

Detecting Mild Traumatic Brain Injury at the Acute Stage: a Diffusion Tensor Imaging Investigation and Neurocognitive assessment

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Introduction: Mild traumatic brain injury (mTBI) has over one million emergency visits each year in the United States. The neurocognitive and functional symptoms after mTBI significantly impact patients' quality of life and working productivity. However, clinical computed tomography (CT) and conventional magnetic resonance imaging (MRI) techniques either underestimate or fail to detect important neuropathology of mTBI. The available biochemical markers are either non-sensitive or non-specific enough to detect complex and heterogeneous pathoanatomical information of mTBI. Consequently, emergency physicians may fail to order adequate management or follow up plan that could address prolonged neurocognitive or functional symptoms in mTBI patients.

Diffusion tensor imaging (DTI) has been reported being sensitive to subtle changes of the brain after mTBI. However, there is a lack of investigation on the role of DTI in mTBI detection at acute stage, especially in emergency settings. So far the limited findings are conflictive and all have been done in a very limited number of patients. In addition, there is very limited data reporting the neurocognitive assessment of mTBI patients at the acute stage. The **objective** of our work is to investigate the role of DTI for mTBI at acute stage in conjunction with neurocognitive assessment.

Materials and Methods: Eighteen mTBI patients were recruited in emergency setting in our Level-1 trauma center. Eighteen aged- and gender-matched healthy controls were also recruited for comparison. All patients met the definition of mTBI by the American Congress of Rehabilitation Medicine (ACRM) with Glasgow Coma Scale (GCS) score of 13-15 at emergency entry. Before MRI scan, all patients had undergone CT scan in emergency setting. All patients were scanned in our 3 Tesla Siemens VERIO magnet with 32-channel head coil. If an MRI scan was not performed due to logistic reason within 24 hours post injury (acutely), the patient would be scanned within 10 days post injury (subacutely). Three patients were later excluded due to previous head injury or other neurologic history. At the same day of MR imaging, twelve subjects completed neurocognitive tests by using Standard Assessment of Concussion (SAC) instrument. SAC is a short form of neurocognitive instrument to test patients' orientation, immediate memory, concentration, and delay recall.

The MRI protocol included SWI, DTI and MR spectroscopy, in addition to baseline T1, T2, and FLAIR sequences. For DTI analysis, both a region of interest (ROI) analysis and tract-based spatial statistical (TBSS) approach were used for group comparison between patients and controls. In ROI analysis, an international consortium of brain mapping (ICBM) atlas was used to define brain regions in a standardized way. In TBSS analysis, once voxel clusters (cluster size >10) at the center lines of white matter (WM) tracts have statistically different FA values from controls, the whole width of the WM segment of these center clusters will be chosen as ROIs for group comparison.

Results: SAC test demonstrated mTBI group has significant lower SAC scores than controls in published data ($p=0.05$), particularly lower scores in delayed recall ($p=0.03$). DTI ROI analysis demonstrated the following regions with significant reductions of fractional anisotropy (FA) in comparison with controls ($p<0.05$) (see Figure 1): superior corona radiata, superior longitudinal fasciculus, splenium of corpus callosum, and posterior thalamus radiation. TBSS analysis also demonstrated scattered regions with significantly lower FA values in mTBI patients than that in controls ($p<0.05$). These scattered regions are located at the same regions as that of ROI analysis except for superior longitudinal fasciculus (see Figure 2). Our data demonstrated that two approaches give decently consistent results. However, TBSS could more precisely pinpoint the lesion areas.

Figure 1 (Right). DTI region of interest analysis demonstrated significantly reduced fractional anisotropy (FA) in the highlighted areas.

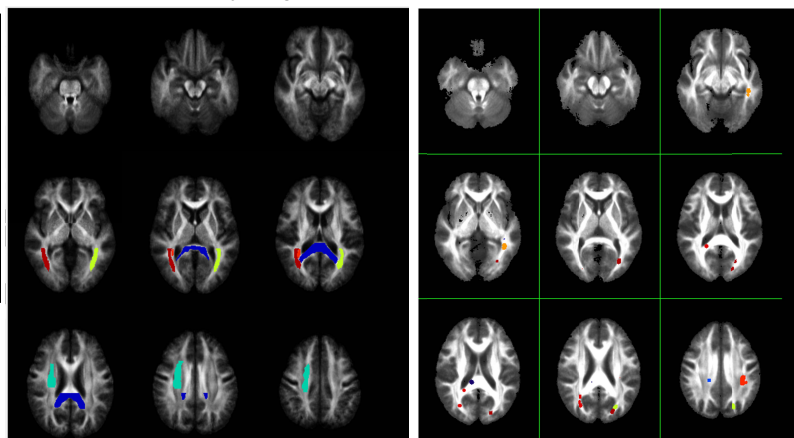


Figure 2 (Left). DTI TBSS detected significantly lower FA values in the regions as highlighted.

Discussion and Conclusions: Traumatic brain injury is heterogeneous with different injury pathology and injury locations [1]. Mild TBI is more difficult to localize the lesions. Our SAC test demonstrated that a) it is feasible to assess patients' neurocognitive status at the acute stage, and b) these mTBI patients do have neurocognitive impairments at the acute stage. Our DTI data showed that both ROI and TBSS approaches can detect white matter lesions in a complementary manner, which account for the neurocognitive symptoms at the acute stage.

Reference: 1. Kou Z, Benson RR, Haacke EM, *Susceptibility weighted imaging in traumatic brain injury*, in *Clinical MR Neuroimaging, 2nd Edition*, Gillard J, Waldman A, Barker P, Editor. 2008, Cambridge University: Cambridge.