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# Analysis of Blood Flow Parameters to Detect Abnormalities in Blood Vessels

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**Abstract:** ***Due to the lifestyle of today's generation, people suffer from cardiovascular diseases. Therefore, there is a high mortality rate in developed countries. The cardio vascular system of the human body consists of a large number of blood vessels, which consists of various important parameters that can be analyses and studied. The pulsating blood flow is extremely complicated due to the large number of blood vessels. Blood flow gives us important information which helps to track down various diseases. In recent times, various techniques have been developed to analyse blood flow. These analyses detect abnormalities in blood flow such as aneurysms and clots. This paper provides a literature survey of various methods to detect abnormality in blood vessels.***

**Keywords:** Blood flow, aneurysm, hemodynamic characteristics, CFD

## 1. Introduction

Over the next 40 years, life threatening events such as stroke and myocardial infraction are expected to double in count. The blood flow diagnosis of subjects suffering from cardio vascular diseases is important. One of the challenges faced is to prevent cardio vascular diseases before it can occur which will eliminate the risk of fatal events. The mortality rate due to cardio vascular diseases in developed countries is over 40%. This happens when proper amount of blood does not reach the organs and tissues. There could be various reasons as to why the blood flow is abnormal. The change of pressure and velocity of blood due to abnormal blood vessels needs to be monitored. Abnormal blood vessels could be due to various reasons, such as, clot, plaque or aneurysms. If these conditions are unnoticed, then in course of time, the subject may develop serious conditions. For this reason, the blood flow needs to be monitored.

In recent years, a number of techniques have been developed to monitor blood flow. This proposed paper provides a literature survey of different techniques to automatically detect abnormalities in blood vessels.

## 2. Literature survey

If the walls of arteries weaken, the velocity and pressure of blood changes. A weakened blood vessel if not diagnosed on time may give rise to aneurysm and in time may rupture, which could cause an even bigger problem such as stroke or myocardial infraction etc. Numerous computer simulation schemes have been developed over the years to diagnose weakened blood vessels. This section of the paper mainly focuses on the different approaches developed over the years by the authors in literature for accurate ways to detect abnormalities in blood vessels.

Steffen Oeltze-Jafra, Juan R. Cebral, G´abor Janiga, and Bernhard Preim in [1] proposed that Computer Fluid Dynamics (CFD) simulations help in understanding the dynamic characteristics of the flow of blood to extract crucial and important information for proper diagnoses. The studies say that there are vortices (or even embedded vortices) present in the blood flow patterns. These vortices lead to aneurysm rupture. In this approach, a clustering approach is presented for analysis of vortical blood flow. streamlines of the blood flow are analysed and grouped together to find embedded vortices. These grouped streamlines show a detailed visualization of the blood flow pattern. These visualizations were also viewed by a group of experts to view the simulation results. It was concluded that hemodynamic characteristics are important to detect abnormalities in blood vessels. The more dynamic characteristics analysed the better is the detection process.

Rocco Gasteiger, Dirk J. Lehmann, Roy van Pelt, G´abor Janiga, Oliver Beuing, Anna Vilanova, Holger Theisel, and Bernhard Preim in [2], also use different types of hemodynamic characteristics such as, inflow jet and impingement zone that are also related to the risk of aneurysm rupture. These parameters are investigated visually by CDF. Here, streamline properties of the blood flow are used to find out the inflow jet and impingement zone. A boundary contour was used to extract the inflow jet on the ostium (neck of an aneurysm) which was then used to identify the impingement zone. This is an automatic and robust method to detect abnormalities in blood vessels.

H. Zakaria, A. Kurniawan, T.L.R. Mengko, and O.S. Santoso in [3] described an approach to detect celebral aneurysm by using one of the most advance techniques of 2D digital subtraction angiogram (DSA) imaging. Here, time to peak and time duration of flow of contrast agent that travels in the blood vessels have been calculated. DSA imaging is an advanced and improved method over traditional techniques to visualise blood vessels and subtract the other structures of the human body. The time duration for the contrast agent to travel in a blood vessel will be different for a normal blood vessel and an abnormal blood vessel, therefore an abnormality can be detected. This is a simple, yet effective method of detecting an abnormality. Large aneurysms (greater than 7mm) can be detected using this method.

Amanda Randles, Erik W. Draeger, Tomas Oppelstrup, Liam Krauss and John A. Gunnels in [4] describes, that the entire arterial structure provides insights about abnormalities in blood vessels and also enables the study on global hemodynamic. A robust method of the lattice Boltzmann method which uses limited memory and also saves bandwidth in complex geometries. A strong scaling of three-dimensional, high resolution simulation of hemodynamic was demonstrated.

A Thesis by Maha Laxmi Shrestha in [5] uses a mathematical model of blood flow. A numerical approach has been used to analyse the blood flow in a human body. The velocity and pressure of blood has been found out by the using the finite elements method. Using this method, it was demonstrated that, the velocity and wall shear stress increases due to presence of stenosis in the part of the blood vessel. This stenosis blocks the flow of blood and will significantly increase in time.

Mohd Azrul Hisham Mohd Adib, Yoshiyuki Watanabe, Satoshi Ii, Shigeo Wada in [6] is a study on patient specific blood flow simulations obtained from DSA and PC-MRI with respect to geometry and velocity. Patient specific models have been reconstructed using DSA imaging where an aneurysm has been developed. A wall shear stress can be developed by using the velocity measurements data without explicitly giving the boundary conditions.

Jubin Mitra, Tanmay Halder and Abhijit Chandra in [7] explains that, The Circle of Willis may develop aneurysms. This paper describes a technique which uses Hough Circle Transform (MHCT) on an image that has been extracted from Digital Subtraction Angiogram to detect an aneurysm.

## 3. Hemodynamic characteristics

The dynamics of blood flow is called as hemodynamic parameters. These parameters play an important role in blood flow analysis and hence, studying these characteristics help in detecting abnormalities in blood vessels. When the blood flow is parallel and in a single front direction, the blood flow is considered normal and is termed as laminar flow. The problem arises when the flow turns to turbulent, i.e., the blood flow is not parallel and not in a single forward direction. Therefore, hemodynamic characteristics can be used to detect theses abnormalities in blood vessels.

### 3.1 Inflow Jet

This hemodynamic characteristic which is visually examined is obtained by Computer Fluid Dynamics (CFD). This parameter tells us the streamline direction of the blood flow. With the help of CFD the streamline properties of the blood flow can be examined. Any irregularities in the streamlines will show an abnormality in blood vessel.

### 3.2 Impingement Zone

This parameter is clubbed along with Inflow Jet to find the affected area of the blood vessel.

### 3.3 Vortices

Vortices is a major part of turbulent, abnormal flow. When blood flows in a circular direction in a blood segment, a vortices are formed. These vortices then give rise to blood clots. Therefore, detection of vortices is an important hemodynamic parameter.

## 4. Navier Stokes Equations

The Navier-Stokes equations governs the motion of fluids and can be seen as Newton's second law of motion for fluids. These equations are the heart of fluid flow. Solving them, will predict the fluid velocity and its pressure in a geometry. Therefore, these equations can be used to find out the velocity and pressure changes in a blood vessel. It is relatively easy to solve these equations for a flow between two parallel plates or a circular pipe.

## 5. Implementations and results

In this proposed paper an analytical method using Navier Stokes equations have been implemented.

This method was implemented using MATLAB to automatically detect an abnormality in blood vessel. The PDE tool was used which is an arrangement of Navier Stokes equation. The results have been implemented in the following figures. Figure 1 shows simulation of a normal blood vessel. Figure 2 shows simulation results for turbulent blood vessel. Figure 3 shows an obstruction inside the blood vessel that could be a plaque or a clot.

Therefore, using Navier Stokes equations blood flow can be analysed and diagnosed. This approach is simple and effective and can be used to model blood flow.

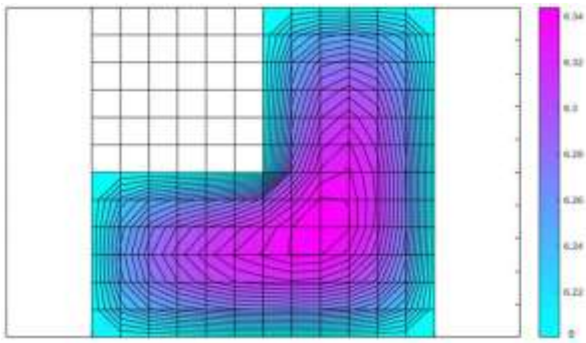

**Figure 1**

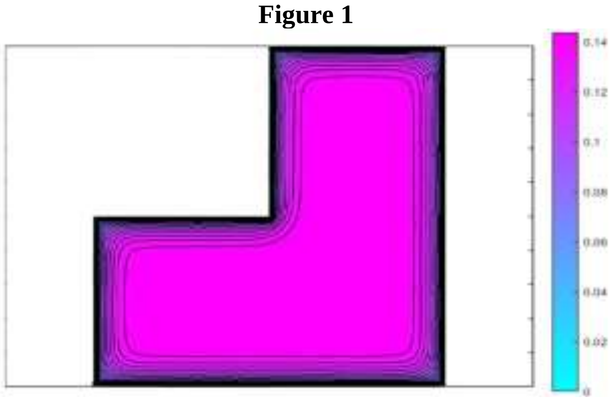

**Figure 2**



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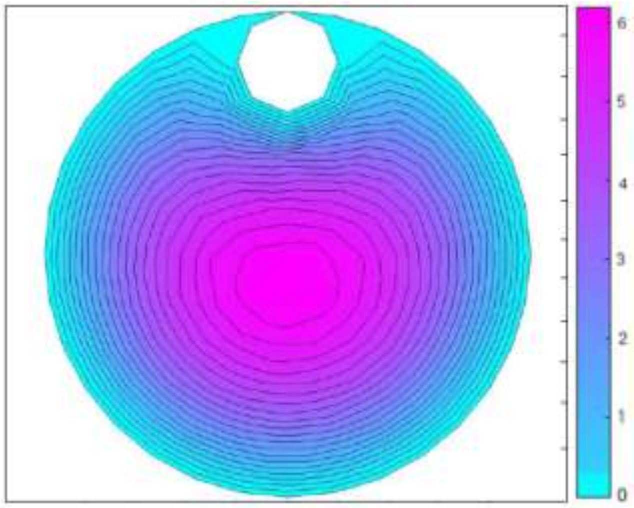


**Figure 3**

## 6. Conclusion

The blood flow describes the flow of blood to various parts of our body and therefore has to be monitored. Abnormal changes in the blood flow leads to change in the velocity and pressure. These abnormal changes in blood could be due to various reasons. Some of these reasons could be aneurysm, clot etc. if these are not monitored then could lead to fatal events such as instant death.

This paper provides a survey of the various techniques developed to find any abnormalities in blood vessels. A method has been developed to automatically detect abnormalities in blood vessels in MATLAB.

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