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Simulation of arterial hemorrhage: Two-way coupling of a local high fidelity SPH model with a full body lumped parameter physiology model BRADLEY FEIGER, Kitware, Inc., Duke University - Department of Biomedical Engineering, ANDREW WILSON, SREEKANTH ARIKATLA, RACHEL CLIPP, AARON BRAY, Kitware, Inc. — Full body computational blood flow simulations allow researchers and clinicians to evaluate the impacts of arterial hemorrhage on patient vitals. In this work, we demonstrate a novel method of simulating hemorrhage by coupling a three-dimensional (3D) high fidelity smoothed particle hydrodynamics (SPH) model at the site of damage with a full body lumped parameter model (https://pulse.kitware.com/). While SPH is commonly used for free surface flows, we adapted the method for arterial flow by implementing buffer regions as dynamic inlet and outlet boundary conditions. Our framework uses a two-way coupling system between the SPH and lumped parameter models at the 3D boundary conditions and hemorrhage location. We validated our framework with pipe flow and demonstrated a realistic scenario within Interactive Medical Simulation Toolkit (iMSTK - https://www.imstk.org/), by simulating 3D flow in an image-derived femoral artery with an artificially introduced hemorrhage. Our framework was able to simulate the impacts of hemorrhage on patient vitals within realistic physiological ranges and create high quality SPH visualizations. Our framework that couples local high-fidelity and global low-fidelity models has the potential to enhance the accuracy of physics-based surgical simulations.

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