ORAL PRESENTATIONS

Quantitative results for the direct participation of the parenchymal vascular system in cerebral waste removal

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Background

Impaired cerebral waste clearance (CWC) has been associated with a broad range of both physiological and pathophysiological neurologic conditions.[1,2] Because of the unique anatomy of the brain parenchyma, theoretically, in the brain parenchyma, biochemically inert waste such as magnetic resonance imaging (MRI) contrast agents can only be removed through two possible pathways: cerebrospinal fluid (CSF) pathway, and/or vascular pathway. Despite the controversy, there seems to be a solid consensus on the participation of the CSF pathway in CWC.[3] In contrast to the CSF system, the current consensus is that the parenchymal vascular system does not participate in CWC. Considering there is a big difference in flow rate between the blood (2 mL/min) and the CSF (3.7 µL/min) and the brain is the most bioactive, energy-consuming organ (20% nutrition for about 5% of body weight) in the body, it is illogical that the brain would rely on the slow CSF circulation for CWC while less bioactive tissues outside the brain require both the fast vascular and slow lymphatic systems to remove waste in a timely manner.[4,5]

Methods

Superparamagnetic iron oxide–enhanced susceptibility-weighted imaging (SPIO-SWI) and quantitative susceptibility mapping (QSM) methods were used to simultaneously study 7 T MRI signal changes in parenchymal veins, arteries, and their corresponding para-vascular spaces in 26 rats, following intra-cisterna magna (ICM) infusion of different CSF tracers (FeREX, ferumoxytol, Fe-Dextran) to determine the amount of tracer in the artery and vein quantitatively.

Results

The parenchymal venous system participated in CSF tracer clearance following ICM infusion of different MRI tracers with different concentrations of iron. Parenchymal venous participation was more obvious when 75 µg iron was injected. In the parenchymal veins, the relative mean (±SE) value of the susceptibility increased by 13.5±1.0% at 15 min post-tracer infusion ($p<0.01$), and 33.6±6.7% at 45 min post-tracer infusion ($p=0.01$), compared to baseline. In contrast to the parenchymal veins, a negligible amount of CSF tracer entered the parenchymal arteries: 1.3±2.6% at 15 min post-tracer infusion ($p=0.6$), and 12±19% at 45 min post-tracer infusion ($p=0.5$), compared to baseline.

Conclusions

MRI tracers can enter the parenchymal vascular system and more MRI tracers were observed in the cerebral venous than arterial vessels, suggesting the direct participation of parenchymal vascular system in CWC.

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