BLUE WATERS
SUSTAINED PETASCALE COMPUTING

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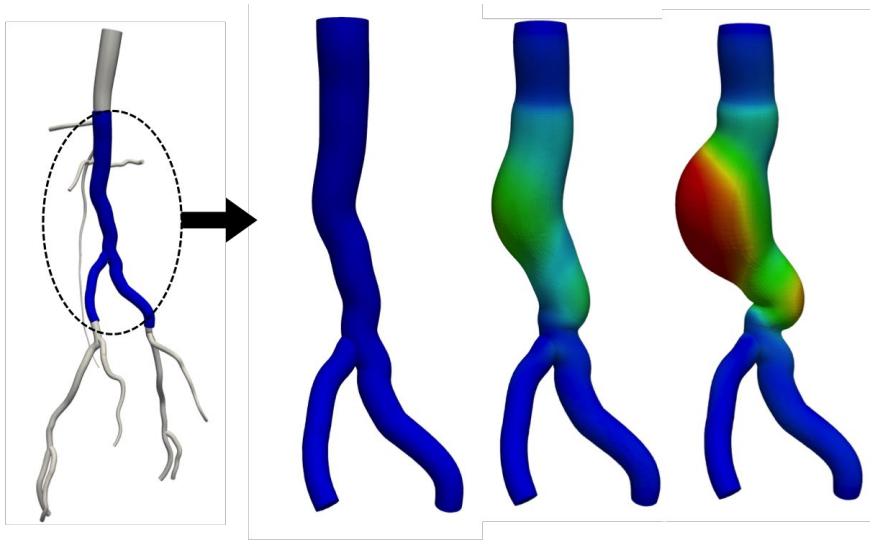
BLOOD-ARTERY INTERACTION AND SIMULATION-BASED ANALYSIS OF AORTIC ANEURYSM



Growth of the abdominal aortic aneurysm (colored by the deformation of the artery wall).

Research Challenge

The research team is developing new finite element method and associated computer code for large deformation modeling of blood–artery interaction and application to the challenging problem of abdominal aortic aneurysm, which is the 10th leading cause of adult death in the United States. These computer codes can be used for modeling the long term progression of the arterial disease as well as local changes in the flow patterns that arise due to marked changes in the geometric structure of the arterial system.

Methods & Codes

- Patient-specific geometric models of the aortic and femoral arteries constructed from CT scans
- Blood modeled as a non-Newtonian fluid, while the deforming artery was modeled as a hyperelastic solid with fiber reinforcement in the circumferential direction
- PETSc

Results & Impact

The team has shown that advanced Fluid–Structure simulations that can provide important data for the diagnosis and treatment of arterial diseases such as an aneurysm are critical in planning and developing strategies to cure these diseases. The team was able to identify high-viscosity regions where blood coagulation can potentially take place and also to project the arterial Wall Shear Stress (WSS) on the arterial walls (WSS is one of the most significant factors for the progression of arterial disease).

Why Blue Waters

The team's algorithms for Computational Fluid–Structure analysis are amenable to efficient parallelization because major portions of the computations are carried out at the local-element level. Smart implementations of the method can take advantage of the local memory that available at the processing nodes. These algorithms are well suited for distributed memory parallelism, and Blue Waters provides an ideal platform for implementation of such algorithms.