World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:15, No:08, 2021

Numerical Simulation of the Fractional Flow Reserve in the Coronary Artery with Serial Stenoses of Varying Configuration

Authors : Mariia Timofeeva, Andrew Ooi, Eric K. W. Poon, Peter Barlis

Abstract : Atherosclerotic plaque build-up, commonly known as stenosis, limits blood flow and hence oxygen and nutrient supplies to the heart muscle. Thus, assessment of its severity is of great interest to health professionals. Numerical simulation of the fractional flow reserve (FFR) has proved to be well correlated with invasively measured FFR used for physiological assessment of the severity of coronary stenosis in arteries. Atherosclerosis may impact the diseased artery in several locations causing serial stenoses, which is a complicated subset of coronary artery disease that requires careful treatment planning. However, hemodynamic of the serial sequential stenoses in coronary arteries has not been extensively studied. The hemodynamics of the serial stenoses is complex because the stenoses in the series interact and affect the flow through each other. To address this, serial stenoses in a 3.4 mm left anterior descending (LAD) artery are examined in this study. Two diameter stenoses (DS) are considered, 30 and 50 percent of the reference diameter. Serial stenoses configurations are divided into three groups based on the order of the stenoses in the series, spacing between them, and deviation of the stenoses' symmetry (eccentricity). A patient-specific pulsatile waveform is used in the simulations. Blood flow within the stenotic artery is assumed to be laminar, Newtonian, and incompressible. Results for the FFR are reported. Based on the simulation results, it can be deduced that the larger drop in pressure (smaller value of the FFR) is expected when the percentage of the second stenosis in the series is bigger. Varying the distance between the stenoses affects the location of the maximum drop in the pressure, while the minimal FFR in the artery remains unchanged. Eccentric serial stenoses are characterized by a noticeably larger decrease in pressure through the stenoses and by the development of the chaotic flow downstream of the stenoses. The largest drop in the pressure (about 4% difference compared to the axisymmetric case) is obtained for the serial stenoses, where both the stenoses are highly eccentric with the centerlines deflected to the different sides of the LAD. In conclusion, varying configuration of the sequential serial stenoses results in a different distribution of FFR through the LAD. Results presented in this study provide insight into the clinical assessment of the severity of the coronary serial stenoses, which is proved to depend on the relative position of the stenoses and the deviation of the stenoses' symmetry.

Keywords : computational fluid dynamics, coronary artery, fractional flow reserve, serial stenoses
Conference Title : ICFMA 2021 : International Conference on Fluid Mechanics and Applications
Conference Location : Sydney, Australia
Conference Dates : August 30-31, 2021