Injury of corticoreticular pathway and corticospinal tract caused by ventriculoperitoneal shunting

Ventriculoperitoneal shunting is a commonly used neurosurgical procedure for management of hydrocephalus (Jang et al., 2015). Various complications of ventriculoperitoneal shunting have been reported, including infection, hemorrhage, shunt malfunction, shunt displacement and brain swelling (Kwon and Jang, 2012, 2015). Although ventriculoperitoneal shunting can cause injury of adjacent neural tracts, little is known about injury of the neural tract by ventriculoperitoneal shunting (Kwon and Jang, 2013).

Diffusion tensor tractography (DTT), derived from diffusion tensor imaging (DTI), enables visualization and estimation of neural tracts in three dimensions (Gold et al., 2008). A previous study using DTT has reported on injury of neural tracts by invasive neurosurgical procedures such as extraventricular drainage or shunt operation (Kwon and Jang, 2013). However, it has not been clearly elucidated so far.

In the current study, using DTT, we attempted to demonstrate injury of the corticoreticular pathway (CRP) and corticospinal tract (CST) caused by ventriculoperitoneal shunting in a patient with normal pressure hydrocephalus.

A 70-year-old female patient who showed gait disturbance for 1 year and enlarged ventricles on the brain CT was diagnosed with normal pressure hydrocephalus at the department of neurosurgery of a university hospital. She underwent ventriculoperitoneal shunting approached through the right posterior parietal area in the brain. Brain CT and T2 weighted MRI after shunt operation revealed hemorrhage at the corona radiata around the passage of the ventriculoperitoneal shunt (Figure 1A, B). After the shunt operation, the patient developed the left hemiparesis and gait difficulty as follows (based on Medical Research Council [MRC] and Functional Ambulation Category [FAC]) (Cunha et al., 2002; Paternostro-Sluga et al., 2008): The MRC score was used for evaluation of motor function: 0, no contraction; 1, palpable contraction but no visible movement; 2, movement without gravity; 3, movement against gravity; 4, movement against a resistance lower than the resistance overcome by the healthy side; and 5, movement against a resistance equal to the maximum resistance overcome by the healthy side (Paternostro-Sluga et al., 2008). The FAC was designed for examination of the levels of assistance required during a 15-m walk. Six categories are included in the FAC: 0 (non-ambulatory), 1 (needs continuous support from one person), 2 (needs intermittent support from one person), 3 (needs only supervision and verbal cues), 4 (help is required on stairs and uneven surfaces), and 5 (can walk independently anywhere) (Cunha et al., 2002). The patient provided signed, informed consent and our institutional review board approved the study protocol.

DTI was acquired at 1 month after the shunt operation using a six-channel head coil on a 1.5-T Philips Gyroscan Intera (Philips, Ltd, Best, The Netherlands) with single-shot echo-planar imaging. Imaging parameters were as follows: acquisition matrix = 96 × 96, repetition time = 10,398 ms, echo time = 72 ms, echo planar factor = 59 and $b = 1,000$ s/mm², number of excitations = 1, slice gap = 0 mm and a slice thickness of 2.5 mm. Fiber tracking for the CRP and CST was performed using the fiber assignment continuous tracking (FACT) algorithm implemented within the DTI task card software. The left CRP and CST showed intact integrities from the cerebral cortex to the medulla. By contrast, the right CRP and CST showed discontinuation at the passage of the shunt of the right corona radiata and degeneration to the right midbrain. In addition, the anterior portion of the right CST also showed discontinuation at the passage of the shunt of the right corona radiata compared with the left CST (Figure 1C).

In the current study, using DTT, we demonstrated injury of the CRP and CST following ventriculoperitoneal shunting in a patient with normal pressure hydrocephalus. Injury of the right CRP and CST in this patient appeared to have resulted from ventriculoperitoneal shunting or ventriculoperitoneal shunting combined with hematoma caused by ventriculoperitoneal shunt operation. We think that the motor weakness of the left upper and lower extremities in this patient was ascribed to injury of the CRP and CST. Furthermore, the characteristics of the motor weakness were compatible with the injury of these motor tracts: more severe weakness of the left proximal joint muscle than the left distal joint muscles, indicating the injury of the right CRP, and milder weakness of the left distal joint muscles than the left proximal joint muscles, indicating the partial injury of the right CST (Jang et al., 2015).

Although many studies have reported on the complications of invasive procedures such as extraventricular drainage or shunt operation, injuries of neural tracts in the brain caused by these procedures have rarely been reported (Gold et al., 2008; Kwon and Jang, 2012, 2013, 2015). The injured neural tracts were as follows: CST, cingulum, fornix, and CRP. Regarding the CRP and CST, Gold et al. (2008) reported on a patient who presented with direct injury of the CST during revision of a ventriculoperitoneal shunt. Kwon and Jang (2015) reported on patients with intracerebral hemorrhage who showed injury of the CRP following external ventricular drainage (Gold et al., 2008; Kwon and Jang, 2015). As a result, to the best of our knowledge, this is the first study to demonstrate combined injury of the CRP and CST following ventriculoperitoneal shunting.

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Figure 1 CT, T2 weighted MRI and diffusion tensor tractography (DTT) images of a 70-year-old female patient undergoing ventriculoperitoneal (VP) shunting approached through the right posterior parietal area in the brain. (A) Brain CT images taken after shunt operation reveal hemorrhage at the corona radiata (yellow arrows) around the passage of the ventriculoperitoneal shunt. (B) T2-weighted MR images taken at 1 month after the shunt operation show a leukomalacic lesion in the right corona radiata (red arrows). (C) DTT images for the corticoreticular pathway (CRP) and corticospinal tract (CST) were acquired at 1 month after the shunt operation. The right CRP showed discontinuation at the passage of the shunt of the right corona radiata and degeneration to the right midbrain, and the anterior portion of the right CST also showed discontinuation at the right corona radiata (red color: right CRP; yellow color: left CRP; blue color: right CST; pink color: left CST). R: Right; A: anterior.

References


