The Influence of Cerebrospinal Fluid Flow Frequency and Amplitude on Subarachnoid Space Pressure Fluctuations in an In Vitro Syringomyelia Model with Spinal Canal Stenosis

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A compliant in vitro model representative of post-traumatic syringomyelia was used to examine the influence of cerebrospinal fluid (CSF) flow frequency and amplitude on the spinal hydrodynamic environment. Results indicated that elevated CSF flow amplitude produced large pulse pressures in the spinal subarachnoid space (SAS) rostral to the stenosis, which could impose significant force on the spinal cord parenchyma. Transmural pressure (TP) forces acted to balloon the syrinx rostral to the stenosis, and compress the syrinx caudal to the stenosis. Driving the system near its natural resonance frequency (~4.7 Hz) resulted in substantial hydrodynamic changes. When driven at higher frequencies (8 and 16 Hz), TP forces increased acting to balloon the syrinx cavity outward greater than at lower frequencies. The results support that CSF frequency, velocity, and magnitude may play an important role in syringomyelia (SM) and provide data for comparison to computational models of SM and disorders associated with spinal stenosis. The model also highlights the importance of tissue properties such as craniospinal compliance on spinal hydrodynamic behavior.

Keywords: Cerebrospinal fluid, craniospinal hydrodynamics and compliance, spinal stenosis, spinal arachnoiditis, subarachnoid space, craniospinal disorders, post-traumatic syringomyelia, Chiari malformation, hydrocephalus, in vitro model.