CILIA DOMINATE NEAR VENTRICULAR WALL CEREBROSPINAL FLUID FLOW

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There is a growing body of evidence suggesting that cerebrospinal fluid (CSF) flow in the ventricular space contributes to neuronal guidance. However, it is unknown whether this is achieved predominantly through beating of the ependymal cilia or by macroscale pulsation of the ventricles and choroid plexus.

We employed magnetic resonance imaging (MRI) to acquire subject-specific brain motion and cerebrospinal fluid flow. Using computational fluid dynamics (CFD), we evaluated the relative contributions of macroscale pulsatile CSF dynamics and cilia-induced flow on the shear forces at the ventricular wall.

When macroscale CSF pulsation is considered without the influence of motile cilia, periodic flow reversals along the ventricular surface can be observed. This results in close to zero time-averaged shear stress on the ventricular walls. In the presence of cilia motion, flow is forced in the anterior direction throughout the cardiac cycle close to the wall, with sharper velocity gradients due to the local flow acceleration. This results in three orders of magnitude increase in wall shear stress.

Our findings suggest that neuronal guidance mediated by CSF flow is likely to be dominated by the action of the ependymal cilia. Conversely, CSF dynamics in the center regions of the ventricles are influenced mostly by wall motion and choroid plexus pulsation.