PREFACE

Cardiovascular diseases (CVDs) are among the most severe public health challenges worldwide. The hemodynamic and blood-vascular interaction aspects are widely considered to have a crucial influence on the development of such illnesses. The important cardiovascular diseases linked with substantial morbidity and death include abdominal aortic aneurysm (AAA), stenosis, coronary artery disease (CAD), and irregular blood flow in the left ventricle. Knowledge of their underlying hemodynamics and biomechanics is essential to effectively diagnose, treat, and prevent these disorders. The objectives of this work is to design, develop and analyze the hemodynamics parameters in the cardiovascular disease's progression using real time patient-specific non-invasive data. Nevertheless, non-invasive blood flow monitoring technologies (such as Doppler ultrasonography and Phase Contrast MRI imaging) cannot give sufficient spatial and temporal resolution to reliably quantify some critical aspects, such as Wall Shear Stress (WSS). This type of feature is broadly known to perform a crucial role in the evolution of CVD. Without adequate hemodynamic data, it is difficult to properly assess the risk of CVDs and choose the best treatment options. Hemodynamics, heart and blood vessel illnesses are linked in various subtle ways. However, well-documented qualitative comprehension, connections, and detailed knowledge of hemodynamic circumstances are required to estimate risk and evaluate causes. Hemodynamics parameters like Wall Shear Stress (WSS), Wall Pressure (WP), Streamlines, Vorticity, Relative resilience time (RRT), Swirling Strength, Time-Average Wall Shear Stress (TAWSS) and Oscillatory Shear Index (OSI) are useful marker for blood flow dynamics studies. In this thesis work; modelling, simulation and analysis of cardiovascular system under normal and pathological conditions with patient data have been evaluated and investigated the results using CFD method. In this work initially, investigated 3D-hemodynamics in a doubly afflicted human descending abdominal artery and compared the results with healthy condition at important cardiac instant systolic and diastolic phase then investigated the suitability and effect of rheological models in the same artery under diseased condition (AAA & RIIAS) with real time patient data from Institute of Medical Science (BHU), Varanasi, India. Furthermore; understanding the patient specific modelling and simulation of abdominal artery in multiply afflicted diseased condition from the previous work, many inferences were noted regarding the AAA shape effect and exact boundary condition implications in aortofemoral arteries. To understand the variations of AAA shape and exact boundary conditions for hemodynamics analysis, further worked on developing a methodology and investigating the morphological variation of abdominal aortic aneurysm in aortofemoral arteries using transient open-loop approach. In the systemic circulation the coronary artery provides the main blood supply to the heart and the myocardium with oxygen to allow for the contraction of the heart and thus causing circulation of the blood throughout the body. Atherosclerosis is the formation and growth of plaques within the coronary arteries. By studying plaque development and progression, researchers can gain insights into the mechanisms underlying CAD and identify potential therapeutic targets. To focus on early detection and diagnosis of CAD in the initial visit to hospital if a patient having complications in heart such as angina, weakness, nausea etc., it is important to understand the stage of CAD using computational approaches (CFD/FSI). Further in this thesis work a new methodology has been proposed for diagnosis of a suspected coronary arterial disease with patient data using coupled (0D-3D) lumped parameter network (LPN) and CFD method. In last objective of the thesis was to develop a combination of manual and automated-based segmentation of LV and 3D modeling approaches to generate geometry from real-time CT data and to do blood flow dynamics investigation. To execute this, a 3D modeling reconstruction using image data from open source provider multi-modality whole heart segmentation (MMWHS) challenge was considered and further model was made compatible for hemodynamics studies based on pulsatile data. In summary the using computational modelling and simulation analysis of various cardiovascular diseases under various pathological condition are investigated which can help in immediate decision planning and as a diagnostic tool to the medical professional dealing with such kind of problems in CVDs.