Three-dimensional white matter tractography with diffusion-tensor analysis and fiber tracking for evaluation of corticospinal tract injury with acute deep intracerebral hemorrhage

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Introduction

Three-dimensional white matter tractography with diffusion-tensor MR analysis and fiber tracking can be used to depict the main white matter tract anatomy, such as of the corticospinal tract (1-2). Seventy percent of intracerebral hemorrhages (ICH) occur in the putamen or thalamus, that is in the deep gray matter. A common symptom of putaminal or thalamic hemorrhage is hemiparesis that results in impaired motor function. Such impairment in patients with deep ICH may be caused by primary or secondary corticospinal tract injury. Perihematomal tissue injury can be seen on diffusion-weighted MR images (3-4).

Our goal was to assess the usefulness of three-dimensional white matter tractography for predicting functional motor outcome in patients with acute deep ICH.

Methods

Study subjects were 35 who underwent MR study within 72 hours after onset of putaminal or thalamic hemorrhage. Diffusion tensor images were obtained with a 1.5T MR scanner (Magnetom Vision, Siemens Medical System, Erlangen, Germany). An echo-planar imaging (TR = 4000 ms, TE = 100 ms, matrix = 128 × 128, FOV = 230 × 230 mm, number of acquisitions = 3, slice thickness = 4 mm, slice gap = 1 mm, 20 axial planes, acquisition time = 84 sec) was used, with diffusion gradient applied in six directions and a maximum b value of 1000 s/mm^2. Softwares (Volume one and dTV) downloaded from the internet [http://www.volume-one.org/][http://www.ut-radiology.umin.jp/people/masutani/dTV.htm] were used for diffusion tensor analysis and fiber tracking (1-2). We were able to depict corticospinal tracts that passed both the cerebral peduncle and precentral gyrus.

In patients in which the corticospinal tract ipsilateral to the ICH side was depicted, we set separate regions of interest (ROI) at three levels bilaterally along the corticospinal tract and obtained apparent diffusion coefficient (ADC). We calculated the minimum ADC ratio between the ICH and the contralateral side among ROIs at each of the three levels.

Depiction of the corticospinal tract and ADC were analyzed in association with functional motor outcome according to the NIH Stroke Scale scores at 4-weeks onset.

Results

Depiction and non-depiction of the corticospinal tract ipsilateral to the ICH is shown in relation to NIH Stroke Scale in Table 1. The corticospinal tract ipsilateral to the ICH was not depicted in 11patients, all of whom had a poor outcome at 4 weeks. In all cases, the corticospinal tract contralateral to the ICH was depicted. In all cases in which the ipsilateral corticospinal tract was depicted, there was an adequate displacement of the tract, which was attributed to the ICH (Figure 2). The minimum ADC ratios are shown in relation to the NIH Stroke Scale scores in Figure 1. The ADC ratios of patients with an NIH Stroke Scale of 3 or 4 were significantly lower than the ADC ratios of patients with a good outcome (□P < 0.05, Bonferroni correction for multiple comparisons).

Conclusion

Our findings indicate that three-dimensional white matter tractography with diffusion tensor MR analysis and fiber tracking is useful for predicting functional motor outcome in patients with deep ICH.

Reference

1) Masutani, et al. European Journal of Radiology 2003.

2) Kunimatsu, et al. Neuroradiology 2003.

3) Carhuapoma JR, et al. Stroke 2000.

4) Kidwell CS, et al. Neurology 2000.

Table 1

NIH Stroke Scale (motor function)	Corticospinal tract of ICH side	
	Depiction	Non-depiction
	(cases)	
0	13	0
1~2	7	2
3~4	4	9

Figure 1

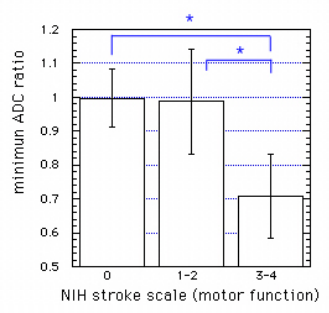

Figure 2