QUANTITATIVE VISUALIZATION OF CSF FLOW

Prof. Vartan Kurtcuoglu

The Interface Group, Institute of Physiology, University of Zurich, Winterthurerstrasse 190, 8057 Zurich

Cerebrospinal fluid (CSF) dynamics are often portrayed as slow, steady flow from the choroid plexus, the fluid's production site, to the arachnoid granulations, the absorption location. This view disregards the strong pulsatile component of cerebrospinal fluid dynamics that influences substance transport and mixing in the CSF. Here we will show visualizations to illustrate and quantify the complex dynamics of CSF flow.

Based on subject-specific magnetic resonance imaging (MRI) data, we reconstructed pulsatile CSF flow in the ventricular system and the cranial subarachnoid space using computational fluid dynamics (CFD). We used the same methodology to investigate the fluid mixing behavior in the third cerebral ventricle.

Cerebrospinal fluid dynamics have two main components: Steady flow due to production and pulsatile flow due to vascular pulsation caused by cardiac action and respiratory modulation. The pulsatile component dominates the instantaneous flow field both in the ventricular as well as the subarachnoid space. Maximum velocities due to pulsation are one to two orders of magnitude higher than the corresponding steady flow velocities caused by CSF production and absorption. Mixing in the third ventricle and likely in other parts of the CSF space is driven predominantly by pulsatile flow.

Our measurements and calculations demonstrate that CSF dynamics are dominated by pulsation, which affects substance transport and mixing substantially. Investigations of drug or biomarker distribution in the CSF should thus take into account transient cerebrospinal fluid flow.