Spinal fMRI of Multiple Sclerosis in Human Subjects

A. D. Bergman[1], C. LeBlanc[2], P. W. Stroman[1,3]

[1]Dept. of Physiology, University of Manitoba, Winnipeg, Manitoba, Canada, [2]Dept. of Radiology, Health Sciences Centre, Winnipeg, Manitoba, Canada, [3]MR Research and Development, Institute for Biodiagnostics, NRC, Winnipeg, Manitoba, Canada

Introduction

Functional magnetic resonance imaging of the spinal cord, spinal fMRI, has been previously shown to detect activity in the spinal cord of healthy and spinal cord injured subjects.[1,2] Multiple sclerosis is a common cause of neurological disability, usually first affecting patients in early adulthood. We present the first spinal fMRI study of patients with multiple sclerosis (MS) as it pertains to patterns of activity observed in the spinal cord and compare these results to the previous studies of healthy and spinal cord injured subjects.

Methods

Spinal fMRI studies were carried out at 1.5 T (General Electric, Signa Horizon LX) with subjects supine, using a phased-array receiver coil. T2-weighted images were obtained to visualize the lesion load in the spinal cord. Functional time-course data were obtained using a single-shot fast spin-echo sequence (TE = 38 msec, TR = 11 sec). Eight slices were selected spanning the spinal cord segments corresponding to sensory or motor deficits, and also where an MS lesion was observed, or in the cervical or lumbar cord if no lesions were found. Slices were oriented transverse to the spinal cord and were aligned with either the intervertebral discs or the centers of the vertebrae according to established methods.[1,2] Thermal stimulation was applied with a Medoc® TSA-II thermal sensory analyzer. The thermal probe was placed against the skin corresponding to the dermatome associated with the area of the spinal cord being imaged. In each experiment, images were acquired repeatedly while the stimulator was cycled between 32ºC for the baseline and 15 ºC for stimulation. Baseline conditions were held for 66 seconds and stimulation periods were maintained for 44 seconds. The time for the transition from 32ºC to 15ºC was 11 seconds. Studies were repeated with the stimulus applied to both sides of the body. Data were analyzed using custom-made software written in MatLab using a correlation method with a p-threshold of 0.05. The paradigm was defined with the signal higher during stimulation than during the baseline conditions. Only data acquired during the constant temperature periods were used for calculating the correlation to the model paradigm, and no model was assumed for the transitions.

Results

Spinal fMRI was performed on 27 patients with multiple sclerosis; 11 secondary progressive (SP), 6 relapsing remitting (RR), 8 primary progressive (PP), 1 unknown. All but two patients had chronic motor or sensory deficits in the trunk or limbs at the time of the study. Durations since diagnosis of MS ranged from 3 – 32 years. Activity was detected in the regions of the spinal cord corresponding to the stimulation in all subjects. The pattern of activity correlated well with the functional deficits experienced by the subjects.

Discussion and Conclusions

Spinal fMRI in subjects with multiple sclerosis followed patterns similar to those observed in healthy subjects in some cases, and similar to the patterns observed in studies of incomplete and complete spinal cord injuries, in other cases. In healthy control subjects the pattern of activity was observed to be primarily a sensory response in the ipsilateral dorsal region, with motor reflex activity observed bilaterally. In subjects with complete spinal cord injury the sensory response was diminished, but the motor reflex response was enhanced on both sides of the cord and around the central canal. Subjects with incomplete injuries had a diminished sensory response, and did not have an augmented motor reflex response. In subjects with MS, these patterns were also observed and corresponded well with their reported deficits. Comparing the spinal fMRI results with the presence of an observable lesion revealed some correspondence, but it was not as clear. When split into subtypes of MS, differences emerged. The group of patients with RRMS had patterns of activity closest to the pattern for healthy controls of all of the subtypes. This was likely due to the fact that the majority of the group had no symptoms or symptoms less severe than the other subtypes. The two patients with symptoms comparable to the other subtypes of the disease displayed altered patterns of activity corresponding to their functional deficit. Patients with both SPMS and PPMS had patterns of activity that varied depending on the presence of a functional deficit or MS lesion. The majority of patients in these subgroups had patterns of activity at a level of the spinal cord that resembled the pattern of activity in spinal cord injured subjects more so than those of healthy controls. The data shows that even with an altered physiology within and outside the areas of macroscopic demyelinated multiple sclerotic plaques, neuronal activity can be seen in recognizable patterns.

References

1. Stroman *et al.* Spinal Cord (in press), 2003.
2. Stroman *et al.* NeuroImage 17, 1854–1860, 2002.