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***Research Article** (Open Access)*

BLOOD FLOW ANALYSIS IN AORTA DURING ATHEROSCLEROSIS

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ABSTARCT

Blood flow measurement plays a vital role to identify and diagnosis of various diseases in different organs of the body. Depending on the change in geometry of aorta, blood flow rate will change based on non Newtonian fluid characteristics. In this paper simulation of the aorta is designed and modulated using ANSYS 18.1 to calculate the viscosity of the aorta to identify atherosclerosis (thickening of aorta) which is major cause for coronary artery disease.

Keywords: *ANSYS, Blood flow, aorta, atherosclerosis, viscosity*

INTRODUCTION

ANSYS is a worldwide company which developed multiphysics engineering simulation software for product design, testing and operation. ANSYS is a Finite Element Analysis software (FEA) which is use to solve the mathematical model for fluid flow, heat transfer, etc. Computational Fluid Dynamics (CFD) is use to analyze the problems which involves in fluid flow. Artery is a major blood vessel in our body. It is use to circulate oxygenated blood from heart to all other parts of the body, except pulmonary artery and umbilical artery. Aorta is a largest artery in our body .Aorta consists of two sections such as thoracic aorta and abdominal aorta. The normal size of the aorta is between 3.5cm to 4.5 cm. If the wall size of the aorta decreases from 4.5cm to 2.5cm means it's known as atherosclerosis part (defective). Atherosclerosis is causes by obesity, high cholesterol, smoking, high pressure, alcohol consumption. Due to atherosclerosis velocity of the blood gets decreases. It causes coronary artery disease, stroke, hyper tension, hypo tension and sometimes leads to sudden death. If aorta atherosclerosis is find in earlier stage means doctors can cure this by giving proper treatment for blood pressure.

LITERATURE REVIEW

The blood flow analysis had done for different shapes of aorta blood vessels; the variation in pressure is measured. In this paper the Navir Stokes and continuity equations are used to govern the flow of blood [1].Aorta CAD model is created for normal aorta, aorta with plaque at descending side and aorta with bypass graft. The various parameters such as velocity, pressure and wall shear stress which affects the blood flow. It is useful at the time of bypass surgery to pre defined the flow of blood [2].The four different models of right subclavian artery are modelled. Complete and detailed analysis had done for the atherosclerosis conditions of the aorta. The evaluation of one cardiac cycle is studied [3].The change in blood flow rate using waveform is investigated; the wall shear stress distribution in the atherosclerosis part is analyzed. The comparison had made between steady state and transient blood flow. The valuable information can be provided by computational hemodynamic simulations [4].The velocity variations in aorta with respect to time are measured. Using computational fluid dynamics the aorta model of younger person is designed and analyzed. Poisson's ratio and young's modules is taken to consideration and geometry model is created [5]. Biomechanics related functions of the aortic system from its geometric properties are experimented. The solution to the boundary value problems is identified using mechanical homeostasis in the vessel wall[6].Using real case imaging data the parameter variations of aortic coarctation between normal and atherosclerosis aorta is studied[7].In this paper it examines the relationship between shear stress in presence of lesions and intima-media thickness. This model is developed to simulate plaque progression to predict future plaque morphology [8].To generate novel

vessel-appropriate material model for plaque tissue is experimented using collected data. This represents the femoral arterial tissue diseases [9]. In this work, it is discussed that the relation between viscosity and velocity for both the normal and aneurysm abdominal aorta stages.

SECTION DETAILS

Section1 says about behavior of non Newtonian fluid with its principle. Section2 says about the geometrical properties of aorta with its dimensions. Section3 says about meshing process of aorta. Section4 says about properties of blood. Section5 explains about simulation output of aorta model.

NON-NEWTONIAN FLUID

Blood is non - Newtonian fluid. So it doesn't obey the Newton law of viscosity.Velocity is not constant. Velocity is depending upon shear stress. Due to atherosclerosis wall size of the aorta get decrease, area become smaller and viscosity decreases. The velocity and viscosity of the blood is directly proportional to the shear stress. So velocity and shear stress of the blood get decreases. The following equation states the relation between shear stress and area.

Here, τ – Shear stress;
F – Force applied;
A – Cross sectional area

$$\tau = F/A$$

SIMULATION OF AORTA USING ANSYS

GEOMETRY

For the geometry of fluid flow analysis, create geometry in ANSYS design modeller, or import the appropriate geometry file. The abdominal aorta is created using ANSYS sketching tools with the diameter of 4.5cm, it contains one inlet and outlet. Diameter of both inlet and outlet is 4.5cm

Fig.1

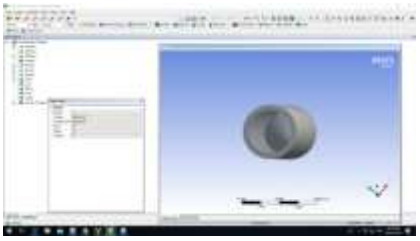

Fig.2

Fig.1 is a geometry representation of normal aorta. Fig.2 is a geometry representation of atherosclerosis aorta.

MESHING

Meshing is an integral part of simulation process where complex geometries are divided into simple elements. Generation of mesh is used to create subdivisions in the abdominal aorta to analyze the fluid flow in abdominal aorta using finite element analysis. It consists of named sections such as input, output and wall.

Fig.3

Fig.4

Fig.3 is a mesh representation of normal aorta. Fig.4 is a mesh representation of atherosclerosis aorta.

PROPERTIES OF BLOOD

In ANSYS fluid is treated as blood. The properties of the blood are mentioned here. Density of the blood is 1060kg/m^3. Specific heat of the blood is 3513 j/kg-k. Thermal conductivity of the blood is 0.44w/m-k. The velocity is considered to minimum at the age between 40 – 50 (0.25m/s). Consider inlet blood pressure as 10000pa (75mmhg) and outlet pressure as 16000pa (120mmhg)

OUTPUT ANALYSIS

After initialization process, the result panel is obtained. Stream line is generated to view the velocity variations in blood flow with respect to created geometry model of abdominal aorta. Contour is use to show eddy viscosity in wall of the aorta. Animation shows how the flow change occurs during normal and atherosclerosis stages of aorta

VISCOSITY ANALYSIS

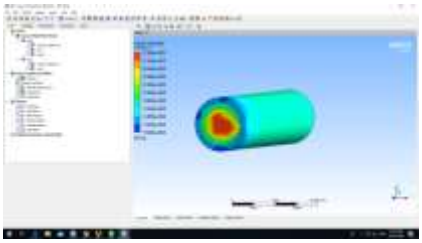

Fig.5

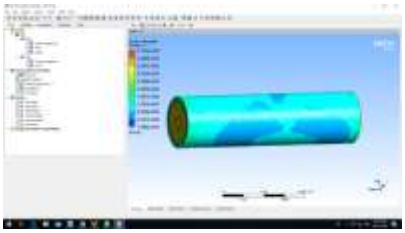

Fig.6

Fig.5 is a wall shear representation of normal aorta. Fig.6 is a wall shear representation of atherosclerosis aorta.

Using above obtained results it is clearly understood that viscosity changes due to atherosclerosis. It causes change in velocity of blood flow with respect to change in shear stress of blood which is directly proportional to viscosity.

VELOCITY ANALYSIS

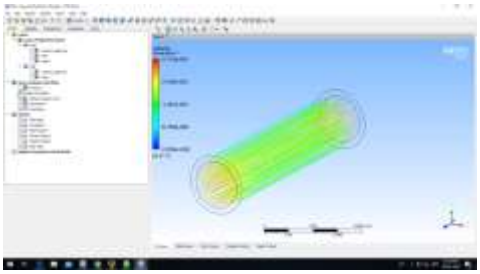

Fig.7

Fig.7 is a streamline representation of normal aorta.

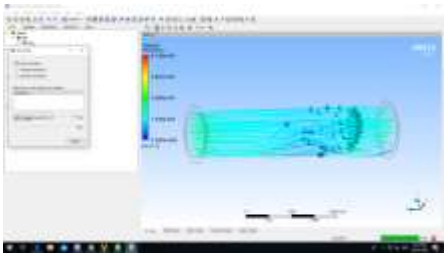

Fig.8

Fig.8 is a streamline representation of atherosclerosis aorta.

From above obtained results it is clearly understood that velocity changes due to atherosclerosis. It cause change in wall shear of the blood flow with respect to change in viscosity of the blood which is directly proportional to velocity.

RESULT

The wall viscosity of the abdominal aorta is inversely proportional to area of the aorta. Due to change in viscosity of the aorta blood velocity also change. From this it is examine the blood velocity is directly proportional to the velocity depending on the characteristics of non Newtonian fluid.

S.No	Stages	Inlet velocity(ms^{-1})	Outlet velocity(ms^{-1})
1	Normal aorta	0.25	0.244
2	Atherosclerosis aorta	0.25	0.229

Above table shows the velocity decreases due to atherosclerosis.

CONCLUSION

This work demonstrates the behavior of aorta subject to viscosity. From the results obtained, it is come to know the variation in blood flow during atherosclerosis. It is helpful for doctors to find the atherosclerosis stage of the aorta using difference in blood velocity. By analyzing the stage of atherosclerosis proper treatment should be given by the doctors such as treatment for pressure, open heart surgery, endovascular surgery, etc.

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