On modeling transport of solutes across the Blood Brain Barrier

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ABSTRACT: The Blood Brain Barrier (BBB) has the role of protecting the Central Nervous System (CNS) from potentially harming agents contained in the blood, while allowing the exchange of small hydrophilic molecules. In a typical brain microvessel endothelial cells are covered internally by the glycocalyx, a thin membrane which is believed to exert a sieving effect on macromolecules. Externally, microvessels are protected by an additional thin membrane, called basement membrane, and the feet of the astrocytes. The breakdown of the BBB with the associated increase of vessel's wall permeability has been observed in traumatic head injury, Alzhaimers's disease and recently it has been associated with Multiple Sclerosis (MS). The present work is motivated by a recent hypothesis that altered venous hemodynamics affects the transport properties of vessel walls. Here, as a first step, we propose a simple mathematical model for water flow and transport of molecules of various dimensions by solving simultaneously the coupled flow and transport equations through the two membranes and the clefts. We analyze, in particular, how blood pressure perturbations and damage of the glycolalyx may alter transport of both small hydrophilic molecules and larger macromolecules through the vessel wall.