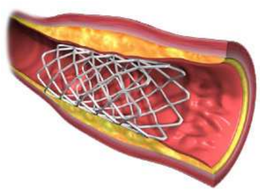
Mathematics and Cardiology: Partners for the Future



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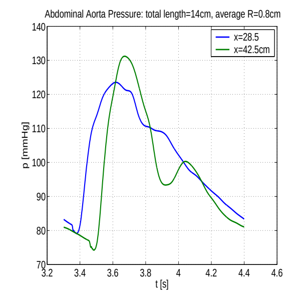

The human cardiovascular system is so complex that it remains unfeasible to numerically simulate its entire function using even simplified three-dimensional models. However, studying wave propagation in pulsating arteries and local hemodynamics is important in understanding the mechanisms leading to various cardiovascular complications. A major complication is coronary artery disease (CAD). One person dies about every minute from a coronary event in the US [AHA]. CAD is the major cause of heart attack, the leading cause of death in the US. Many clinical treatments, including the treatment of CAD, can only be studied in detail if a reliable model describing the response of arterial walls to the pulsatile blood flow is considered.

In an interdisciplinary effort involving mathematicians, cardiologists, and engineers, our group has begun a comprehensive study of the fluid-structure interaction between pulsatile blood flow and human arterial walls in healthy and diseased states. In particular, our focus is on studying improved design of vascular devices called stents and stent-grafts used in the treatment of CAD and in aortic abdominal aneurysm. Stents are implanted in the diseased arteries to prop the arteries open and to secure normal blood flow. See the figure on the top left. A major complication following the treatment of CAD is "restenosis" or reclosure of a coronary artery, in part due to poor biocompatibility of metallic stents. To improve their biocompatibility we have begun investigating a possibility of lining vascular stents with patient's own ear cartilage cells, genetically engineered to produce nitric oxide, known to interfere with clotting associated with restenosis.

By developing fluid-structure-cell interaction algorithms and adhesion models to study the cell-coated stents implanted in arteries, we have been able to aid the experimental studies for cell-coated stents design.

Through an interplay between mathematical modeling, analysis, scientific computing, and experimental validation performed at the Cardiovascuar Research Laboratory at Texas Heart Institute, we made considerable progress not only in the study of improved stent and stent-graft design but also in the development of new mathematical tools to study fluid-structure interaction in blood flow. The underlying cardiovascular application pushed the limits of the current mathematical knowledge, while at the same time it benefited from the newly developed mathematical methods.

The speaker will show the vascular devices studied and summarize the main results obtained in this research. Movies showing experimental validation of the computational results will be presented.

Collaborators: Dr. D. Rosenstrauch and Dr. Z. Krajcer (Texas Heart Institute), Dr. C. Hartley (Baylor College of Medicine), Profs. R. Glowinski, T.W. Pan, G. Guidoboni (UH), Prof. A. Mikelic (University of Lyon1, France)

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