Reorganization of injured anterior cingulums in a hemorrhagic stroke patient

In this study, we reported on a patient who showed a new neural tract between the injured anterior cingulums and the basal forebrain, as shown by diffusion tensor tractography (DTT).

A 62-year-old female underwent coiling for a ruptured aneurysm in the left middle cerebral artery (M1) and decompressive craniectomy for intracerebral hemorrhage in the left fronto-temporal lobe, intraventricular hemorrhage, and subarachnoid hemorrhage (Figure 1A, B). At three weeks after a hemorrhagic stroke, she showed bilateral motor weakness (right side: 2-/5 and left side: 2/5) and severe cognitive impairment (decreased alertness, Mini-Mental State Exam score: uncheckable). She began to recover gradually after two months of rehabilitation.

Diffusion tensor imaging was performed at three weeks after onset using a 6-channel head coil on a 1.5T Philips Gyroscan Intera (Hoffman-LaRoche Ltd, Best, The Netherlands) with single-shot echo-planar imaging and navigator echo. Sixty contiguous slices (acquisition matrix = 96 × 96; reconstruction matrix = 192 × 192; field of view = 240 × 240 mm²; repetition time = 10,726 ms; echo time = 76 ms, b = 1000 s/mm², number of excitations = 1, slice gap = 0 mm and thickness = 2.5 mm) were acquired for each of the 32 non-collinear diffusion-sensitizing gradients. Fiber tracking was performed using the fiber assignment continuous tracking (FACT) algorithm implemented within the diffusion tensor imaging task card software (Philips Extended MR Work Space 2.6.3). For reconstruction of the cingulum, the seed region of interest (ROI) was placed in the middle portion of the cingulum and the target ROI was placed in the posterior portion of the cingulum on the colored coronal images. Termination criteria were fractional anisotropy (FA) < 0.15 and an angle change > 27° (Yoo et al., 2014).

On 3-week DTT images, both cingulums showed discontinuations between the anterior cingulum and the basal forebrain. However, the discontinued right anterior cingulum was connected to the left basal forebrain via the genu of the corpus callosum. In addition, the discontinued left anterior cingulum was connected to an unusual neural tract from the right anterior cingulum connected to the left basal forebrain (Figure 1C).

In this patient, discontinuations of both anterior cingulums appeared to be ascribed to the left intracerebral hemorrhage and subsequent subfalcine herniation (Figure 1A, B). We observed an unusual neural tract between the discontinued right anterior cingulum and the left basal forebrain via the genu of the corpus callosum, and the discontinued left anterior cingulum was connected to this unusual neural tract.

The cingulum, which connects the orbitofrontal cortex and the medial temporal lobe, plays an important role in cognition. In particular, it is associated with...
memory function because the cingulum is the passage of cholinergic innervation from the cholinergic nuclei (the medial septal nucleus [Ch1], the vertical nucleus of the diagonal band [Ch2], and the nucleus basalis of Meynert [Ch4]) in the basal forebrain to the cerebral cortex (Woolf and Butcher, 1986; Selden et al., 1998; Nieuwenhuys et al., 2008; Naidich and Duvernoy, 2009). Therefore, the unusual neural tract between the left basal forebrain and the injured anterior cingulums likely contributes to a compensatory phenomenon to obtain cholinergic innervations from cholinergic nuclei in the left basal forebrain after interruption of cholinergic innervations by complete injury of both anterior cingulums (Woolf and Butcher, 1986; Selden et al., 1998; Nieuwenhuys et al., 2008; Naidich and Duvernoy, 2009).

Discontinuations of both anterior cingulums indicate blockage of cholinergic innervation from the basal forebrain to the cerebral cortex. Therefore, we believe that the development of this unusual neural tract between the basal forebrain and injured cingulums after interruption of cholinergic innervation from the basal forebrain by complete injury of the anterior cingulum might have resulted in the reorganization of cholinergic innervations after stroke (Yeo et al., 2012; Seo and Jang, 2013, 2014; Yoo et al., 2014; Jang et al., 2015).

In conclusion, we reported a stroke patient who showed a new neural tract between the injured anterior cingulums and the basal forebrain. This finding appears to suggest the reorganization of cholinergic innervations after stroke.

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