Early prediction of the prognosis for motor function after stroke using diffusion tensor imaging

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Introduction

The anterograde (or Wallerian) degeneration of white matter fibers at a distance from a primary lesion is a common finding in central nervous system (CNS) pathology such as stroke. Prognosis for motor function in stroke patients with Wallerian degeneration in corticospinal tracts is poor. Thus, early detection of this degeneration in corticospinal tracts is possibly useful to predict prognosis for motor function. However, conventional CT and MRI can sometimes reveal signal intensity and/or volumetric changes only in chronic stage after fiber degeneration. Recently diffusion tensor imaging (DTI) has been used to observe the diffusion properties of tissue water. Because normal white matter fibers are oriented coherently, high diffusion anisotropy is observed in normal white matter. In contrast, water diffusion has been reported to be altered in white matter tracts following Wallerian degeneration, which is histologically observed several days after the onset. The goal of this study was to test the hypothesis that the prognosis for motor function is predicted using DTI in the early stage after stroke.

Materials and Methods

Thirteen patients with hemiparesis due to supratentorial stroke lesions were examined at 0, 7, 14, 21, and 28 days after the onset. The patients' motor functions were evaluated according to Brunnstrom stage (BS) criteria. In addition, patients were classified into 2 groups using this criteria as follows: The good recovery was defined as final BS V and VI; the poor recovery as final BS I to IV. All MRI studies were performed using 1.5-T whole-body imager (Signa LX; GE) capable of echo planar imaging (EPI). Imaging parameters for DTI and T2-weighted EPI were repetition time (TR) = 6.5s, echo time (TE) = 107ms, field of view (FOV) = 24cm, matrix = 128x128, slice thickness = 7mm, and 20 axial multislices with no gap. The diffusion b value of 1000 s/mm^2 was applied in six directions according to previous reports. An additional image with no diffusion weighting (b=0) was also acquired for T2-weighted EPI, resulting in a total of 7 images per slice. The fractional anisotropy (FA) was measured in regions along the corticospinal tracts (internal capsule, cerebral peduncle, and pons) at a distance from a primary stroke lesions. The relative FA and relative signal intensity on T2-weighted MRI, divided by mean values in contralateral region, were calculated, which compensated for individual differences in patients and measurements independent of pathologic changes. Normalized relative FA (rFA) and relative signal intensity on T2-weighted MRI (rT2W), divided by initial values in day 0, was also calculated.

Results and Discussion

The rFAs in internal capsule, cerebral peduncle, and pons of the poor recovery group was significantly decreased at 14 days or later. Furthermore, the rFA in these regions at 14 days or later was well correlated with the final BS. Especially, the most sensitive region to observe fiber degeneration was cerebral peduncle. In a recent report, three-dimensional anisotropy contrast (3D-AC) MRI enabled to detect degeneration at 3 weeks after the onset, suggesting that DTI may be more sensitive to detect Wallerian degeneration. In conclusion, our findings were consistent with the hypothesis that the prognosis for motor function after stroke is predicted using DTI at 14 days.

References

Pierpaoli C, et al. Radiology 201: 637-648, 1996;

Pierpaoli C, et al. NeuroImage 13: 1174-1185, 2001

Watanabe T, et al. J Neurosurg 94: 955-960, 2001