Clinical Case Report

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Restoration of the corticoreticular pathway following shunt operation for hydrocephalus in a stroke patient

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Abstract

Rationale: We report on a stroke patient who showed restoration of discontinued corticoreticular pathways (CRPs) on serial diffusion tensor tractography (DTT) concurrent with recovery of gait disturbance following shunt operation for hydrocephalus.

Patient concerns: A 67-year-old female patient underwent stereotactic drainage for management of intraventricular hemorrhage due to a rupture of the left posterior communicating artery.

Diagnoses: After 4 weeks from onset, the patient exhibited quadriparesis with more severe weakness in the proximal muscles and could not even stand or walk. She underwent comprehensive rehabilitation for 3 weeks. Her quadriparesis, as a result of hydrocephalus, did not improve significantly.

Interventions: On the pre-op DTT, discontinuations (the right CRP: at subcortical white matter level, and the left CRP: at the midbrain level) of the CRP fibers from the premotor cortex were observed in both hemispheres.

Outcomes: She underwent a ventriculo-peritoneal shunt operation and her quadriparesis improved, especially the proximal muscles. Consequently, she could walk with mild assistance on an even floor at 5 days and walk on stairs at 4 weeks after the shunt operation. On the post-op DTT, the discontinued CRP fibers were elongated to the premotor cortex in both hemispheres.

Lessons: Restoration of discontinued CRPs concurrent with recovery of gait disturbance following shunt operation for hydrocephalus was demonstrated in a stroke patient.

Abbreviations: CRP = corticoreticular pathway, DTT = diffusion tensor tractography, DTI = diffusion tensor imaging, CT = computed tomography, ROI = regions of interest.

Keywords: corticoreticular pathway, diffusion tensor imaging, diffusion tensor tractography, gait, stroke

1. Introduction

Hydrocephalus is a dilatation of the ventricular system of the brain accompanied by an elevated intraventricular pressure.[1] The increased intraventricular pressure can cause compression of the neural tracts adjacent to ventricles; therefore, successful shunt operation for hydrocephalus can result in decompression of the compressed neural tracts around the ventricles.[2] Gait disturbance is an important clinical manifestation of hydrocephalus and it typically improves following a shunt operation.[3,4] However, the underlying mechanisms of these conditions need further description.

The corticoreticular pathway (CRP) originates from the premotor cortex, descends through the reticular formation in the brainstem, and is involved in postural control and gait function by innervating the proximal muscles of extremities and axial muscles.[5,6] Diffusion tensor tractography (DTT), derived from diffusion tensor imaging (DTI), enables 3-dimensional visualization and estimation of the CRP.[5]

In the current study, we report on a stroke patient whose discontinued CRPs were restored on serial DTTs concurrent with recovery of gait disturbance following a shunt operation for hydrocephalus.

2. Case report

A 67-year-old female patient underwent brain computed tomography (CT)-guided stereotactic drainage at the department of neurosurgery of a university hospital to manage an intraventricular hemorrhage, a result of a rupture of the left posterior communicating artery. Four weeks after the drainage, she was transferred to the rehabilitation department of the same hospital and hydrocephalus was detected on the brain CT and magnetic resonance imaging (MRI; Fig. 1A,B). The patient exhibited quadriparesis with more severe weakness in the proximal muscles (shoulder abductor: 3/3, elbow flexor: $3^+/3^+$, finger flexor: $3^+/3^+$, hip flexor: 2/2, knee extensor: $2^+/2^+$, ankle dorsiflexor: $2^+/2^+$) and she could neither stand nor walk. She

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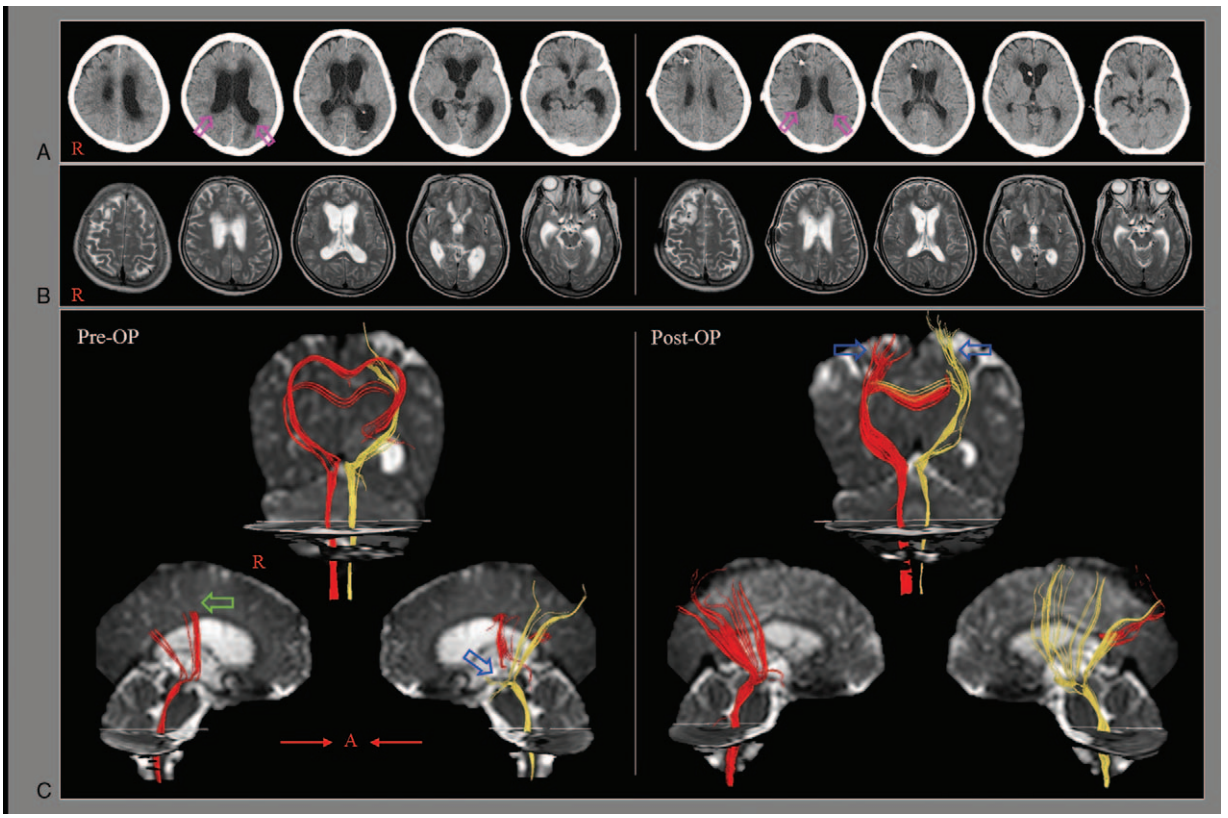

Figure 1. Pre-OP brain CT images (A) and MR images (B) show dilatation of the ventricular system and reduced dilatation of the ventricular system after shunt operation (pink arrows) Results of diffusion tensor tractography (DTT) for the corticoreticular pathway (CRP) (C). On the pre-OP DTT, discontinuations (the right CRP: at subcortical white matter level-green arrow, and the left CRP: at the midbrain level-blue arrow) of the CRP fibers from the premotor cortex were observed in both hemispheres. On the post-OP DTT, the CRP fibers were elongated to the respective premotor cortex in both hemispheres (arrows).

underwent comprehensive rehabilitation, which included neurotropic drugs, physical therapy, and occupational therapy for 3 weeks. However, quadriparesis did not improve significantly, due to hydrocephalus. As a result, she underwent a ventriculoperitoneal shunt operation with a right frontal approach. Her quadriparesis improved 5 days after the shunt operation: shoulder abductor: 4/4, elbow flexor: 4/4, finger flexor: 4/4, hip flexor: 3/3, knee extensor: 3/3, ankle dorsiflexor: 4/4. Consequently, she was able to walk with mild assistance on an even floor at 5 days and walk on stairs at 4 weeks after the shunt operation. The patient provided signed, informed consent, and the study protocol was approved by our Institutional Review Board.

2.1. Diffusion tensor imaging

DTI was performed twice (3 weeks before and 5 days after the shunt operation) using a 6-channel head coil on a 1.5T Philips Gyroscan Intera (Philips, Ltd, Best, The Netherlands) with single-shot echo-planar imaging. Imaging parameters were as follows: acquisition matrix: 96×96; reconstructed to matrix: 192×192 matrix, field of view: $240 \times 240\,mm^2$, repetition time: 10,398 ms, echo time: 72 ms; EPI facto: 59, b:1000 s/mm^2, and a slice thickness of 2.5 mm. We used fiber assignment continuous tracking algorithm included in the DTI software (Philips Extended MR Work Space 2.6.) to track neural fiber. For reconstruction of tracts, the seed and target regions of interest (ROIs) were determined. A seed ROI was placed on the reticular formation of the medulla and the target ROI was placed on the midbrain tegmentum. Termination criteria were fractional anisotropy <0.1 and an angle change >30.[5]

On the pre-op DTT, discontinuations (the right CRP: at subcortical white matter level, and the left CRP: at the midbrain level) of the CRP fibers from the premotor cortex were observed in both hemispheres. On the post-op DTT, the discontinued CRP fibers were elongated to the premotor cortex in both hemispheres (Fig. 1C).

3. Discussion

In this study, we evaluated the change of both discontinued CRPs using serial DTT following shunt operation in a stroke patient: Both discontinued CRPs at the subcortical areas on the pre-op DTT were restored to the respective premotor cortices, the main origin area of the CRP on the post-op DTT.[7] The motor recovery occurred mainly in the proximal muscles (shoulder and hip) and the gait disturbance improvement, which is responsible for the CRP function, appears to be consistent with the change of CRPs on DTTs.[5,6] We believe that high intraventricular pressure severely compress to the CRPs and attributed to the discontinuation of CRPs on the pre-op DTT; therefore, we could assume that decompressed pressure contribute to restoration of the discontinued CRPs on the post-op DTT.

Since the introduction of DTI, a few studies have reported decompression of the compressed periventricular white matter or neural tracts around the lateral ventricle by shunt operation.[8,9] In 2005, Assaf et al[8] demonstrated normalization of fractional anisotropy values of the neural fibers in the periventricular white

matter by shunt operation in 7 patients with acute hydrocephalus. In 2011, Jang and Kim[9] reported on a patient with hydrocephalus after aneurysmal subarachnoid hemorrhage whose fractional anisotropy value of the corticospinal tract adjacent to the lateral ventricle was reduced by shunt surgery. To the best of our knowledge, this is the first study to describe change of the CRP following shunt surgery for hydrocephalus in stroke patients.

However, the limitations of DTT should be considered. Because regions of fiber complexity and crossing can prevent full reflection of the underlying fiber architecture, DTT may underestimate or overestimate the fiber tracts.[10]

In conclusion, restoration of discontinued CRPs concurrent with recovery of gait disturbance following shunt operation for hydrocephalus was demonstrated in a stroke patient.

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