

Prediction of spinal cord perivascular flow based on a coupled computational simulation of the cardiovascular and cerebrospinal fluid system

Bryn A. Martin¹, Jan Novy², Olivier Balédent³, Philippe Reymond¹, Nikolaos Stergiopoulos¹

¹Laboratory of Hemodynamics and Cardiovascular Technology, EPFL, Lausanne, Switzerland

²Department of Neurology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland

³Department of Magnetic Resonance Image Processing in University Hospital of Amiens, France

The strong coupling between the cardiovascular and CSF system is considered to be important to understand the pathophysiology of craniospinal diseases such as hydrocephalus and syringomyelia. In particular, it has been hypothesized that perivascular fluid movement within the brain and spinal cord could be influenced by delay between arterial and CSF pulsations. To examine this hypothesis, a coupled computational simulation of a simplified cardiovascular and CSF system was constructed based on *in vivo* measurements and information in the literature. The cardiovascular system simulation incorporated all systemic arteries greater than 2 mm in diameter including a complete circle of Willis (103 segments) and a simplified vascular anatomy of the spinal cord (17 segments). Coupling of the cardiovascular to CSF system was accomplished by a transfer function based on *in vivo* MRI measurements relating CSF and cerebral blood flow pulsations. The CSF in the spinal subarachnoid space was modeled as fluid in a compliant tube with a varying cross sectional area. Perivascular flow to the spinal cord was determined based on the computational simulation results and perivascular flow predictions in the literature. The coupled simulation resulted in similar pressure and flow in the cardiovascular and spinal subarachnoid space as in a healthy adult. The predicted direction and magnitude of perivascular flow to the spinal cord was influenced by CSF and cardiovascular system compliance and anatomy. Overall, the coupled cardiovascular and CSF system model provides predictions about the flow and pressure environment present in the spinal cord and spinal subarachnoid space.