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TWO-DIMENSIONAL MATHEMATICAL MODELS FOR MICROPOLAR BLOOD FLOW THROUGH AN ARTERIAL STENOSIS

ILYANI ABDULLAH

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Mathematics)

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I declare that this thesis entitled "*Two-Dimensional Mathematical Models for Micropolar Blood Flow Through an Arterial Stenosis*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved husband, family and friends.

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ABSTRACT

The purpose of this study is to investigate the flowing blood in a constricted artery. The blood is characterized by a non-Newtonian, micropolar fluid which accounts for the suspension of naturally buoyant particles in a viscous fluid which Newtonian model is inadequate to describe. In this study, the blood flow is assumed to be unsteady, incompressible, laminar, two-dimensional and axisymmetric. It has been observed that the flowing blood is altered once a stenosis, which describes a constriction in an artery, develops. Thus, the arteries with an overlapping, a cosine and an irregular-shaped stenosis are considered as representing the constriction in arterial segment. Furthermore, the effect of tapering on the arterial segment and the influence of the external forces, namely body acceleration and magnetic field, are studied. The governing equations involving unsteady nonlinear partial differential equations in the cylindrical coordinate system are transformed using radial coordinate transformation, and then are solved numerically employing a finite difference scheme. A quantitative analysis has been performed through numerical computation on the velocities and the flow characteristics such as the flow rate, the resistance to flow and the wall shear stress. Numerical results showed that the velocity and the flow rate decrease for a higher magnitude of micropolar parameter compared to Newtonian fluid, in the presence of magnetic field and in the converging arterial segment. However, under the influence of body acceleration, the velocity and flow rate increase. On the other hand, the resistance to flow and the shearing stress at the wall decrease. The results concluded that the rheological effect and the geometry of artery together with the influence of the external forces altered the flowing blood.

ABSTRAK

Kajian ini dilakukan bertujuan untuk mengkaji aliran darah dalam arteri yang tersumbat. Darah dicirikan sebagai bendalir mikropolar iaitu bendalir tak Newtonan yang mempertimbangkan ampaian zarah yang terapung di dalam bendalir likat yang mana tidak memadai untuk dijelaskan oleh model Newtonan. Dalam kajian ini, aliran darah dianggap sebagai aliran tak mantap, tak boleh mampat, laminar, dua matra dan berpaksi simetri. Dengan kehadiran stenosis, keadaan di mana arteri adalah tersumbat, darah yang mengalir telah dikatakan terganggu dan berubah. Oleh itu, arteri dengan stenosis bertindih serta stenosis berbentuk kosinus dan berbentuk tak licin telah dipertimbangkan sebagai mewakili keratin arteri yang tersumbat. Tambahan lagi, kesan daripada keratin arteri yang menirus serta pengaruh daripada daya luaran, iaitu pecutan badan dan medan magnet, dikaji. Persamaan penaklukan yang melibatkan persamaan pembezaan separa tak linear dan tak mantap dalam sistem koordinat silinder dijelmakan dengan menggunakan penjelmaan koordinat jejarian dan diselesaikan secara berangka dengan menggunakan skema beza terhingga. Analisis perangkaan dilaksanakan secara pengiraan berangka terhadap halaju serta cirian aliran seperti kadar aliran, rintangan aliran dan tekanan ricihan. Keputusan berangka menunjukkan halaju dan kadar aliran berkurangan bagi nilai parameter mikropolar yang tinggi dibandingkan dengan model Newtonan, dengan kehadiran medan magnet dan di sepanjang keratin arteri yang meruncing. Walau bagaimanapun, di bawah pengaruh pecutan badan, halaju dan kadar aliran adalah bertambah. Sebaliknya, rintangan aliran dan tekanan ricihan pada dinding memberikan hasil yang berlawanan daripada halaju dan kadar aliran dalam semua kes yang dipertimbangkan. Hasil yang diperolehi merumuskan bahawa kesan reologi dan penirusan arteri berserta pengaruh daya luaran telah mengubah aliran darah.