Investigation of T2* Mapping on Combat-related TBI patient

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Introduction

Traumatic Brain Injury (TBI) accounts for the majority of explosive blast injury and combat causalities in recent conflicts, with mild TBI being the most frequent pattern of injury among this group. These injured warriors present various degrees of functional and cognitive impairment, such as poor concentration, loss of memory, depression, and other psychological disorders. However, conventional neuroimaging studies (such as structural T1-, T2-weighted MR) have been shown to be inadequate for detecting brain lesions. T2* weighted gradient-echo MRI has been reported to be superior to other conventional MR image modalities in detecting small hemorrhagic lesions [1, 2], since T2* is related with the heterogeneity in a magnetic susceptibility induced static field. In this study, we evaluated T2* mapping in detecting brain lesions in TBI patients from military population and investigated the results with clinical neurobehavioral symptoms of military-related TBI patients.

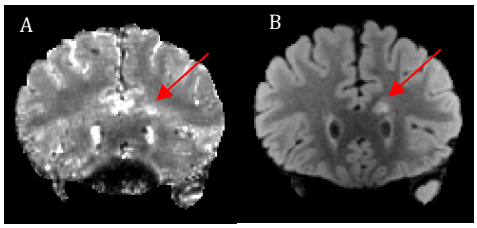

Figure 1 Lesion showed in T2* map (A) and FLAIR image (B)

Methods

Image acquisition: Thirty-five (35) documented TBI patients (27 mild, 7 moderate and 1 severe, 28 males, 7 females, mean age= 27.9±5.6 years) and eleven (11) healthy controls (HC) (mean age= 24.5±3.3, 7 males and 4 females) were imaged on a 3T scanner (GE 750, GE Healthcare, Milwaukee, WI) equipped with a 32-channel phased array head coil. Structural T1 images were acquired with TR=6.636ms, TE=2.52ms, Flip angle=12 and FOV=24cm, T2 FLAIR images were acquired with TR=6500ms, TE=130.85ms, Flip angle=90° and FOV=24cm. Multiecho gradient-echo images (TR = 45 ms, Flip Angle = 20°, scan matrix = 512 X 256 X 88, Field of View = 24 × 24 cm², slice thickness = 1.5mm.) were acquired with TE=13, 19, 25,31,37ms using the SWAN sequence.

Image analysis: T2* maps were calculated using a linear fitting model (equation: T2 signal intensity=$(TE_2\text{-}TE_1)/\ln(S_1/S_2)$). These T2* maps were transformed to a population-based template, which was created by spatially normalizing the T1 images to the MNI template using the same nonlinear normalization algorithm (ANTS, http://picsl.upenn.edu/ANTS/) [3]. Whole brain voxel-wise analysis was performed on the normalized T2* maps corrected for multiple comparisons using a two sample t-test. Significant clusters from voxel-wise analysis were selected to perform a confirmatory ROI analysis. In addition, whole brain linear regression was used to evaluate the relationship between T2 relaxation time and neurobehavioral symptoms (Neurobehavioral Symptom Inventory (NBSI) average score) of TBI patients. All statistical analyses were performed using AFNI (http://afni.nimh.nih.gov/afni)

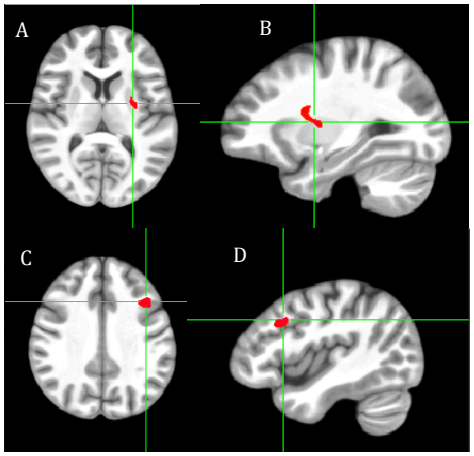

Figure 2 Regions of significantly longer T2* in TBI patients than HC: left Putamen (A, B) and left Frontal lobe (C, D), p<0.005 and cluster size>150

Results

Figure 1 shows an example of a brain lesion (red arrow) demonstrated by the T2* map (left) and the FLAIR image (right). Voxel-wise analysis demonstrated TBI patients as a group had significantly longer T2* relaxation time than HC in several regions, include left putamen (Figure 2 A, B) and left frontal lobe (Figure 2 C, D), left cingulate, and left thalamus (p<0.005, and cluster size >150) (Figure 2). The mean T2* relaxation time from these four areas confirmed the same relationships (Figure 3). Figure 4 shows the clusters with significance correlation (p<0.005 and cluster size>150) between T2* and neurobehavioral data cognitive symptoms (an average score) in the orbito-frontal region of TBI patients, i.e. larger NBSI score, longer T2*.

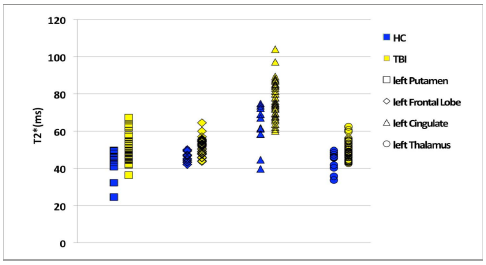

Figure 3 ROI analysis result in all T2* increasing area

Conclusion

The exact source of the differences in T2* signal between the normal and TBI subjects are not clearly known at this moment. The location of these differences in the cingulate, frontal lobe and putamen would suggest potential disruption in cognitive function associated with learning, memory and concentration [4]. However specific correlations between these injury sites and individual patient neuropsychological assessments would need to be further assessed. Overall, our findings indicate the T2* is useful in evaluating brain lesions in TBI patients, which is consistent with the findings from previous studies [1,2], and may be used to predict the clinical symptoms of military-related TBI patients.

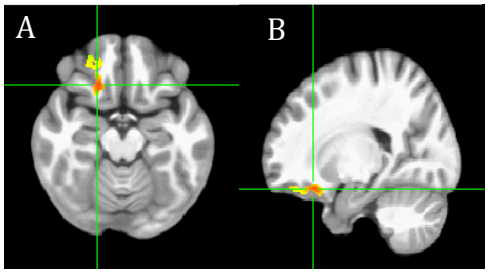

Figure 4 Regression result in TBI patients' T2* and their NBSICOGA score, p<0.005 and cluster size>150

References

1. S. Chan, K. Kartha, et al., *AJNR am J Neuroradiol*. 1996; 17:1821-1827
2. Y. Yanagawa, Y. Tsushima, etal., *J. Trauma* 2000; 49:272-277
3. B. B. Avants, C. L. Epstein, et al., *Med Image Anal*, 2008, 12: 26-41
4. E. Kandel, J. Schwartz and T.Jessell, Principle of Neural Science, 2000.

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