A Computational Model of Cerebrospinal Fluid Production and Reabsorption
Driven by Starling Forces.

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A novel intracranial water transport model with microcirculation, perivascular spaces, ECS and CSF.

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Abstract

Aims

Experimental evidence has cast doubt on the classical model of river-like cerebrospinal fluid (CSF) flow from the choroid plexus to the arachnoid granulations. We propose a novel model of water transport through the parenchyma from the microcirculation as driven by Starling Forces. This model investigates the effect of osmotic pressure on water transport between the cerebral vasculature, the extracellular space (ECS), the perivascular space (PVS), and the CSF.

Methods

A rigorous literature search was conducted focusing on experiments which alter the osmolarity of blood or ventricles and measure the rate of CSF production. Investigations of osmotic gradients on the ventricular volume and the flux of ions in the blood, choroid plexus epithelium, and CSF are reviewed.

Results

Increasing the osmolarity of the serum via a bolus injection completely inhibits nascent fluid flow production in the ventricles. A continuous injection of a hyperosmolar solution into the ventricles can increase the volume of the ventricle by up to 125%. CSF production is altered by 0.231 µL per mOsm in the ventricle and by 0.835 µL per mOsm in the serum.

Discussion

Water flux from the ECS to the CSF is identified as a key feature of intracranial dynamics. A complete mathematical model with all equations and scenarios is fully described, as well as a guide to constructing a computational model of intracranial water balance dynamics.

Conclusion

The model presented in this paper predicts the effects the osmolarity of ECS, blood, and CSF on water flux in the brain, establishing a link between osmotic imbalances and pathological conditions such as hydrocephalus and edema.