Parameter Estimation in a Perivascular Cerebrospinal Fluid Flow using Bayesian Inference

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Cerebrospinal fluid (CSF) plays a critical role in clearing metabolic waste from the brain. Several studies hypothesize that the astrocyte endfeet function as a flexible valve to regulate the CSF flow within penetrating perivascular spaces (PVSs). However, the values of key parameters governing this system, including the material properties of endfeet walls and the flow resistances of the pial PVS, extracellular space (ECS), and endfeet walls, are still unknown. We apply Bayesian inference to an endfoot valve mechanism model to estimate these parameters while quantifying their uncertainty using in vivo measurements of arterial pulsations of penetrating artery and CSF flow velocity in pial PVS. This approach not only provides posterior distributions but also reveals the sensitivity of CSF flow dynamics to specific parameter variations. By integrating a mathematical model with Bayesian inference, this work advances the understanding of CSF transport mechanisms and establishes a framework for calibrating future models of brain-wide solute clearance.

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