2021 Mihara Praise Award Memorial Lecture

Elucidation of cerebrospinal fluid dynamics in patients with chronic cerebral ischemia

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Background

In patients with chronic steno-occlusive diseases of main cerebral arteries, neural cells in the cerebral cortex are lost and the cerebral white matter is damaged when severe cerebral ischemia such as misery perfusion persists. These may be explained as follows: 1) metabolic heating produced by active cerebral metabolism is not sufficiently cooled due to decreased brain perfusion, resulting in increased brain temperature in the cerebral hemisphere with misery perfusion; 2) the higher the brain is, the more severely the brain is damaged. We hypothesized that cerebrospinal fluid (CSF), another "flow" has a role of a "radiator effect" in the above situation. Glymphatic system is recently proposed as a novel concept of CSF dynamics related to production, diffusion and aspiration of CSF. In this concept, perivascular space (PVS) surrounding the cerebral arteries and veins may be an important role of CSF pathway and the CSF may moves in the neural tissues. Improvement of signal-to-noise ratio on images obtained from magnetic resonance with higher magnetic field such as 7T and intravoxel incoherent motion (IVIM) obtained from diffusion-weighted imaging (DWI) have been made it possible to measure simultaneously the diffusion and perfusion with high accuracy. As a result, quantification of CSF dynamics via the PVS and identification of a pathway from the PVS to the neural tissue is being investigated.

Purpose of research

To elucidate whether the CSF has a role of a "radiator effect" when severe hypoperfusion such as misery perfusion exists, we determine presence or absence of misery perfusion using positron emission tomography (PET) and make brain temperature maps using 3T magnetic resonance spectroscopy

(MRS) and CSF dynamics maps using IVIM analysis obtained from DWI with 7T magnetic resonance imaging (MRI) in patients with chronic steno-occlusive diseases of main cerebral arteries

Methods

We include patients with atherosclerotic cebrovascular diseases or moyamoya diseases. These patients undergo ^{15}O gas PET, 3T MRS, and 7T DWI. Presence or absence of misery perfusion is determined by ^{15}O gas PET. Brain temperature maps and CSF dynamics maps are derived from 3T MRS and from IVIM analysis on 7T DWI, respectively. These patients also undergo neuropsychological testing including Wechsler adult intelligence scale-revised (WAIS-R), Wechsler memory scale-revised (WMS-R), and Rey test. IVIM is analyzed as follows: 1) IVIM parameters are determined using signals of the CSF in the ventricle and cistern; 2) IVIM parameters are compared between the CSF in the ventricle and cistern; 3) IVIM parameters are determined using the signal decrease curves of the CSF; and 4) CSF dynamics maps are accomplish in the whole brain.

Based on the above data, brain temperature, CSF dynamics and cognitive function are compared in patients with and without misery perfusion.

Conclusions

We elucidate whether the CSF has a role of a “radiator effect” when severe hypoperfusion such as misery perfusion exists. The results of this study will demonstrate mechanisms of damages of neural cells in the cerebral cortex and the cerebral white matter in patients with chronic steno-occlusive diseases of main cerebral arteries.