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A computational approach to an in-depth investigation of erythrocytes-driven flow characteristics in cardiovascular inflammation

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The mortality caused by cardiovascular diseases is dramatically increasing. Cardiovascular Inflammation is the main contributor to this extremely high cardiovascular disease mortality. The initiation and development of inflammation-related diseases as atherosclerosis is controlled by mechanical forces exerted by the flow of blood on the inner lining of arteries, the endothelium. In order to fight this lethal disease, a realistic computational model is required that offers an accurate understanding of the effect of blood flow on the arterial wall. In order to realistically describe complex blood flow patterns and their interaction with the arterial wall, we have developed an integrative computational technique that takes into account both the particulate cellular composition of the blood and the interactions between the particulate blood and the vessel wall, in macro-circulation. The cellular composition of the blood was modelled using a multiphase fluid dynamics method by computing both a Eulerian fluid domain for modelling blood plasma, and a Lagrangian solid domain that represented the blood cells. Interactions of the blood with the vessel wall were realistically modelled using a novel iterative immersed boundary method. Both the multiphase technique and the immersed boundary method were validated by comparing obtained numerical results with the literature, and a high degree of similarity was found. Our model revealed that under realistic non-Newtonian multiphase cell-containing blood flow conditions, the pressure at the stenosis site is c. 30% higher than predicted by single-phase Newtonian fluid dynamics models. This effect is most probably explained by a decrease of c. 28% in the peak velocity. The latest seems to be caused by the momentum interchange due to the collision of the particles (blood cells) with each other, with the vessel wall, and with the fluid phase (plasma). The most significant difference in velocities between the single-phase and the two-phase results was registered at the stenosis site. It was also found that high blood cell content (peak particle concentration) correlates with increasing flow laminarization. This means a decrease in velocity, which is more evidenced at the site of the stenosis. Additionally, our findings indicated that wakes forming downstream of the stenosis might be much weaker in non-Newtonian blood flow simulations compared to the Newtonian models. Taken together, our mathematical model and the resulting computational results might offer a more accurate understanding of the effects of realistic blood flow patterns on atherosclerotic vessels. This is of crucial importance since this deadly disease is initiated and progressed by blood flow related mechanical factors, such as the wall shear stress.

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Development of UWB Antenna for Microwave Imaging Systems for Breast Cancer Detection

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Microwave imaging is a promising method in biomedical applications such as breast cancer detection due to its good penetration property, non ionizing and non invasive nature which has the potential to be a complementary modality to standard mammography. In this paper, An UWB Microstrip-fed Vivaldi antenna for microwave imaging systems aimed for an early breast cancer detection is presented. The Vivaldi antenna is designed to operate between 8.821 to 22.30 GHz with dimensions of 44.85 × 25.28 mm that permits good radiation within the frequency range. To achieve UWB performance, Taconic TLC-32 substrate which has relative permittivity of 3.2 has been used to simulate the antenna by using Antenna Magus Software. The simulation results show that the return loss is better than -10dB within the range of 7.143 GHz to 24.60 GHz with the maximum return loss of -37.56 dB at 18.39 GHz. A comparison of performance with various substrates including ROGERS RO4003C, TMM4 and Taconic are also presented in this paper.

Keywords: Ultra-wideband(UWB); Microwave Imaging; Return loss; Radiation pattern.

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