Accepted Manuscript

Magnetic field interaction with blood flow and heat transfer through diseased artery having Abdominal Aortic Aneurysm

G.C. Shit, Sreeparna Majee

PII: S0997-7546(17)30656-8
DOI: https://doi.org/10.1016/j.euromechflu.2018.03.010
Reference: EJMFLU 3275

To appear in: *European Journal of Mechanics / B Fluids*

Received date : 28 November 2017
Revised date : 9 March 2018
Accepted date : 23 March 2018

Please cite this article as: G.C. Shit, S. Majee, Magnetic field interaction with blood flow and heat transfer through diseased artery having Abdominal Aortic Aneurysm, *European Journal of Mechanics / B Fluids* (2018), https://doi.org/10.1016/j.euromechflu.2018.03.010

Magnetic field interaction with blood flow and heat transfer through diseased artery having abdominal aortic aneurysm

G.C. Shit, Sreeparna Majee

Department of Mathematics, Jadavpur University, Kolkata - 700032, India.
Corresponding Author. Email: gopal_iitkgp@yahoo.co.in (G. C. Shit), Tel. Phone: +91 33 2457 2716

Abstract

Unsteady magnetohydrodynamic flow of blood and heat transfer characteristics are numerically simulated with an aim to understand the flow pattern in a diseased arterial segment having Abdominal Aortic Aneurysm (AAA). Thermal energy equation has been analyzed by considering dissipation of energy due to applied magnetic field and the viscosity of blood. Vorticity-stream function formulation is used for numerical simulation in the diseased artery. Different stages of enlargement of AAA is very significant in understanding the cause and progression of vascular diseases due to the formation of large vortex rings in the aneurysm region which interacts with the arterial wall. This lead to the generation of WSS which drastically differ by a magnitude of 37% in 50% AAA and 18% in 10% AAA in comparison with the value in a healthy abdominal aorta in the laminar flow. With increase in Reynolds number, mild AAA also become harmful as it exhibits higher WSS increase percentage in comparison with a healthy arterial segment. The vorticity, streamlines and temperature contours are plotted to have a better understanding of the flow characteristics. Qualitative as well as quantitative profiles of wall shear stress and Nusselt number are plotted and determined that both increases with the effect of magnetic field strength. Moreover, shear stress decreases with increasing Reynolds number whereas it increases with increasing size of the aneurysm. The area of low WSS region inside the aneurysm reduces when exposed to magnetic field strength and makes the arterial state less pathological. Furthermore, Nusselt number has an enhancing effect on both Reynolds number and Prandtl number. The results have significant bearing in medical sciences for assessing temperature rise during hyperthermic treatment of tumor and drug delivery system with magnetic nanoparticles in the diseased artery.

Keywords: Magnetohydrodynamics, Blood flow, Abdominal Aortic Aneurysm, Heat transfer, Energy dissipation,

1. Introduction

The aorta is the largest blood vessel in the human circulatory system which carries/supplies blood to the head, arms, abdomen, legs, and pelvis. The walls of the aorta can swell or bulge out like balloon if they become weak. This phenomenon is known as abdominal aortic aneurysm (AAA) when it happens in the abdominal part of the aorta. AAAs are usually classified by their size which can be either small or slow growing with a much lower risk of rupture and large or fast growing can lead to internal bleeding as well as some other serious complications. The larger the aneurysm is, the more likely that it will need to be treated with surgery. Aneurysm is a biomechanical phenomenon which occurs on diseased aortic tissue where the inner wall exceeds the failure strength of the mechanical stress acting on it. The hemodynamics of AAA becomes an important element of study for characterization of biomechanical environment within the aneurysm due to its internal mechanical forces are initiated and maintained by the dynamic action of blood flow. AAAs occurs likely to male, obese or overweight, people of age above 60 years, having family history of heart conditions and diseases, high blood pressure, high cholesterol or fatty build-up in the blood vessels (atherosclerosis), have had trauma in abdomen or other damage in the midsection due to smoke tobacco products. In particular, specific wall shear stress conditions (WSS) regulate the production of nitric oxide [1], which causes loss of elastin and accelerates the growth of aneurysm, causes activation of blood platelets [2], playing the main role in thrombus formation and anisotropic displacements of aneurysmatic sac [3]. Duclaux et al. [4] experimentally studied the growth of aneurysms and observed that abdominal aneurysms tend to develop above a critical flow rate, whenever