Degeneration of Subcortical White Matter in Alzheimer's Disease: Topographical Analysis

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Introduction

Cortical damage in Alzheimer's disease (AD) has been extensively studied using neuropathological as well as MR imaging methods. On the other hand, nature of white matter damage in AD has been less well understood. Diffusion-weighted imaging (DWI) has proven useful to detect microstructural degradation of neural tissue in AD. We studied the topographical pattern of microstructural damage in subcortical white matter associated with AD using DWI.

Materials and Methods

All images were obtained using a 1.5 T clinical MRI scanner (Magnetom Symphony, Siemens). DWIs were obtained using a diffusion-tensor imaging (DTI) pulse sequence with a CSF-nulling inversion pulse. The images were obtained with 6-directional diffusion-encodings (b value = 800 s/mm^2) as well as with no diffusion encoding. High-resolution T1-weighted images were also obtained. From the DTI data, maps of mean diffusivity (MD) were created. 3D mapping of MD in subcortical white matter was performed using a previously reported method (1). To obtain mean MD values in each cortical regions, we used a free software package (Individual Brain Atlases using Statistical Parametric Mapping Software, IABSPM: Cuban Neuroscience Center), which automatically divide the gray matter of individual brain into 116 regions according to the standard brain atlas. For our analysis, 76 cortical regions were selected discarding those in the cerebellum and deep gray matter. Nine AD patients (2 males and 7 females, 52-81 years old, mean 63.4 years old) and six healthy aged subjects (4 males and 2 females, 52-78 years old, mean 63.2 years old) were compared.

Results

In the comparison between the normal and AD groups, the mean MD values among the AD group were higher than those among the normal group in all 76 cortical regions. Fig. 1 shows a map of percent elevation of MD values in the AD group in comparison with the normal group. Result of t-test is mapped in Fig. 2. Significant elevation of mean MD was observed in right superior frontal gyrus, left middle frontal gyrus, bilateral inferior frontal gyri, right anterior and middle cingulate gyri, bilateral posterior cingulate gyri, bilateral parahippocampal gyri, right fusiform gyrus, bilateral angular gyri, right superior temporal gyrus, and left middle temporal gyrus ($p < 0.05$, Bonferroni corrected).

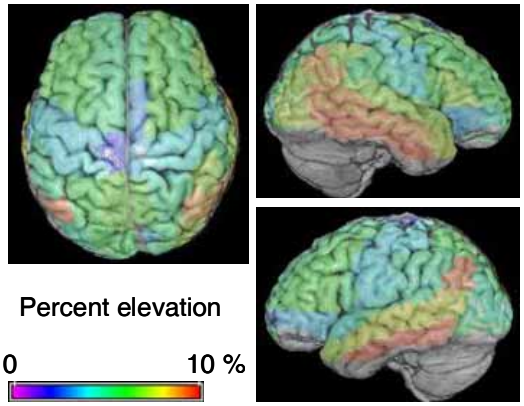

Fig. 1: 3D mapping of percent elevation of MD in AD patients in comparison with healthy subjects.

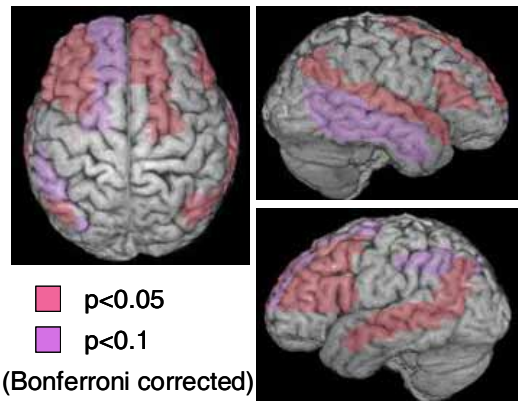

Fig. 2: Regions of statistically significant MD elevation in AD patients.

Discussion

Spatial pattern of subcortical white matter damage revealed in this study was closely related to pathologically proven topographical pattern of cortical involvement in AD. It was suggested that damage in subcortical white matter in AD is secondary to cortical degeneration. Subcortical mapping method (1) in combination with IABSPM is useful to analyze microstructural changes in the subcortical white matter in individual cortical regions.

Reference

1. Yoshiura T, Mihara F, Tanaka A, et al. Novel method to estimate and display cerebral cortical degeneration using diffusion-weighted magnetic resonance imaging. Magn Reson Med 2005;54(2):455-459.