World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:8, No:01, 2014

A Geometrical Multiscale Approach to Blood Flow Simulation: Coupling 2-D Navier-Stokes and 0-D Lumped Parameter Models

Authors : Azadeh Jafari, Robert G. Owens

Abstract : In this study, a geometrical multiscale approach which means coupling together the 2-D Navier-Stokes equations, constitutive equations and 0-D lumped parameter models is investigated. A multiscale approach, suggest a natural way of coupling detailed local models (in the flow domain) with coarser models able to describe the dynamics over a large part or even the whole cardiovascular system at acceptable computational cost. In this study we introduce a new velocity correction scheme to decouple the velocity computation from the pressure one. To evaluate the capability of our new scheme, a comparison between the results obtained with Neumann outflow boundary conditions on the velocity and Dirichlet outflow boundary conditions on the pressure and those obtained using coupling with the lumped parameter model has been performed. Comprehensive studies have been done based on the sensitivity of numerical scheme to the initial conditions, elasticity and number of spectral modes. Improvement of the computational algorithm with stable convergence has been demonstrated for at least moderate Weissenberg number. We comment on mathematical properties of the reduced model, its limitations in yielding realistic and accurate numerical simulations, and its contribution to a better understanding of microvascular blood flow. We discuss the sophistication and reliability of multiscale models for computing correct boundary conditions at the outflow boundaries of a section of the cardiovascular system of interest. In this respect the geometrical multiscale approach can be regarded as a new method for solving a class of biofluids problems, whose application goes significantly beyond the one addressed in this work.

Keywords : geometrical multiscale models, haemorheology model, coupled 2-D navier-stokes 0-D lumped parameter modeling, computational fluid dynamics
Conference Title : ICCB 2014 : International Conference on Computational Biomechanics
Conference Location : Zurich, Switzerland
Conference Dates : January 14-15, 2014