

BLOOD FLOW DYNAMICS IN MICROVESSEL BIFURCATIONS

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated to my parents

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ABSTRACT

This thesis deals with the blood flow behaviour in the microvessel bifurcation using variety of blood parameters. There are two situations for the analysis which normal microvessel and abnormal microvessel bifurcations. The objectives of this thesis are to investigate the effect of bifurcation on blood flow distributions and predict flow abnormalities due to blood properties. The thesis describes the finite volume technique to predict the abnormalities and identify the effect of the bifurcation. The structural three-dimensional solid modeling of normal and abnormal blood vessel were developed using the computer-aided drawing software. The strategy of validation of finite volume model was developed. The finite volume analysis was then performed using COSMOS Flow in Solidwork software. From the result, it is observed that bifurcation give an effect to the blood flow behavior. For normal and abnormal case, using the different pressure for same diameter of blood vessel bifurcation, the pressure result shown an increment when blood flow into the bifurcation. It is same when analyze using different velocity for same diameter, the value will decrease when it goes to the bifurcation. For analysis using different diameter of blood vessel bifurcation, the effect of bifurcation will clearly seen. Pressure and velocity will be proportional in values of analysis refer to the equation of fluid dynamics. Peak velocity of the normal and abnormal also showed different values. Normal microvessel bifurcation has a higher value of peak velocity than abnormal microvessel bifurcation. Reynolds Number also get an effect when the diameter of the blood vessel increase. Finally, the correlations obtained from this numerical result could be used to investigate the pressure and velocity distribution around the diseased segment.

ABSTRAK

Tesis ini membentangkan tentang sifat darah pada salur darah yang bercabang dua menggunakan parameter darah yang berbeza. Terdapat dua situasi di dalam analisis ini iaitu salur darah bercabang normal dan juga salur darah bercabang tidak normal. Objektif tesis ini ialah untuk mengenalpasti kesan salur darah bercabang kepada pergerakan darah dan untuk menjangka pergerakan darah tidak normal berdasarkan sifat darah itu sendiri. Tesis ini membincangkan penilaian kebolehtahanan untuk menjangka sesuatu tidak normal dalam salur darah dan kesan cabang pada pergerakan serta sifat darah. Permodelan struktur tiga dimensi untuk salur darah normal dan tidak normal dibangunkan dengan perisian lukisan bantuan komputer. Strategi pengesahan model kelantangan terhingga dibangunkan. Analisis kelantangan terhingga dijalankan dengan COSMOS di dalam perisian Solidwork. Keputusan yang diperolehi daripada analisis ialah cabang pada salur darah memberi kesan kepada pergerakan dan sifat darah. Bagi kes salur darah normal dan tidak normal menggunakan tekanan yang berbeza tetapi diameter sama, nilai tekanan menunjukkan peningkatan apabila darah melalui cabang. Ia juga sama apabila analisis kelajuan darah berbeza pada diameter yang sama, ia menunjukkan penurunan apabila sampai ke salur darah yang bercabang. Bagi analisis untuk diameter salur darah yang berbeza, kesan disebabkan salur darah bercabang dapat kelihatan dengan jelas. Tekanan dan kelajuan adalah bertentangan antara satu sama lain merujuk kepada persamaan dalam dinamik berdalir. Kelajuan tertinggi darah turut memberi nilai yang berbeza dalam kes salur darah normal dan tidak normal. Salur darah normal mempunyai nilai kelajuan tertinggi lebih daripada salur darah tidak normal. Nombor Reynold juga menunjukkan kesan apabila diameter salur darah berubah. Perkaitan diperolehi daripada kajian ini boleh dimanfaatkan untuk lanjutan taburan tekanan dan kelajuan bagi darah disekitar tempat yang sakit.

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LIST OF SYMBOLS

| | | |
|---------------|---|-----------------------------------|
| u_i | : | velocity in the i -th direction |
| P | : | pressure |
| f_i | : | body force |
| μ_i | : | viscosity |
| δ_{ij} | : | Kronocker delta |
| ρ | : | density |
| v | : | mean velocity |
| D | : | diameter |
| ∂t | : | partial differential of time |
| ∂p | : | partial differential of pressure |
| R | : | radius |
| L | : | length |
| α | : | alpha |
| A | : | area |
| V | : | volume |

LIST OF ABBREVIATIONS

- MCA : Middle cerebral artery
- CFD : Computational Fluid Dynamics
- CAD : Computer Aided Design
- FEM : Finite Element Method
- CT : Computer-assisted tomography
- CAE : Computer Aided Engineering
- CSS : Computational Solid Stress
- FEA : Finite Element Analysis
- PDE : Partial Differential Equation