Cardiovascular Modeling and Simulations: Applications to Patient-Specific Clinical Studies

A. Sequeira[1]

Abstract: Cardiovascular diseases, such as heart attack and strokes, are the major causes of death in developed countries, with a significant impact in the cost and overall status of healthcare. Understanding the fundamental mechanisms of the pathophysiology and treatment of these diseases are matters of the greatest importance around the world. This gives a key impulse to the progress in mathematical and numerical modeling of the associated phenomena governed by complex physical laws, using adequate and fully reliable *in silico* settings.

The acquisition of medical data and the understanding of the local hemodynamics and its relation with global phenomena, in both healthy and pathological cases, using appropriate mathematical models and accurate numerical methods, play an important role in the medical research. They help, for instance, in predicting the consequences of surgical interventions, or in identifying regions of the vascular systems prone to the formation and growth of atherosclerotic plaques or aneurysms.

The growing collaboration between scientists working in multidisciplinary areas such as medical researchers and clinicians, mathematicians and bioengineers has contributed to data information exchange that can be used in the numerical simulations. Although many substantial achievements have been made, most of the difficulties are still on the ground and represent major challenges for the coming years. The final goal is to setup patient-specific models and simulations incorporating data and measurements taken from each single patient, that will be able to predict results of medical diagnosis and therapeutic planning with reasonable accuracy and using non-invasive means.

In this talk we describe some mathematical models of the cardiovascular system and comment on their significance to yield realistic and accurate numerical results. They include fluid-structure interaction (FSI) models to account for blood flow in compliant vessels and the geometrical multiscale approach, using appropriate boundary conditions, to simulate the reciprocal interactions between local and systemic hemodynamics. Recent results on modeling and simulation of some patient-specific clinical problems will also be presented.

---

[1] Department of Mathematics and Center for Computational and Stochastic Mathematics
Instituto Superior Técnico, University of Lisbon
Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal
adelia.sequeira@math.tecnico.ulisboa.pt