

Department of Applied and Computational Mathematics and Statistics Colloquium

Alison Marsden

Department of Mechanical and Aerospace Engineering
University of California, San Diego

will give a lecture entitled:

Multiscale Finite Element Simulations and Optimization for Surgical Repair in Single Ventricle Heart Patients

Abstract

Single ventricle heart patients are among the most challenging for pediatric cardiologists to treat, and these patients typically undergo a series of three open heart surgeries starting within the first few days of life. The final anatomy (a total cavopulmonary connection, or Fontan) directly connects the venous return to the pulmonary arteries, separating the systemic and pulmonary circulations. We will present our recent work combining shape optimization and multiscale modeling to test surgical designs of the first and third stages of the single ventricle repair, the BT shunt and the Fontan surgery. The optimization algorithm we present is an efficient derivative-free surrogate pattern search method with well established convergence theory. The optimization routine is coupled to a finite element flow solver in a fully-automated loop. Multiscale modeling couples the 3D Navier Stokes solution with a 0D lumped parameter network to model the systemic and pulmonary circulations. The use of a multiscale method allows us to capture changes in global circulatory response resulting from changes in local anatomy. A new implicit coupling algorithm for this system will be presented. Issues of numerical stability for the coupled system will be discussed, and methods for preventing divergence will be quantified and compared. Optimization results for the BT shunt will be presented, and the effect of shunt size, and anastomosis location on coronary and systemic perfusion will be presented. Similar methods were also applied to model the third stage Fontan surgery. We will present a novel Y-graft design for the Fontan surgery that has been developed and tested in simulations on multiple patient models. Optimization of the design has led to improvements in hepatic flow distribution, an important clinical parameter related to lung development. Issues and goals related to clinical translation of the Y-graft design will be discussed.



**Monday, September 12th, 2011
4:00 p.m. to 5:00 p.m.
127 Hayes-Healy Center**