Visualizing Plasticity and Altered Neuronal Signaling in the Injured Human Spinal Cord with fMRI

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Introduction

Evidence of CNS plasticity after traumatic spinal cord injury has been observed in animal models and human brain fMRI studies. In this work, we conduct a spinal fMRI study and apply a functional connectivity analysis to determine whether or not the injured spinal cord processes sensory information differently than healthy controls.

Methods

Using an automated thermal delivery system, heat (44°C) was applied to 2 dermatomes above and 2 below the level of SCI. Spinal fMRI data was collected on a 3T system using a SEEP-based protocol developed by our group (SSFSE, TE=30msec, TR=1sec). Data were spatially normalized and analyzed using the general linear model (P=0.001). We divided the cervical spinal cord into zones based on known anatomical relationships of nerve rootlets entering the cord from the segmental nerve root. We conducted a functional connectivity analysis between the dorsal quadrant of the spinal cord corresponding to the stimulated dermatome and other regions of the spinal cord and brainstem. Clinical measures were conducted at the time of scan (AISA examination).

Results

35 people were examined: 20 control, 9 incomplete SCI and 6 ASIA E patients. We demonstrate that dermatomes of abnormal sensation negatively correlate with the number of active voxels ($R2 = 0.93$, $p < 0.001$). We show that the number of interspinal connections is significantly higher in incomplete SCI patients stimulated above the level of their injury in a dermatome of normal sensation, $p = 0.045$, in comparison to healthy controls. This was also observed in ASIA E patients ($p=0.03$).

Conclusions

For the first time, we report a graph theory analysis of spinal fMRI data to understand how neural networks change after spinal cord injury. We show for evidence for spinal plasticity in incomplete SCI patients; these plastic changes are evident in those who fully recover from their injury.

Learning Objectives

1) To understand the application of graph theory analysis to spinal sensory networks

2) To appreciate how the spinal cord changes after traumatic SCI

[DEAULT POSTER]