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Simulating transitional hydrodynamics of the cerebrospinal fluid at extreme scale KARTIK JAIN, Simulation Techniques and Scientific Computing, Univ., of Siegen, Germany and Center for Biomedical Computing, Simula Research Lab., Lysaker Norway, SABINE ROLLER, Simulation Techniques and Scientific Computing, University of Siegen, Germany, KENT-ANDRE MARDAL, Center for Biomedical Computing, Simula Research Lab., Lysaker, Norway and Dept., of Mathematics, Univ., of Oslo, Norway — Chiari malformation type I is a disorder characterized by the herniation of cerebellar tonsils into the spinal canal through the foramen magnum resulting in obstruction to cerebrospinal fluid (CSF) outflow. The flow of pulsating bidirectional CSF is of acutely complex nature due to the anatomy of the conduit containing it - the subarachnoid space. We report lattice Boltzmann method based direct numerical simulations on patient specific cases with spatial resolution of $24\mu m$ amounting meshes of up to 2 billion cells conducted on 50000 cores of the Hazelhen supercomputer in Stuttgart. The goal is to characterize intricate dynamics of the CSF at resolutions that are of the order of Kolmogorov microscales. Results unfold velocity fluctuations up to $\sim 10KHz$, turbulent kinetic energy ~ 2 times of the mean flow energy in Chiari patients whereas the flow remains laminar in a control subject. The fluctuations confine near the cranio-vertebral junction and are commensurate with the extremeness of pathology and the extent of herniation. The results advocate that the manifestation of pathological conditions like Chiari malformation may lead to transitional hydrodynamics of the CSF, and a prudent calibration of numerical approach is necessary to avoid overlook of such phenomena.

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