bilateral putamen, thalamus, hippocampus, insular and occipital cortex (Fig. 2 left). Except for the hippocampal region in all these structures reduced grey matter values were observed (Fig. 2 right). In contrast, in the amygdala and temporal cortex reduced grey matter values but no change of TSC was detected.

Discussion and Conclusion

This is the first *in vivo* sodium MR imaging study carried out on a 4 Tesla MR scanner in HD demonstrating a significant enhancement in sodium concentration in affected key regions in HD. Sodium MR imaging may provide a deeper insight into the pathophysiological mechanisms of tissue injury in the neurodegenerative disorder HD.

References

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