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Investigation of the Treatment and Radiation Effects on Oscillatory Blood Flow through a Stenosed Artery

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ABSTRACT: *An overseeing governing model was developed to examine the impact of treatment and radiation on oscillatory blood in a stenosed channel. The model was scaled into dimensionless structure with the limiting condition, solved analytically and scientific computation was done with Mathematica 10, programming software. It is observe that the relevant parameters have incredible influence on temperature profile of blood, flowing in the channel. In addition, it is seen that the treatment parameter increase affects the growth stenosis, that seem to be helpful in controlling influx of cholesterol in the body as it effectively improved the flow. In conclusion, radiation heat and prescribe quantity of treatment can help in the treatment of stenosed condition as a result of excessive cholesterol as we have seen from the simulation and the graphical results.*

KEYWORDS*: Atherosclerosis, Heat, Treatment, Blood, Cholesterol, Oscillation.*

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I. INTRODUCTION

Blood is a suspension of formed elements in particular erythrocytes (red platelets), leukocytes (white platelets), and platelets in a plasma liquid. By and large, blood is comprised of to great extent red platelets otherwise called erythrocyte of around 45 percent of the blood volume. The level of red platelets in absolute blood volume is called hematocrit.

Atherosclerosis is the constriction and solidifying in the artery, it is a notable cause of death around the world. Basic instance of atherosclerosis represses the dissemination of blood in human body, if not check could result to a genuine ailments, for example, hypertension, ischemia and peripheral ailments Bunonyo *et al*. [1]. The reason is that extreme admission of fatty or cholesterol nourishments or substances which are increasingly insoluble to a more noteworthy degree and even awful or dangerous in a cooler situation, if not check may prompt plaque development in the lumen of the arterial channel which is calamitous. Because of the difficulties, it is appropriate to make it a state of obligation to watch what we eat and the type of diet in order to debilitate high oxidation abstains from food with water, since water really helps in absorption process.

The investigation of biofluid elements has supported a few mathematicians and researchers have examined using numerical models, the morphological and physical conduct of the blood stream in medication and other modern liquid applications.

Heat movement and thermal conductivity of fluid has helped in lifting the heat conductivity of the blood, which have been settled upon by certain researchers and analysts the same throughout the years.

For example, Almari *et al* [4] explored the impact of mass exchange on magneto hydrodynamics second grade liquid towards an extending chamber toward Cattaneo-Christov heat liquid portrayal. Hassan et al. [3] considered the convective warmth move stream of nanofluid in wavy permeable surface. In a comparative vein, Ellashi [2] looks at the impact of MHD and temperature driven consistency of non-Newtonian fluid stream in a channel.

Throughout the years, a few authors have additionally researched blood rheology and course system under some exceptional conditions and dynamism because of certain elements, for example, when practicing and in a position.

The idea and handiness of electromagnetic field in biomedical research was first discussed by Kollin [5] and the conceivable use of attractive field to manage the course of blood was inspected by Korchevskii and Marochnik [6]. In the further examinations, Abdullah et al. [7], Bose and Banerjee [8] discussed attractive molecule catch for biomagnetic liquid stream in an atherosclerotic aorta. The previously mentioned creators saw that the impact of attractive field is to hinder the stream speed of blood. On the off chance that an attractive field is applied to an electrically directing liquid, for example, blood flow, the connection between the attractive field and electric field results a power called the Lorentz power, and has the penchant to either contribute or oppose the blood course.

Bhatti *et al* [13] looked into on blood coagulation utilizing a coagulation model and examined the heat movement on peristaltically incited development of molecule loaded suspension with variable consistency. Massoudi and Christie [15], Pantokratoras [16] and Nadeem and Akbar [17] researched the impact of warmth move with temperature subordinate thickness. Then again, Petrofsky et al. [18] researched the impact of dampness substance of warmth source on blood stream reaction of the skin through information.

Prakash et al. [19] developed a model to examine the bifurcated supply routes systematically and they researched the impact of warmth source on magnetohydrodynamic (MHD) blood stream. Be that as it may, none of the creators referenced above thought about the impact of warmth and treatment on atherosclerotic blood.

Hijaz et al. [20] investigated modified variational iteration algorithm-II for finding approximate solutions of nonlinear parabolic equations by comparing the following methods MVIA-II with trigonometric B-spline collocation method, variational iteration method, homotopy perturbation transform method.

In this research, the aim is to formulate an energy equation to investigate the fluid flow in an arterial channel, with the geometry of stenosis and assuming the rate of cholesterol influx is through human diet above the threshold of 300mg, and subject to some scoped boundary condition, solve the governing differential equation and carry out numerical simulation to investigate the impact of the resulting pertinent parameters on the flow profile using the scientific programming software Mathematica.

II. MATHEMATICAL FORMULATION

We consider the unsteady viscous, incompressible and electrically conducting blood flow through a stenosed arterial channel. The stenosis is assumed to be due to poor diet and excessive cholesterol laden meals that could easily increase the heart risk; we require little heat in the form of warm water after meal to take control of these fatty meals and cholesterol treatment drugs by stating the energy equation in dimensional form in the arterial channel as:

$$\rho c_p \frac{\partial T^*}{\partial t^*} = k_T \frac{\partial^2 T^*}{\partial y^{*2}} + Q_H \left(T^* - T_\infty\right) \tag{1}$$

The corresponding boundary conditions are as:

$$\left.\begin{aligned} T^* &= T_\infty \quad \text{at} \quad y^* = 0 \\ T^* &= T_w \quad \text{at} \quad y^* = R \end{aligned}\right\} \tag{2}$$

$$y^* = R_0 - \delta^* \cos 2\frac{\pi x^*}{\lambda} \tag{3}$$

We introduce the following non-dimensional conditions as:

$$\left.\begin{aligned} & y = \frac{y^*}{R_0}; w = \frac{w^*}{w_0}; t = \frac{tw_0}{R_0}; \theta = \frac{T^* - T_\infty}{T_w - T_\infty}; Pe = \frac{w_0 R_0 \rho c_p}{k_T}; \\ & Pr = \frac{\mu c_p}{k_T}; Rd = \frac{Q_H R_0^2}{\mu c_p}; x = \frac{x^*}{\lambda}; \delta^* = \frac{R_0}{R_T} \end{aligned}\right\} \tag{4}$$

After using equation (4) into equation (1), we obtain the following:

$$Pe\frac{\partial \theta}{\partial t} = \frac{\partial^2 \theta}{\partial y^2} + RdPr\theta \tag{5}$$

$$y = 1 - \frac{1}{R_T}\cos 2\pi x \tag{6}$$

where: $x = \frac{1}{\lambda}\left(d_0 + \frac{\lambda}{2}\right)$ (7)

With the corresponding boundary conditions are as:

$$\left.\begin{aligned}\theta &= 0 \quad \text{at} \quad y = 0\\ \theta &= 1 \quad \text{at} \quad y = h\end{aligned}\right\} \qquad (8)$$

III. METHOD OF SOLUTION

Since the temperature distribution is oscillatory due to the pumping rate of the heart, we assume the solution of equation (5) to take following form:

$$\theta = \theta_0 e^{i\omega t} \qquad (9)$$

Substitute equation (9) into the dimensionless equation (5) and equation (8), we obtain:

$$\frac{\partial^2 \theta_0}{\partial y^2} + \left(RdPr - Pei\omega\right)\theta_0 = 0 \qquad (10)$$

Subject to the boundary condition:

$$\left.\begin{aligned}\theta_0 &= 0 \quad \text{at} \quad y = 0\\ \theta_0 &= e^{-i\omega t} \quad \text{at} \quad y = h\end{aligned}\right\} \qquad (11)$$

Applying transformation $\xi = \frac{y}{h}$ into equation (10) and equation (11), they are reduced to the following:

$$\frac{\partial^2 \theta_0}{\partial \xi^2} + \beta_1 \theta_0 = 0 \qquad (12)$$

where: $\beta_1 = h\left(RdPr - Pei\omega\right)$

Subject to the corresponding boundary conditions:

$$\left.\begin{aligned}\theta_0 &= 0 \quad \text{at} \quad \xi = 0\\ \theta_0 &= e^{-i\omega t} \quad \text{at} \quad \xi = 1\end{aligned}\right\} \qquad (13)$$

Solving equation (12), we obtain the following homogenous solution:

$$\theta_0\left(\xi\right) = Acos\left(\sqrt{\beta_1}\xi\right) + Bsin\left(\sqrt{\beta_1}\xi\right) \qquad (14)$$

We solve equation (14) subject to the corresponding boundary conditions in equation (13) and obtain the solution:

$$\theta_0\left(\xi\right) = \frac{sin\left(\sqrt{\beta_1}\xi\right)}{sin\left(\sqrt{\beta_1}\right)} e^{-i\omega t} \qquad (15)$$

Substituting equation (15) into equation (9), we obtain the following:

$$\theta\left(\xi\right) = \frac{sin\left(\sqrt{\beta_1}\xi\right)}{sin\left(\sqrt{\beta_1}\right)} \qquad (16)$$

IV. RESULTS

The flow investigation has been carried out by studying the effect of individual factors like radiation parameter, Prandtl number, oscillatory parameter, treatment parameter and the Peclet number. The objective of the study is to investigate the role of the aforementioned parameters on blood temperature distribution. In addition, to study the influence of the pertinent parameters by formulating codes to simulation the analytical results in the previous section using the software called Mathematica 10, standard parameters values used are stated at the bottom of each graphical result.

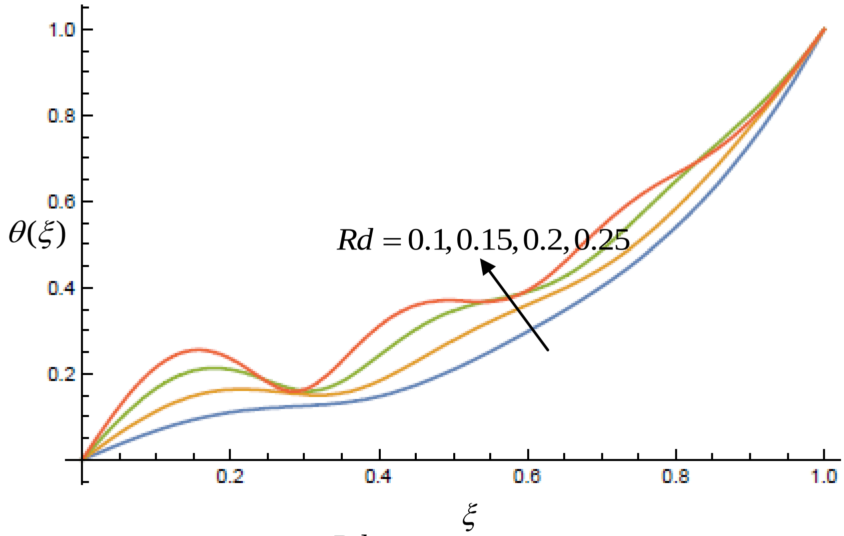

Fig 1 The effect of the increase in Rd on the temperature of the fluid, where other parameter values are taken as: $Pe = 2, Pr = 21, R_T = 0.05, \omega = 1.1, L_0 = 0.4$

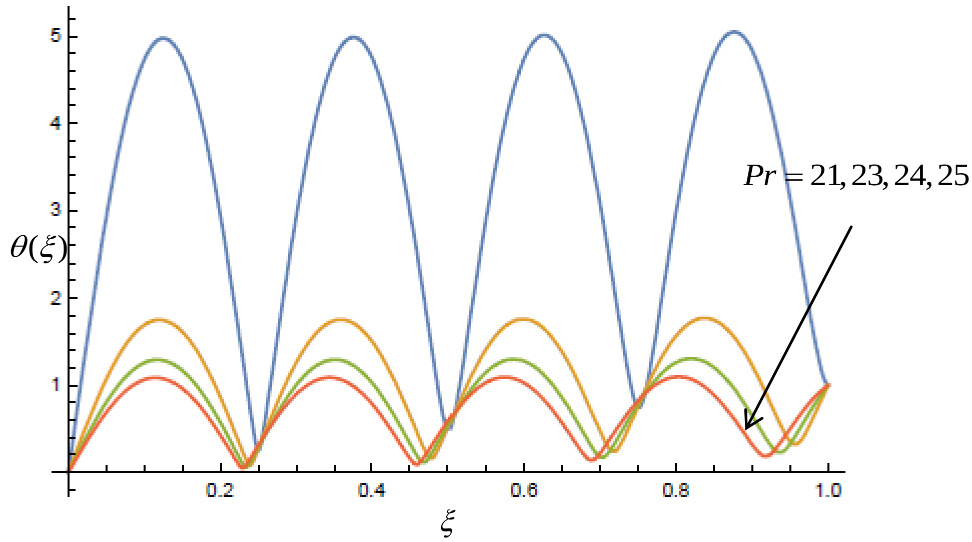

Fig 2 The effect of the increase in Pr on the temperature of the fluid, where other parameter values are taken as: $Pe = 2, Rd = 0.3, R_T = 0.05, \omega = 1.1, L_0 = 0.4$

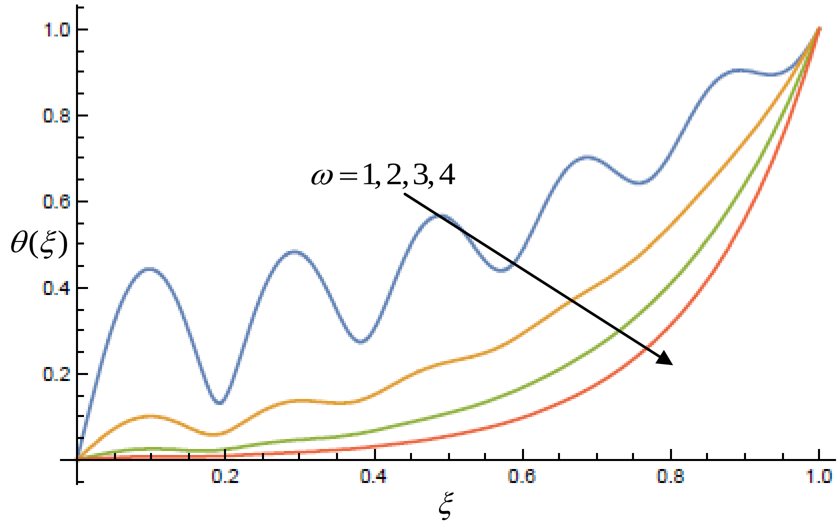

Fig 3 The effect of the increase in ω on the temperature of the fluid, where other parameter values are taken as: $Pe = 2, R_T = 0.04, Rd = 0.5, Pr = 21, L_0 = 0.4$

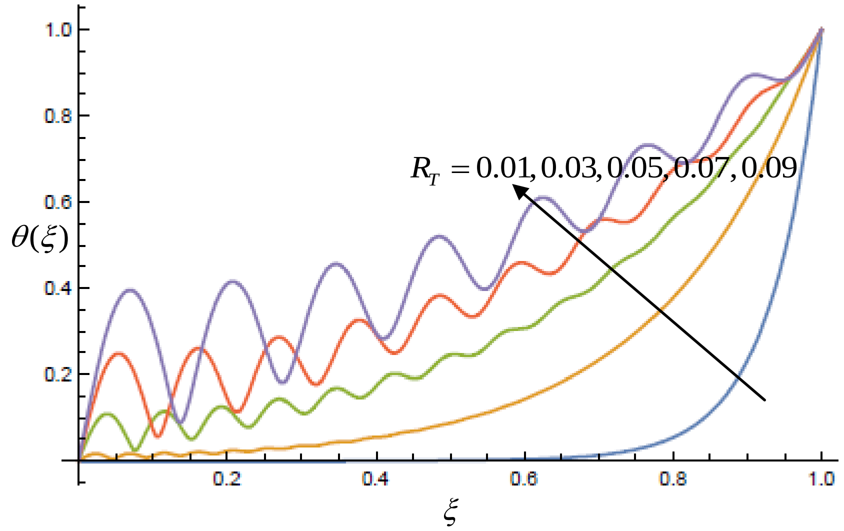

Fig 4 The effect of the increase in R_T on the temperature of the fluid, where other parameter values are taken as: $Pe = 2, Rd = 0.2, Pr = 21, \omega = 2.0, L_0 = 0.4$

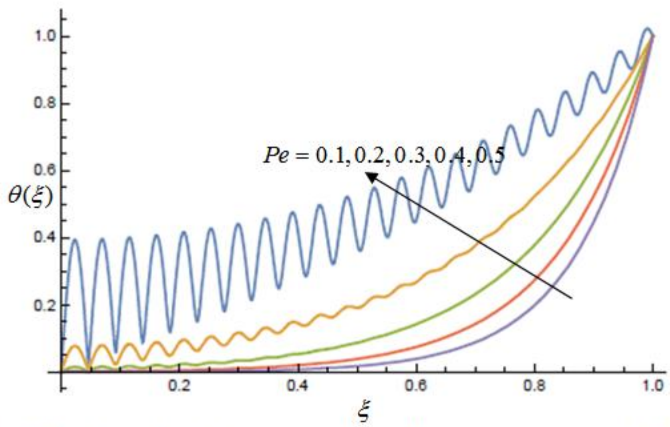

Fig 5 The effect of the increase in Pe on the temperature of the fluid, where other parameter values are taken as: $Pr = 21, R_T = 0.03, Rd = 0.2, \omega = 2, L_0 = 0.4$

V. DISCUSSION

The investigation the effect of the pertinent parameters on temperature profile was done firstly by solving the dimensionless equation analytically then scientific simulation using with the important parameter values with results shown in **Fig 1- Fig 5**.

It is seen that an increase in radiation parameter Rd caused a corresponding increase in temperature profile, as seen in **Fig 1**. As a matter of fact, blood temperature increase helps in the circulation of blood and deep heat treatment is another application of heat treatment of cancerous cell growth.

In **Fig 2** depicts a variation of Prandtl number. The simulated results showed that the temperature profile decreases as a result of an increase in Prandtl number. This is so because an increase in Prandtl number signifies reduction of fluid thermal conductivity of blood, thereby resulted in the Pr increase and decrease in temperature at the stenosed region. The oscillatory parameter effect on the fluid was also investigated and it is found in **Fig 3** that increase in the parameter could not create an increase in temperature changes leaving the other pertinent parameters.

Fig 4 illustrates that increasing the treatment parameter could lead to an increase in the distribution of temperature profile within the circulatory system. In addition, this increase is a result of the treatment of mile stenosis as a control measure for excessive cholesterol intake into the arterial segment. Finally, we noticed in **Fig 5** that increases in the Peclet number resulted to a corresponding increase in the temperature profile.

VI. CONCLUSION

The study of treatment and radiation effect on blood flow through a stenosed artery was investigated by formulating a mathematical model for the heat transfer was obtained for blood flow. The resulting governing equation was solved analytically. Various fluid parameters were introduced and used to study the influence of these parameters on the temperature distribution, here are the following findings:

(a) It is seen that with the appropriate geometry of the stenosed region defined, we were able use the geometry to study the impact of the heat radiation on the region.

(b) The research showed that the radiation parameter increase influenced the temperature distribution by increasing the rate of heat transfer in the arterial segment. The temperature increase helps in warming the area under investigation.

(c) The investigation showed the impact of the Prandtl number as seen in our results, increase in Prandtl number actually decrease the temperature, of course, this is in line with physical laws because the increase means reduction in fluid thermal conductivity which reduces the rate of heat transfer.

(d) The oscillatory parameter influenced the fluid temperature distribution to reduce on the stenosed region due to high rate of absorption.

(e) The treatment parameter influenced the temperature distribution because it helps in controlling the sedimentation of more waxy substances

(f) The Peclet number also affects the temperature distribution.

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NOMENCLATURE

y : The perpendicular distance

T^* : Dimensional temperature

T_∞ : Dimensional far field temperature

ρ : Blood density

k_T : Thermal conductivity

c_p : Blood specific heat capacity

Pe : Peclet number

Pr : Blood Prandtl number

λ, L_0 : Length of arterial segment

δ^* : Maximum height of stenosis

R_T : Treatment parameter

h : Boundary thickness

θ : Dimensionless temperature

θ_0 : Perturbed dimensionless temperature

t : Time parameter

ω : Oscillatory parameter

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