FINITE ELEMENT MODELING OF CEREBRAL ANEURYSM

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BACHELOR OF MECHANICAL ENGINEERING
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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LIST OF SYMBOLS

ε	normal strain
L	elongated length
L_0	gauge length
ε_x	normal strain in x-direction
γ_{xy}	shear strain in xy-plane
δ	displacement
σ_x	normal stress in x-direction
v	Poisson's ratio
E	Young's modulus

LIST OF ABBREVIATIONS

CA	Cerebral Aneurysm
AAA	Abdominal Aortic Aneurysm
COW	Circles of Willis
CFD	Computational Fluid Dynamics
FEA	Finite Element Analysis
FSI	Fluid Structure Iteraction
WSS	Wall Shear Stress

ABSTRACT

An aneurysm is an abnormal bulging or widening of a portion of an artery due to weakness in the wall of the aortic wall. It happens when the mechanical stress exceeds the tensile strength of the tissue. Nowadays, an accurate decision to predict the rupture of the aneurysm is not is founded yet. This study is focusing on cerebral aneurysm that is occurring at the circle of Willis area. By using the simulation tools, the stress behaviour on cerebral aneurysm (CA) area will be analyzed. As the size of an aneurysm increases, there is a potential of rupture of aneurysm. Studying the mechanical properties in real CA's can better the research of aneurysm behaviour. This study consists of three cases with the different size of aneurysms which are 2.5 mm and 3.5 mm in radius. The simulation of the model was studied under incompressible, non-Newtonian, viscous, non pulsatile condition in which we investigated computationally in a three-dimensional configuration using a Computational Fluid Dynamics (CFD) program. Currently, the decision to treat a diagnosed, unruptured aneurysm is based primarily on the maximum dimension of the lesion even though there is controversy over the critical size. Our results from finite element analysis reveal important roles of lesion shape, material properties, and loading conditions in governing the distributions of stress within the saccular aneurysms. This research finds that maximum stresses increase markedly with increases in lesion size, the ratio of neck diameter to lesion height, and the pressure.

ABSTRAK

Aneurism adalah kejadian ganjil pembengkakan atau pembesaran bahagian arteri disebabkan oleh dinding aorta yang lemah. Ini berlaku apabila tekanan mekanikal melebihi kekuatan tegangan dinding aorta. Pada hari ini, keputusan yang tepat untuk meramal aneurism akan pecah masih belum ditemui. Kajian ini akan difokuskan di serebral aneurism yang berlaku di kawasan lingkaran Willis. Dengan mengunakan kaedah simulasi, sifat-sifat tekanan di kawasan ini akan dianalisis. Apabila saiz aneurism meningkat, terdapat potensi untuk aneurism pecah. Untuk setiap lokasi, terdapat tiga kes dengan saiz aneurism yang berbeza iaitu 2.5 mm dan 3.5 mm dalam radius. Simulasi model dikaji dengan parameter aliran mampat, non-Newtonian, bendalir likat dan keadaan tiada denyut menggunakan program dinamik bendalir tiga dimensi (CFD). Pada masa ini, keputusan untuk mengubati didiagnosis, aneurisma tidak pecah didasarkan terutama pada dimensi maksimum lesi walaupun ada kontroversi melebihi saiz kritikal. Keputusan dari analisis elemen hingga menunjukkan peranan penting dari bentuk lesi, bahan, dan keadaan pembebanan dalam mengatur edaran stres dalam aneurisma saccular. Penyelidikan ini mendapati bahawa voltan maksimum meningkat tajam dengan peningkatan dalam saiz lesi, nisbah diameter leher ke quality lesi, dan tekanan

CHAPTER 1

INTRODUCTION

1.1 ANEURYSMS

Aneurysm is a localized, blood-filled dilation (balloon-like bulge) of a blood vessel caused by disease or weakening of the vessel wall. Aneurysms most occur in arteries at the base of the brain (the circle of Willis) and in the aorta (the main artery coming out of the heart, a so-called aortic aneurysm). A sign of an arterial aneurysm is a pulsating swelling that produces a blowing murmur on auscultation (the act of listening for sounds in the body) with a stethoscope.

There are four main locations where aneurysms always happen that are Cerebral Aneurysms (CA), Aorta Aneurysms, Abdominal Aneurysms and Thoracic Aortic Aneurysms. As the size of an aneurysm increases, there is an increased risk of rupture, which can result in severe hemorrhage or other complications including sudden death. Severe bleeding can occur if the aneurysms break or rupture. Not all aneurysms are life-threatening. But if the bulging stretches the artery too far, this vessel may burst, causing a person to bleed to death. An aneurysm that bleeds into the brain can lead to stroke or death. Aneurysms usually appear in either fusiform or saccular.

A fusiform aneurysms is spindle shaped without a neck. While, the second type of aneurysms is saccular. The saccular aneurysms are the most frequent cerebral aneurysms showing a berrylike outpouchings of the vessel wall: they often develop at the curved side of the vessels or at the apex of bifurcations.

1.2 PROBLEM STATEMENT

Nowadays, the case of rupture of CAs is often occurs without any preceding symptoms. The rupture occurs when the stress acting on the aorta wall exceeds the strength of the aorta wall itself. It was necessary to establish reliable criteria of the rupture risk assessment procedures in CAs for these lesions, and criteria based on the mechanical field. Besides that, the prediction of rupture happens is not available yet. The stress distribution caused by pressure in the cerebral is one element factor that influenced the rupture of aneurysm. So it was necessary to study the behavior of these elements to better understanding of aneurysm.

1.3 PROJECT OBJECTIVES

The first objective of this project is to study the the wall stresses in each virtual of CA and investigate the finite element analysis with different diameter of CA..

The second objective is to analyze the effect of geometry that influence the magnitude and distribution of the peak wall stress in the aneurysm. The cerebral aneurysms is locate at the brain and focus on the saccular shape of aneurysms. In this objective, the project will focused on the diameter of aneurysms to determine how it influence the rupture of aneurysm .

1.4 PROJECT SCOPE

In order to achieve those objectives, some limitations were decided to range the whole study. Therefore, the main concerned is to analyze cerebral aneurysms located in COW (Circle of Willis) with certain software. Three-dimensional (3D) models of CA with different diameter of aneurysm are created before the finite element analysis take place.

All the solutions of the problem presented in this study will be based on numerical approach only. The results of these analyses through numerical solutions are expected to explain the wall shear distribution and peak wall stress in the aneurysm.

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