World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:11, No:01, 2017

[Keynote Talk]: Mathematical and Numerical Modelling of the Cardiovascular System: Macroscale, Mesoscale and Microscale Applications

Authors : Aymen Laadhari

Abstract : The cardiovascular system is centered on the heart and is characterized by a very complex structure with different physical scales in space (e.g. micrometers for erythrocytes and centimeters for organs) and time (e.g. milliseconds for human brain activity and several years for development of some pathologies). The development and numerical implementation of mathematical models of the cardiovascular system is a tremendously challenging topic at the theoretical and computational levels, inducing consequently a growing interest over the past decade. The accurate computational investigations in both healthy and pathological cases of processes related to the functioning of the human cardiovascular system can be of great potential in tackling several problems of clinical relevance and in improving the diagnosis of specific diseases. In this talk, we focus on the specific task of simulating three particular phenomena related to the cardiovascular system on the macroscopic, mesoscopic and microscopic scales, respectively. Namely, we develop numerical methodologies tailored for the simulation of (i) the haemodynamics (i.e., fluid mechanics of blood) in the aorta and sinus of Valsalva interacting with highly deformable thin leaflets, (ii) the hyperelastic anisotropic behaviour of cardiomyocytes and the influence of calcium concentrations on the contraction of single cells, and (iii) the dynamics of red blood cells in microvasculature. For each problem, we present an appropriate fully Eulerian finite element methodology. We report several numerical examples to address in detail the relevance of the mathematical models in terms of physiological meaning and to illustrate the accuracy and efficiency of the numerical methods.

Keywords : finite element method, cardiovascular system, Eulerian framework, haemodynamics, heart valve, cardiomyocyte, red blood cell
Conference Title : ICMMMAS 2017 : International Conference on Mathematical Models and Methods in Applied Sciences
Conference Location : Zurich, Switzerland
Conference Dates : January 13-14, 2017