Development of Diffusion-weighed MRI to Study Structural Changes in the Brain Stem following Mild Traumatic Brain Injury

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Introduction

Mild traumatic injury (mTBI) often results in sleep disturbance, which may be associated to changes in the structural organization of brain stem white-matter tracts[1]. Diffusion weighted MRI with tractography is an ideal method to study the brain organization of white matter *in vivo*[2] that allows the observation of changes in tracts, which are directly associated to the sleep architecture. The locus coeruleus (LC) is a main noradrenergic nucleus of the brain and directly associated to sleep regulation and the hypothalamus (HT) is associated with the regulation circadian rhythms, so sleep disturbances could be affected by structural architecture connecting these regions to the rest of the brain. Using the 3 T magnet system in the AMRIS Facility, we have developed diffusion weighted imaging and tractography methods for characterizing changes in the brain stem connectivity between regions of interest (ROI's) controlling sleep architecture (LC and HT) to measure the integrity of the white matter structure around the brainstem in healthy controls and war veterans with mTBI.

Experimental

The UF Institutional Review Board approved this study. We optimized a spin echo diffusion weighted echo planar sequence and acquired sagittal slices centered on the brain stem with a 1.5 mm isotropic resolution. T1-weighted image was acquired to segment the HT and a FGATIR image for the LC. After segmentation, these images were registered using FSL's FLIRT to the diffusion weighted images[3]. The diffusion weighted data was modeled with a distribution of diffusion tensors that allowed discriminating multiple fibers per voxel[4], which improved the tracking in the desired midbrain areas. Finally deterministic fiber tracking was performed following the FACT algorithm [5], and fibers connecting the ROI's were obtained using the method described by Colon-Perez et. al.[6].

Results and Discussion

Using this approach, white matter connecting the LC and HT (for example see Figure 1) in each side of the brain was observed and the strength of connection was quantified in 3 healthy controls.

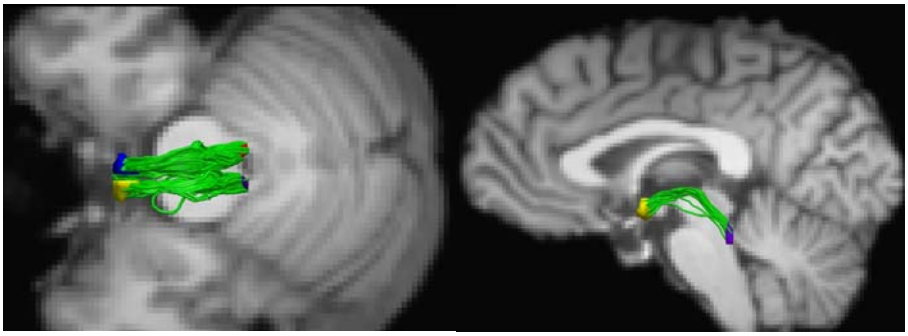

Figure 1: Left shows axial view of bilateral LC and HT connectivity and right shows sagittal view of left-side connectivity (yellow, left HT ROI, blue = right HTs ROI, purple = left LC ROI, and red = right LC ROI.

Conclusions

With these methods, we are able to observe the white matter architecture connecting these important subcortical brain regions *in vivo*, and compare the tract volume, and edge weight [6]. This approach will allow these methods to be used for the study war veterans who have suffered mild traumatic brain injury. Additionally, sleep and neuropsychological testing can be used to correlate with these connectivity measures.

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