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An idealized hydraulic network model for predicting cerebrospinal fluid transport throughout perivascular spaces in the brain[1]

JEFFREY TITHOF, University of Minnesota, PETER BORK, University of Copenhagen, MAIKEN NEDERGAARD, University of Rochester Medical Center, JOHN THOMAS, DOUGLAS KELLEY, University of Rochester — Recent advances in experimental techniques have enabled direct measurement of cerebrospinal fluid (CSF) flow through perivascular spaces (PVSs) near the surface of the brain. These PVSs are annular channels surrounding blood vessels in the brain which compose part of the glymphatic system, a waste removal pathway demonstrated to play an important role in Alzheimers disease, stroke, and more. Currently, technical challenges prevent high-resolution measurements of CSF flow far below the surface of the brain. Hence, we have developed a hydraulic network model to estimate CSF transport throughout the interconnected PVSs. This model is based on the hydraulic analog of Ohm's law and utilizes an idealized geometry based on prior quantification of vasculature topology in the brain. We use this model to compute the approximate pressure gradients necessary to drive the flows observed experimentally, and we estimate the flow speeds, Reynolds number, and Péclet number throughout the PVS network, including regions where experimental measurements are currently not feasible. Our results generate testable hypotheses, some of which may be confirmed with existing technology and others that require further advancement of measurement techniques.

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Jeffrey Tithof
University of Minnesota

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