Numerical Simulation of Blood Flow in a Straight Artery Under the Influence of a Magnetic Field

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Abstract

In this work, we have developed a three-dimensional numerical simulation for blood flow through an arterial segment in the presence of an externally applied magnetic field. The study bears the potential applications in simulation-based medical planning system for cardiovascular disease that provides computational methods to evaluate alternative surgical treatment. This study also motivates towards the increase of magnetic field strength in MRI machines with an aim to get better resolution of the scan images. The system of nonlinear coupled partial differential equations governing the magnetohydrodynamic flow of blood has been solved without neglecting the induced magnetic field.

The software has been used to perform numerical simulation for blood flow. The convergence of numerical solutions has been verified by using mesh refinement. The large amount of computations has been performed by solving seven equations for seven unknowns. The number of degrees of freedom at each node points of the model has increased by seven times.

The interaction between electrically conducting fluid (blood) with the applied magnetic field causes reduction in blood velocity and thereby increases blood pressure in order to maintain constant flow rate within the artery. Figure 1 shows that the axial induced magnetic field creates two lobes on each side of the main current line along Y-direction. One of these two lobes of axial induced magnetic field circulating in the same direction as the direction of flow, while the other circulates opposite to the flow direction. The arrow plot indicates the direction of current flows. It is observed that the current is circulating along the central Y-direction perpendicular to the direction of flow and applied magnetic field. Once the current reaches near the wall of the vessel, it moves downwards and forms lobes. This fact lies in the consideration of non-conducting vessel walls and forces them to re-circulate within the vessel.

Thus our study presented here bearing some important physiological phenomena and provides a lot of information to the scientists/researchers/experimentalists who are interested in cardiovascular flow simulation particularly in the patient-specific models. In the near future, our aim is to study the blood flow simulation using COMSOL Multiphysics® software in the curved artery under magnetic environment.

Reference

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Figures used in the abstract

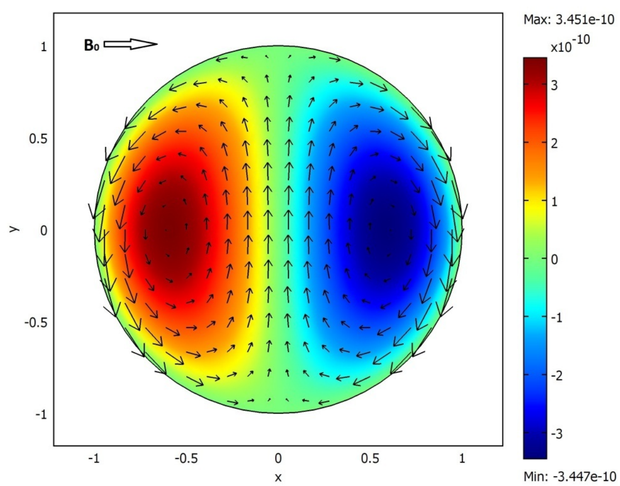

Figure 1: Axial induced magnetic field for Re=100 and Ha=2.0.