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Recovery from a Persistent Vegetative State to A Functional State by Focused Rehabilitation In a Stroke Patient

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Abstract

Objectives: We report on a patient who recovered from a persistent vegetative state (PVS) to a functional state by comprehensive rehabilitation beginning eight months after the intraventricular hemorrhage (IVH).

Case Presentation: A 37-year-old female patient underwent extraventricular drainage for IVH due to rupture of an arterio-venous malformation. She underwent rehabilitation for six months, beginning two months after the IVH at a local hospital. Eight months after the IVH, she was admitted to the rehabilitation department of a university hospital. The patient showed impaired consciousness, with a Glasgow Coma Scale score of 6. On 8-month DTT, the lower ARAS was well-reconstructed in both sides. However, neural connectivity of the upper ARAS was decreased in prefrontal cortices, occipital cortices and basal forebrains. She underwent rehabilitative therapy focused on the prefrontal cortex: medication, repetitive transcranial magnetic stimulation, and tilt table standing. After three months' rehabilitation, her Glasgow Coma Scale score had recovered to 11. She was able to eat food after removing the Levin tube at 11 months and walk with a walker 14 months after onset.

Keywords: Diffusion tensor tractography, ascending reticular activating system, Consciousness, Vegetative state, Stroke.

1. INTRODUCTION

Human consciousness consists of arousal and awareness, controlled by action of the ascending reticular activating system (ARAS). Vegetative state (VS) is a condition of preservation of arousal with complete unawareness of self or environment. It is regarded as permanent three months after non-traumatic brain injury or 12 months after traumatic injury [1]. Many studies have reported rehabilitation stragtegies for recovery in patients with impaired consciousness and several studies have demonstrated recovery of impaired consciousness in patients with brain injury [2-14]. However, little is known about the patients who recovered from a PVS to a functional state by rehabilitation [10].

In this study, we report on a patient who recovered from a PVS to a functional state by focused rehabilitation starting eight months after an intraventricular hemorrhage (IVH).

2. CASE REPORT

A 37-year-old female patient underwent extraventricular drainage to manage an IVH following rupture of an arterio-venous malformation at the department of neurosurgery of a university hospital. Two months later she underwent a ventriculo-peritoneal shunt operation for hydrocephalus, and began a period of rehabilitation for six months at a local hospital (Fig.1-A). At eight months from the IVH, she was admitted to the rehabilitation department of the university hospital. The patient showed impaired consciousness, with a Glasgow Coma Scale score of 6 (eye opening: 4, best verbal response: 1, and best motor response: 1) and a Coma Recovery Scale-Revised score of 6 (auditory function: 2, visual function: 1, motor function: 1, verbal function: 0, communication: 0, and arousal: 2) [15,16]. She underwent comprehensive rehabilitative therapy, physical therapy, and occupational therapy: 1) drugs for impaired consciousness (methylphenidate 10mg, amantadine 300 mg, levodopa 500mg, baclofen 30mg, pramipexole 1.5mg, donepezile 5 mg zolpidem 10mg, and venlafaxine 75mg) [6,7,9], 2) repetitive transcranial magnetic stimulation therapy (MAGPRO, Medtronic Functional Diagnostics, Skovlunde, Denmark: the bulbar somatotonic area of the precentralgyrus, frequency of 10 Hz, intensity of 80% motor threshold, and a total of 160 pulses for 8 minutes, seven sessions per week) for facilitation of both prefrontal cortices [17], and 3) tilt table standing: 20 minutes/two times/day for six days per week [14]. After three months' rehabilitation, her Glasgow Coma Scale score recovered to 11 (eye opening: 4, best verbal response: 1, and best motor response: 6) with a Coma Recovery Scale-Revised score of 16 (auditory function: 3, visual function: 3, motor function: 5, verbal function: 1, communication: 1, arousal: 3). She was able to eat food after removing the Levin tube at 11 months (three months' comprehensive rehabilitation), and walk with a walker at 14 months (six months' comprehensive rehabilitation) after onset. The patient's husband provided signed, informed consent, and the study protocol was approved by our Institutional Review Board.

3. DIFFUSION TENSOR IMAGING

DTI data were acquired twice (four and 10 months after onset) using a 6-channel head coil on a 1.5 T Philips GyroscanIntera (Philips, Best, The Netherlands) with single-shot echo-planar imaging. Imaging parameters were as follows: acquisition matrix= 96×96; reconstructed to matrix= 192×192; field of view= 240×240mm2; the repetition time= 10,398ms; the echo time= 72ms; parallel imaging reduction factor (SENSE factor)= 2; echo-planar imaging factor= 59; b= 1000s/mm2; slice gap= 0mm and a slice thickness= 2.5mm. The Oxford Centre for Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library was used for analysis of DTI data. Affine multi-scale two-dimensional registration was used to correct head motion effect and image distortion due to eddy current. FMRIB Diffusion Software with routines option (0.5 mm step lengths, 5000 streamline samples, curvature thresholds=0.2) was used for fiber tracking. The lower and upper ARASs were reconstructed by selection of fibers passing through regions of interest (ROIs). For analysis of the lower ARAS, the seed region of interest (ROI) was placed on the pontine reticular formation (PRF) at the level of the trigeminal nerve entry zone and the target ROI was placed on the thalamic intralaminar nucleus (ILN) at the level of the commissural plane. For analysis of the connectivity of the thalamic ILN, the seed ROI was placed on the thalamic ILN [18,19]. Out of 5000 samples generated from the seed voxel, results for contact were visualized at a threshold for the ARAS of a minimum of 2 and for connectivity of the thalamic ILN of 15 streamlined through each voxel for analysis.

On 8-month DTT, the lower ARAS between the PRF and the ILN was well-reconstructed in both sides. However, neural connectivity of the upper ARAS between the thalamic ILN and the cerebral cortex was decreased in prefrontal cortices, occipital cortices, and basal forebrains (Fig.1-B).

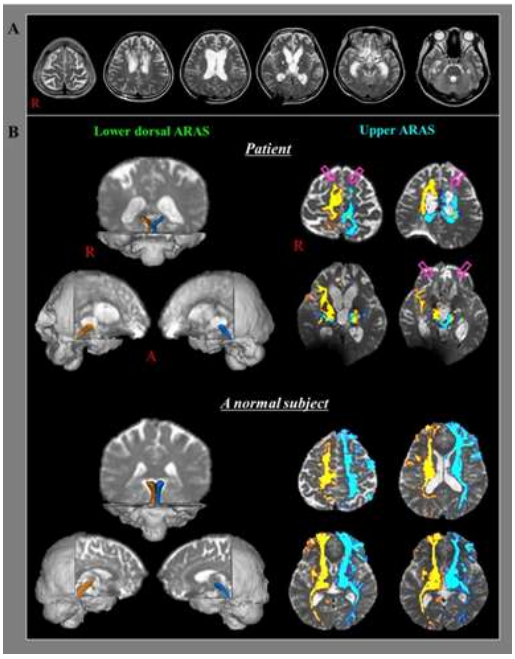

Figure 1. *(A) Brain MR images at four and ten months after onset show leukomalactic lesions in the right basal ganglia, thalamus, and both brainstems.(B) Results of diffusion tensor tractography for the ascending reticular*

activating system (ARAS) of the patient and a normal subject (38-year old female). On 8-month diffusion tensor tractography, the lower ARAS between the pontine reticular formation and the thalamic intralaminar nucleus is well-reconstructed in both sides. However, neural connectivity of the upper ARAS between the thalamic intralaminar nucleus and the cerebral cortex is decreased in both prefrontal cortices (pink arrows), occipital cortices, and basal forebrains (blue arrows).

4. DISCUSSION

In this study, we described a patient with IVH who showed delayed recovery of consciousness from a PVS to a functional level by a focused rehabilitation. The patient did not significantly recover from impaired consciousness by eight months after an IVH, despite rehabilitation at a local hospital beginning two months after onset. At eight months after onset, upon examination we found that the neural connectivity between the thalamus to the cerebral cortex was decreased whereas the lower ARAS between the RF and the thalamus was almost intact. Many studies have demonstrated that the prefrontal lobe is a very important area for awareness. We decided that the impaired consciousness of our patient was mainly related to the decreased neural connectivity to the prefrontal cortex in the upper ARAS [2,3,5,8,10,12]. Based on the results of DTT for the ARAS, we focused on facilitation of function of the prefrontal cortex using medications (dopaminergic, cholinergic and serotonergic drugs, baclofen and zolpidem), repetitive TMS, and tilt table standing [6,7,9,10,14,20-22]. She could eat food without Levin tube after three months' focused rehabilitation and walk with walker after six months' focused rehabilitation. We think the recovery of impaired consciousness in our patient highlights the importance of precise evaluation of the ARAS and focused rehabilitation based on the results of the ARAS examination for patients with impaired consciousness. However, the limitations of DTT should be considered: it may underestimate the fiber tracts due to regions of fiber complexity and crossing [23].

In conclusion, the recovery of impaired consciousness from a PVS to a functional state by focused rehabilitation was described in a patient with IVH. In this case, the practical clinical significance to physiatrists and rehabilitation therapists is that the importance of focused rehabilitative strategies based on the state of the ARAS in successful rehabilitation in patients with impaired consciousness. Precise diagnosis of the state of ARAS can lead to focused rehabilitation and better outcome.

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DISCLOSURE

The authors report no disclosures relevant to the manuscript.

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