

Fluid flow and transport in the brain

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ABSTRACT

The cerebrospinal fluid (CSF) is a water-like fluid surrounding the brain and spinal cord and plays a vital role in maintaining the homeostasis of the central nervous system. A glymphatic fluid pathway through the brain interstitium has been proposed, with the main purpose of clearing waste products from the brain [1]. Over the last decade, after the proposal of the glymphatic theory, the topic has gained interest, from experimentalists, mathematicians and computational modelers from many different parts of the world. Many different components are involved in this process, e.g. inflow along blood vessels driven by arterial pulsations, aquaporin-dependent transport from the paravascular space to the extracellular space and bulk water flow through the brain interstitium, to name some key components.

Mathematical and computational modelling has shown to be a useful tool in exploring the mechanism behind fluid and molecular transport in the brain. Key questions involve determining transport mechanisms (diffusion vs convection) and pathways (intra-cellular vs. extra-cellular), and what forces are responsible for the observed transport. It has for instance been shown that sleep enhances clearance both in mice and humans [2], but that clearance (and influx) rates differ between species. So far, many of these studies have been purely experimental, and very few studies have combined novel experimental data with state-of-the-art computational modelling to explain the observed results.

Specifically, regarding waste clearance, changes in CSF dynamics, blood flow and electrophysiological signals have all been investigated as possible drivers of clearance, but the complexity of the models involved makes it difficult to develop a holistic “full brain” transport model for the central nervous system. However, with increasing computing power, and with recently developed reduced models, the time has come to explore the relationship between models in order to close in on a full brain transport model.

In this Minisymposium, we want to bring together scientists developing mathematical models and numerical techniques to solve relevant fluid mechanical problems at various scales and in various sub-systems. We welcome contributions related to transport in the central nervous system, CSF dynamics, blood flow, or other relevant subjects. We welcome relevant models on all spatial and temporal scales, from the nanometer to centimeter, and from milliseconds to years.

REFERENCES

1. Iliff, Jeffrey J., et al. "A paravascular pathway facilitates CSF flow through the brain parenchyma and the clearance of interstitial solutes, including amyloid β ." *Science translational medicine* 4.147 (2012): 147ra111-147ra111.
2. Eide, Per Kristian, et al. "Sleep deprivation impairs molecular clearance from the human brain." *Brain* 144.3 (2021): 863-874.