Blood Rheology and Multiscale Modeling of Cardiovascular Flows

Adélia Sequeira
Department of Mathematics and CEMAT, Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal,
adelia.sequeira@tecnico.ulisboa.pt

Mathematical modeling and simulations of the human circulatory system is a challenging and complex wide-range multidisciplinary research field that has seen a tremendous growth in the last few years. This field, with a strong socio-economic impact in the cost and overall status of healthcare, is rapidly progressing, motivated by the fact that cardiovascular diseases are a major cause of death in developed countries.
Multiscale modeling and simulation of blood flow in the human circulatory system can give an interpretation about the interaction between complex processes that occur at different scales determined by the flow features in the large and medium size arteries at a macroscale level (diameter of 500 μm or larger), in the smaller arteries and arterioles at mesoscale (diameter of 500 μm to 10 μm) and in the capillaries of the microvasculature (mean diameter of 5 μm). For instance, at the macroscale, in addition to the complexity of the vascular geometry, blood may be considered as a Newtonian or a nonh Newtonian fluid, depending on the size of the vessel, which interacts with the vessel wall, that deform under the action of blood pressure waves. Appropriate 3D fluid structure interaction (FSI) models need to be considered to locally represent these phenomena, while reduced 1D (distributed parameter) and 0D (lumped parameter) approximations are used to account for the remaining parts of the systemic circulation (geometric multiscale). Several challenges arise when coupling continuum macroscale with atomistic mesoh and microscale models. The most relevant are the design of efficient and robust interface conditions and the accuracy of the results obtained from the interaction between the local smallh scale resolutions with the global ones.
In this talk we present a short overview of some macroscopic constitutive models that can mathematically characterize the rheology of blood and describe their known phenomenological properties. Some approaches in multiscale modeling and simulations of blood flow problems and applications to clinical cases will also be presented.

References:

[1] A. Fasano and A. Sequeira, Hemomath - The Mathematics of Blood, MS&A Modeling, Simulation and Applications, vol. 18, Springer, 2017.

[2] L. Formaggia, A. Quarteroni, A. Veneziani (Eds.), Cardiovascular Mathematics: Modeling and Simulation of the Cardiovascular System, MS&A, Modeling, Simulation and Applications, vol. 1, Springer, 2009.