P 3-89

Recovery of impaired consciousness and injured ARAS during rehabilitation

Jang Sung Ho[1†], Kwak Dong Gyu[1*†]

college of medicine, Yeungnam University, Department of Rehabilitation Medicine[1]

A 47-year-old male patient underwent craniectomy and hematoma removal for traumatic epidural hematoma in the right fronto-parieto-temporal area in the neurosurgery department of a university hospital. Approximately eight weeks after onset, he was transferred to the rehabilitation department of the same university hospital. Brain magnetic resonance images (MRIs) at eight weeks after onset showed leukomalactic lesions in the right fronto-parieto-temporal lobes (Fig. 1-A), and the patient was in a vegetative state (VS) with a Coma Recovery Scale-Revised (CRS-R) score of 7 (auditory function: 1, visual function: 2, motor function: 2, verbal function: 0, communication: 0, and arousal: 2). He underwent comprehensive rehabilitation, which included neurotropic drugs (modafinil, ropinirole, pramipexole, amantadine, levodopa, and baclofen) and physical and occupational therapies including tilt table standing and neuromuscular electrical stimulation on both finger extensors and ankle dorsiflexors [1]. Transcranial direct current stimulation (tDCS) was also administered with a neuroConn DC-stimulator (neuroConn, Ilmenau, Germany) [2]. DC was applied with a battery-driven constant-current stimulator with saline-soaked surface sponge electrodes (7 cm × 5 cm). The anode was placed at the prefrontal cortex (either position of Broadmann area 9 of the 10–20 international electroencephalography system locations for electrode placement). The cathode was placed at the opposite supraorbital region (approximate positions Fp1 or Fp2, as appropriate). Stimulation intensity was 2 mA and stimulation duration was 20 minutes/session with two sessions/day (either side of Broadmann area 9) and 14 sessions/week. Repetitive transcranial magnetic stimulation (rTMS) using a MagPro stimulator (Medtronic Functional Diagnostics, Skovlunde, Denmark) was applied to each prefrontal cortex (frequency of 10 Hz with 80% motor threshold intensity and 160 pulses) for 8 minutes once/day for each prefrontal cortex with seven rTMS sessions per week. After five weeks of rehabilitation, the patient had recovered to a minimally conscious state (MCS) with a CRS-R score of 14 (auditory function: 2, visual function: 3, motor function: 4, verbal function: 2, communication: 1, arousal: 2). At that time, he was able to open his mouth and perform partial grasp-release with his hands on verbal command. The patient's wife provided signed, informed consent, and the study protocol was approved by our institutional review board. Diffusion tensor imaging (DTI) data were acquired twice (at 8 and 13 weeks after onset) using a 6-channel head coil on a 1.5 T Philips Gyroscan Intera (Philips, Best, Netherlands) with single-shot echo-planar imaging.

For each of the 32 non-collinear diffusion sensitizing gradients, 67 contiguous slices were acquired parallel to the anterior commissure-posterior commissure line. Diffusion-weighted imaging data was analyzed using tools within the Oxford Centre for Functional

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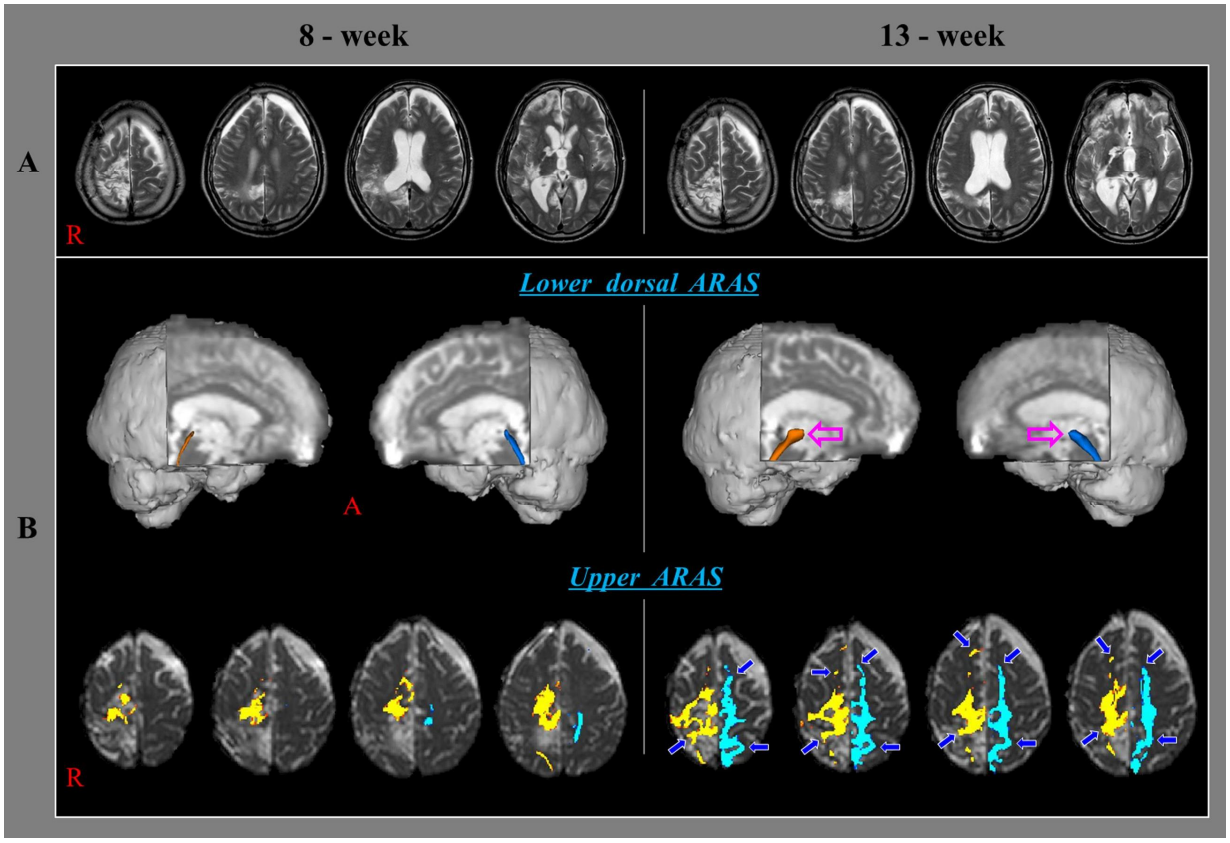

Fig 1. (A) Brain magnetic resonance images (MRIs) at 8 and 13 weeks after onset show leukomalactic lesions in the right fronto-parieto-temporal lobes.