Integrating Computational Modeling and Analysis with in Vivo Observations for Enhanced Hemodynamics Diagnostics and Prognosis

Authors : Shreyas S. Hegde, Anindya Deb, Suresh Nagesh

Abstract : Computational bio-mechanics is developing rapidly as a non-invasive tool to assist the medical fraternity to help in both diagnosis and prognosis of human body related issues such as injuries, cardio-vascular dysfunction, atherosclerotic plaque etc. Any system that would help either properly diagnose such problems or assist prognosis would be a boon to the doctors and medical society in general. Recently a lot of work is being focused in this direction which includes but not limited to various finite element analysis related to dental implants, skull injuries, orthopedic problems involving bones and joints etc. Such numerical solutions are helping medical practitioners to come up with alternate solutions for such problems and in most cases have also reduced the trauma on the patients. Some work also has been done in the area related to the use of computational fluid mechanics to understand the flow of blood through the human body, an area of hemodynamics. Since cardio-vascular diseases are one of the main causes of loss of human life, understanding of the blood flow with and without constraints (such as blockages), providing alternate methods of prognosis and further solutions to take care of issues related to blood flow would help save valuable life of such patients. This project is an attempt to use computational fluid dynamics (CFD) to solve specific problems related to hemodynamics. The hemodynamics simulation is used to gain a better understanding of functional, diagnostic and theoretical aspects of the blood flow. Due to the fact that many fundamental issues of the blood flow, like phenomena associated with pressure and viscous forces fields, are still not fully understood or entirely described through mathematical formulations the characterization of blood flow is still a challenging task. The computational modeling of the blood flow and mechanical interactions that strongly affect the blood flow patterns, based on medical data and imaging represent the most accurate analysis of the blood flow complex behavior. In this project the mathematical modeling of the blood flow in the arteries in the presence of successive blockages has been analyzed using CFD technique. Different cases of blockages in terms of percentages have been modeled using commercial software CATIA V5R20 and simulated using commercial software ANSYS 15.0 to study the effect of varying wall shear stress (WSS) values and also other parameters like the effect of increase in Reynolds number. The concept of fluid structure interaction (FSI) has been used to solve such problems. The model simulation results were validated using in vivo measurement data from existing literature

Keywords : computational fluid dynamics, hemodynamics, blood flow, results validation, arteries
Conference Title : ICCMAS 2015 : International Conference on Computational Modeling, Analysis and Simulation
Conference Location : Paris, France
Conference Dates : September 21-22, 2015