Evaluation of Resting State Networks Following Traumatic Brain Injury

Leanne Y Lin[1], Christine L MacDonald[1], Megan H Lee[1], Abraham Z Snyder[1], David L Brody[1], and Joshua S Shimony[1]
[1]*Washington University School of Medicine, St. Louis, MO, United States*

Purpose: Survivors of traumatic brain injury (TBI) suffer cognitive dysfunction especially in tasks that depend on memory and control of attention. It is thought that the axonal injury and consequent disruption of functional networks contributes to the cognitive dysfunction.[1] Resting state fMRI (rsfMRI) is well established as a modality for evaluating the integrity of functional neural networks. Previous studies have shown reduced functional connectivity within the default mode network (DMN) associated with impaired attention in patients with TBI.[2,3] The goal of this study was to investigate changes in several resting state networks in 5 severe and 11 moderate chronic TBI patients using a fuzzy-c-means clustering algorithm.[4]

Methods: 16 patients with clinically diagnosed chronic TBI (ages 18-50) and 16 controls matched for age and handedness were scanned in a 3T Allegra MRI scanner (Siemens, Erlangen, Germany). Following previously described protocols[5], we acquired rsfMRI (4 cubic mm voxels, 438 frames), high resolution MPRAGE and T2-weighted fast spin echo scans. Post-processing included compensation for asynchronous slice timing, retrospective correction for head motion and atlas transformation. A voxel-by-voxel correlation matrix was analyzed for each patient and averaged across the three groups (control, moderate, and severe). The fuzzy-c-means clustering algorithm was used to classify each group's averaged correlation matrix into seven resting state networks. The resulting connectivity maps were compared across groups.

Results: Differences were noted in several networks. The default mode network (Figure 1A: control; 1B: moderate TBI; 1C:severe TBI) showed decreased weight in the medial pre-frontal cortex and increased weight in lateral parietal and occipital cortices, and these changes varied with severity of injury. The dorsal and ventral attention networks showed loss in symmetry, most notably in the severe TBI patients. The language network showed decreased cortical weights with preservation of weights in deep nuclear structures. The fronto-parietal control network showed losses in deep nuclear and occipital cortex, and preservation in pre-frontal cortex.

Discussion: These findings provide preliminary information regarding changes in resting state networks in patients with moderate and severe TBI. The changes in the default mode network and the attention networks may help us understand the cognitive dysfunction in patients with severe TBI. Loss of symmetry in the attention networks suggests corpus callosal disruption interfering with inter-hemispheric communication. Further investigation is needed to quantify the extent of changes and to correlate these with changes with formal cognitive measures and with clinical outcomes.

References:

1. C.L. MacDonald, et al. Neurology. 2008 October 7; 71(15): 1199–1201;
2. F.G. Hillary, et al. Int J Psychophysiol. 2011 Oct;82(1):115-23. Epub 2011 Apr 21;
3. V. Bonnelle, et al. J Neurosci. 2011 Sep 21;31(38):13442-51;
4. M.H. Lee, et al. PLoS One. 2012;7(7):e40370. Epub 2012 Jul 9;
5. Fox, et al. Proc Natl Acad Sci U S A. 2005 Jul 5;102(27):9673-8. Epub 2005 Jun 23.