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Role of Electric Field Parameter on Blood Flow for Time-Dependent Heat and Mass Transfer Passing through a Diverging Artery

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Abstract

Time-dependent blood flow through diverging arterial segments involves complex interactions among hemodynamic, thermal, and mass-transfer processes under external forces. This study develops a mathematical model and numerical simulation of transient blood flow coupled with heat and mass transfer in a diverging artery, with particular emphasis on the effects of electric fields, velocity slip, and body acceleration. Blood is modeled as an electrically conducting fluid subjected to an external electromagnetic field. The governing partial differential equations for momentum, energy, and concentration are solved using an implicit finite-difference scheme implemented in MATLAB. The electric-field parameter is examined in relation to electro-osmotic and Lorentz forces that regulate flow velocity and temperature distributions. A velocity-slip boundary condition is incorporated to represent nonzero fluid velocity at the arterial wall and its effects on the shear rate and near-wall temperature field. Body acceleration is also considered to simulate external vibrations, physiological effects, and inertial forces associated with sudden movement. The numerical results indicate that increasing the electric-field intensity and velocity-slip parameter elevates the velocity profile and volumetric flow rate, thereby enhancing flow regulation. Body acceleration increases both quantities by modifying the pressure gradient while producing pronounced transient oscillations in axial velocity and the skin-friction coefficient. These findings clarify the combined roles of electromagnetic forcing, wall slip, and body acceleration in transient arterial transport and may inform the development of electrohydrodynamic drug-delivery systems and thermal-management strategies for diverging arterial geometries.

Keywords: Blood Flow; Body Acceleration; Diverging Artery; Electric Field; Velocity Slip

Introduction

Electric field is defined to be a region of space where a body carrying electric charge experiences a force of electric origin which can simply be a region of space where an electric charge placed in that space experiences a force. The study of electric fields in blood flow with stenosis helps to understand how electrical forces affect blood cells and flow motions. It improves medical treatment for blocked arteries and tumor cells treatment, design better heart devices and help clear fatty deposits using electric charges leading to a generated fluid flow by applying electric field resulting to an electrically driven flow. Hussain et al. (2025). Effect of electric field have been investigated extensively in the lat two decades due to its applications in biomedical engineering. Akram et al. (2023), investigated the effect of electric field of Sutterby blood flow graphene oxide nanofluid model flowing through capillary and delineated the behavior of nanofluid velocity in the presence of electric field parameter where a negative velocity corresponds to a situation when electric field is applied in the direction of the peristaltic wave. A rise in negative U means that the strength of externally applied electric field is increased which produces a rapid of ionic species in the fluid. However, increasing electric field parameter increases the axial velocity. Hussain et al. (2025) studied the irreversibility analysis and electro-thermal effect of an unhealthy artery which elucidated the impact of electro-osmotic effect on velocity and this shows increasing higher value of electric field parameter increases velocity profile contrary to the thickness of electric double layer as seen by the relationship between it and Debye length D. The velocity outline upsurges as a result of the decrease in EDL thickness or the growing value of electric field parameter. This reaction is caused by the decline in the electric double layer width, which increases electroosmotic powers and decreases fluid drag leading to a significant amount of fluid flow quickly at the channel axis with respect to the charged surface. Yadav and Singh (2025) studied the rule of electric field on non-Newtonian hybrid nanofluid with hematocrit through a porous overlapping stenosed artery. It was found that, increasing electric field from 0 to 1 a significant reduction in flow resistance was seen due to reduction in thickness of the electric double layer (EDL), which elevates the flow of blood, leading to the reduction in flow resistance.

Blood flow in human circulatory system is caused by the pumping action of the heart as established by many researchers, medical practitioners and clinicians. The heart is the fundamental organ in human and animals, which produces a pulsatile pressure gradient throughout the system. Blood is carrier of drug to tumor cell membrane which becomes the cause of chemical reaction between tumor and the flowing fluids.

The study of blood through arteries is very important because of the fact that many cardiovascular diseases are closely related to the nature of blood movement and the dynamic behavior of blood vessels with many lives loss due to various kind of cancers, Tripathi et al, (2021b) and Kumar et al. (2021). Atherosclerosis or stenosis has been a primary cause of death in various nations. According to the World Health Organization (WHO, 2018), reports that, almost 31% of the world's population is affected by cardiovascular diseases. Some of the diseases include coronary artery disease, hypertension, arrhythmias, congenital heart disease, peripheral heart disease, cardiomyopathy, rheumatic heart disease, aortic aneurysm and dissection all can be life-threatening for human beings. The deposition of low-density lipoprotein and cholesterol inside the lumen which hardens the artery is termed atherosclerosis. So also, the constriction of an artery due to the plague accumulation is referred to as stenosis. Yadav & Singh, (2025).

Many researchers have considered blood flow problem with stenosis. Ellahi *et al*, (2013), investigated the effects of permeable walls along with slip in blood flow problems with nanoparticles through a composite stenosed artery. The non-dimensional governing equations, considering the case of mild stenotic condition, was solved using homotopy perturbation method (HPM). Tripathi *et al* (2022), investigated the unsteady magnetohydrodynamic blood flow of a power law fluid model comprising two stenoses composite and irregular in the presence of copper nanoparticle using explicit finite difference method. It was disclosed that inclusion of nanoparticles (Cupper), Darcy parameter, thermal buoyancy increases the axial velocity of blood flow while increasing external magnetic field in the radial direction, axial velocity is significantly damped.

Chemical reaction is basically the process where one or more substances(reactants) transformed into new substances(products). The flow of chemically reacting fluid have significant technological applications. Blood is a complex mixture of plasma, proteins, cells and other chemicals. An increment in plasma concentration of reactants occurs due to injection of drugs, hormones and metabolism, Zigta (2020). Chemical reactions on blood flow can cause the blood vessels to constrict or dilate by either reducing the diameter of blood vessels leading to decreased in blood flow or increasing the diameter of blood vessels leading to increase in blood flow. These changes in blood vessel diameter can occur due to the release of substances like neurotransmitters, hormones, or local factors such as PH or temperature changes. Generally, chemical reaction plays crucial roles in regulating blood flow through various mechanisms such as vascular tone, clotting, inflammation, oxygen transport metabolic regulation and PH balance. Any disruption in these processes leads to abnormalities in blood flow, Danish et al, (2021). Many researchers have shown great concern on the effect of chemical reactions in blood flow due to its applications in plasma physics, for the last few decades. Researchers like, (Hayat et al,2020; Zigta, 2020; Qayyum et al, 2023), Investigated the effect of chemical reaction and thermal radiation on MHD blood flow of a stretching permeable vessel with time dependent magnetic field intensity. By the use of similarity transformation, the governing partial differential equations was transformed to ordinary differential equation and solved numerically. It was observed from the graph that, as the chemical reaction parameter increases, the concentration of blood flow decreases. Physiologically, it shows that, higher value of chemical reaction parameters results in a decrement of molecular diffusivity which directly decreases the concentration of blood. Isah et al, (2023), Investigated the effect of chemical reaction and thermal radiation on MHD flow, heat and mass transfer over a stretching porous medium. The governing partial differential equations of the flow was transformed to a system of nonlinear ordinary differential equation using similarity transformation and solved using an efficient numerical technique known as Keller Box method. It was observed that, an increase in concentration profile leads to the increase in the value of thermophoresis parameter whereas an opposite trend was observed with increase in the value of chemical reaction parameter, Brownian motion parameter.

Activation energy is a critical threshold that must reached for a chemical reaction to occur. It represents the minimum energy required for the reactants to form products and can be found in the form of kinetic energy or potential energy. Without this energy, the reaction cannot proceed. Activation energy finds diverse applications in various fields such as geothermal engineering, chemical engineering, oil emulsions and food processing. This also finds applications in health science in the context of blood flow because it influences blood flow by affecting the rate of chemical reaction which in turn can alter blood properties like viscosity and temperature, or influences nutrient transport within the blood, Borah et al (2023). In recent years, several researchers have explored their research on the influence of Arrhenius activation energy in boundary layer flow, particularly in the context of non-Newtonian fluid flow consisting different physical aspects. Devi et al, (2022), studied the impact of various factors including thermal radiation, buoyancy force, chemical reaction and activation energy on the behavior of MHD nanofluid flow past a vertically stretching surface. Babu et al, (2022), Examined the effect of second order chemical reaction on steady two-dimensional MHD Casson fluid model of an electrically conducting stratified porous medium over an exponentially stretching sheet. The transformed non dimensional ordinary differential equations were solved Via BVP4c method, the emerging parameters were obtained graphically. Irfan et al, (2018), Investigated the impact of Arrhenius activation energy by utilizing the properties of nonlinear mixed convection and binary chemical reaction of a time dependent Carreau nanofluid model. The partial differential equations were transformed to ordinary differential equation using similarity transformation and elucidated graphically Via bvp4c method.

In biomedical engineering and computational fluid dynamics (CFD) simulations of cancer therapies, the **slip parameter** and **body acceleration** are critical variables used to model and optimize targeted drug delivery and thermal treatments (such as hyperthermia)

The Slip Parameter (Velocity Slip), blood at the vessel wall is modeled using a "no-slip" condition (velocity is zero at the wall). However, micro vessels feeding a tumor are highly abnormal, porous, and lined with leaky endothelial gaps. To reflect this reality, researchers introduce a velocity slip parameter at the boundary due to its wide applications in biomedical engineering.

Slip velocity causes an increment in blood velocity and a decrement in skin friction. It is significant in cancer treatment to increase the heat transfer rate at targeted cancerous cells.

Increasing the slip velocity allows therapeutic fluids and suspended nanoparticles to overcome wall friction. This prevents the localized stagnation of drugs and promotes smoother, faster penetration deeper into the constricted tumor feeding vessels.

Minimizing Wall Shear Stress (WSS)**,** high viscosity and friction can damage blood vessels or cause premature drug release, the wall shear stress decreases significantly with the application of slip velocity.

Body acceleration refers to external periodic forces acting on the entire biological system such as vibrations, physical movement, or targeted magnetic/gravitational forces.

The involvement of body acceleration influences the volume of medication concentration and potency in the supply of blood. Pumping Drugs Through Structural Barriers: Tumors often create high interstitial fluid pressure (IFP) which acts as a barrier, stopping passive nanodrugs from exiting the bloodstream. Introducing periodic body acceleration elevates the axial blood velocity and volumetric flow rate. This pushes therapeutic elements through narrow, constricted, or partially blocked tumor vessels. Improving Solute Dispersion, in a steady state, drugs may travel down the center of a blood vessel and bypass the tumor wall entirely. Body acceleration disrupts this laminar pattern by adding a secondary oscillatory motion. This distributes the medicine laterally, driving it closer to the leaky vessel walls where it can cross into the cancer tissue via the Enhanced Permeability and Retention (EPR) effect.

In view of the above literatures with a particular reference to the work of Kumar et al. (2021) as the base paper of the present research work, electric field in the presence of slip parameter and body acceleration effect has to the authors knowledge not been considered anywhere in biomedical engineering.

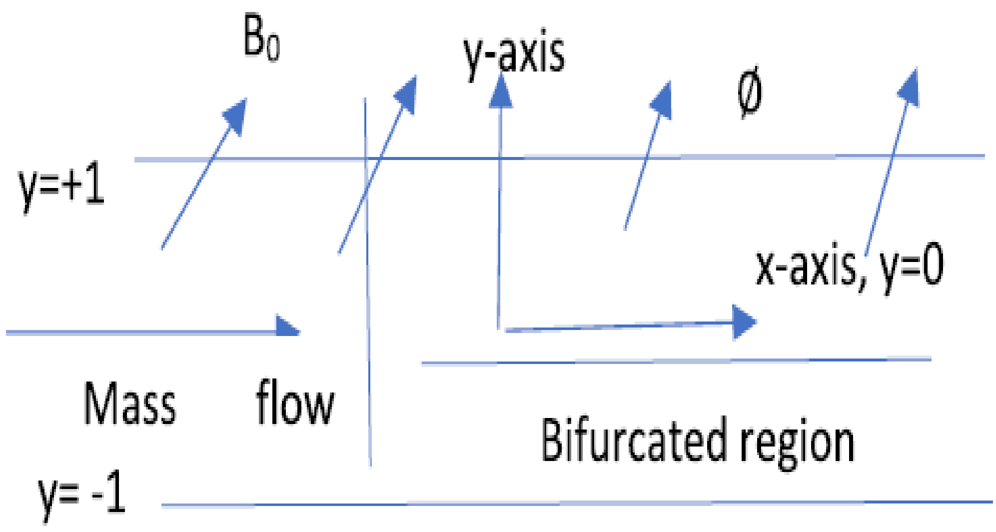

Figure 1: Geometry of the bifurcated artery

Schematic diagram of bifurcated channel in the presence of slip condition

Mathematical formulation

In the mathematical point of view following assumptions are made. Considering blood to be a Newtonian fluid model, Incompressible, homogeneous and viscous fluid flowing in a non-conducting parallel plate channel in such away that the flow is from trunk to branches. The rate of mass flow at any cross-section perpendicular to the direction of flow is $m = 2b\,V$. Where V is the mean velocity of the flow, b is the diameter and ρ is the blood density. The bifurcating wall is negligibly small to have the rate of mass flow at any cross section of branched channel as $m/2$ (see figure 1).

In the present work, magnetic field is applied at an angle φ to the flow such that produced induced magnetic field and electric field by blood flow are considered to be negligible as the magnetic Reynolds number $R = \rho\vec{v}b/$ consider is low. Angle of bifurcation is considered to be zero, so blood flow region is bifurcated in two streams parallel to the large artery. Blood viscosity is constant ignoring the Fahreu-Lindquist effect and Roah. See Kumar et al. (2021).

Basic equations of motion and solutions

Blood flow through a porous medium under magnetic field and heat and mass transfer is considered under the assumption of two-dimensional boundary layers. Let U^* *and* V^* be the velocity components in x^* *and* y^* direction respectively at time t in the flow field, ρ *and* η to be the density and viscosity of the blood, p be the pressure. K_T is define to be the thermal conductivity of the of the fluid, C_p is the specific heat capacitance at constant pressure, Q is the amount of the heat, T is the temperature, β is the volumetric expansion parameter, φ is the angle of inclination of applied magnetic field, θ is the temperature distribution, K is the Darcy parameter, us is the slip parameter and $B2$ is the body acceleration parameter.

$$\frac{\partial U}{\partial t} + \frac{1}{\rho}\frac{\partial p}{\partial t} = \frac{\eta}{\rho}\frac{\partial^2 U}{\partial y^2} + \beta Gr(T - T_\infty) + \beta' Gc(C - C_\infty) - \frac{\sigma B_0^2 \sin^2\varphi}{\rho}U - \frac{1}{K}U + G(t) + \rho_e E_x \quad (1)$$

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0 \quad (2)$$

$$\frac{\partial T}{\partial t} = \frac{K_T}{\rho C_p}\frac{\partial^2 T}{\partial y^2} + \frac{Q}{\rho C_p}(T - T_\infty) - \frac{\partial q}{\partial y} \quad (3)$$

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial y^2} - Kc(C - C_\infty) \tag{4}$$

Where $\frac{\partial q}{\partial y}$ is taken to be the radiative heat flux. In the blood vessel, $T \ and \ T_\infty$ are enough high and their difference is manageable to induce radiative heat transfer. $q = \frac{16\sigma T_0^3}{3k}\frac{\partial T}{\partial y}$, where k' is the Roselands mean absorption coefficients, σ is the Stefan-Boltzmann constant, $G(t)$ is the dimensional body acceleration and D is the diffusion coefficient.

All these are subject to the initials and boundary conditions as follows:

$$U(y,t) = 0, T(y,t) = 0, C(y,t) = 0 \text{ at } t = 0 \tag{5}$$

$$\frac{\partial U(y,t)}{\partial y} = 0, \frac{\partial T(y,t)}{\partial y} = 0, \frac{\partial C(y,t)}{\partial y} = 0 \text{ at } y = -1 \tag{6}$$

$$U(y,t) = u_s, T(y,t) = 0, C(y,t) = 0 \quad \text{at } y = 1 \tag{7}$$

The non dimensional governing equations of motion are as follows:

$$\left.\begin{aligned} & x = \frac{\bar{x}}{b}, U = \frac{\bar{U}}{m/2b\rho}, h(x,t) = \frac{(d\bar{p}/d\bar{x})}{(\eta m/2b^3\rho)}, K = \frac{\bar{K}}{\left(\frac{b^2\rho}{\eta}\right)}, \phi = \frac{\bar{C}\left(2b^3\rho^2\right)}{m\eta} \\ & \tau = \frac{\eta}{\rho}, y = \frac{\bar{y}}{b}, V = \frac{\bar{V}}{\frac{m}{2b\rho}}, \theta = \frac{\bar{\theta}\left(2b^3\rho^2\right)}{m\eta} \end{aligned}\right\} \tag{8}$$

The non-dimensional governing equation of motion for continuity, momentum, energy and concentrations are as follows:

$$\frac{\partial U}{\partial t} + h = \frac{\partial^2 U}{\partial y^2} + \beta Gr\theta + \beta' Gc\phi - M^2\sin^2\varphi U - \frac{1}{K}U + B2\cos(c1t) + ke^2\left(\psi_w \frac{\cosh(key)}{\cosh(keH)}\right) \tag{9}$$

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0 \tag{10}$$

$$\frac{\partial \theta}{\partial t} = \left(\frac{1}{\tau \Pr} + R\right)\frac{\partial^2 \theta}{\partial y^2} + \frac{S}{\tau \Pr}\theta \tag{11}$$

$$\frac{\partial \phi}{\partial t} = \frac{1}{Sc}\frac{\partial^2 \phi}{\partial y^2} - Kr\phi \quad (12)$$

Where $S = \frac{Qb^2}{K_T}$, is the heat source parameter, $\Pr = \frac{\rho C_p}{K_T}$ is the Prandtl number, $M^2 = \frac{kn}{\sigma b^2}$, is the magnetic field parameter, $R = \frac{16\sigma T_0^3}{3k'\tau}$, is the radiation parameter, $K = \frac{kn}{\sigma b^2}$, is porous medium parameter, $Sc = \frac{\tau}{bD}$, is the Schmidt number and $Kr = \frac{Kcb^2}{\tau}$ is the chemical reaction parameter.

Electric field applied

The electric field applied along the axial direction of the hybrid nanofluid flow generates an electric body force $(\rho_e E_x)$, resulting in the formation of an electric double layer (EDL) near the walls. This leads to the development of an electrical charge density (ρ_e) for an electrolyte in an equilibrium $(Z_+ = Z_- = Z_0)$ which is expressed as:

$$\overline{\rho}_e = \overline{Z}_0 \overline{e}_0 (\overline{n}_+ - \overline{n}_-) \quad (13)$$

See Yadav and Singh (2025).

The emerging parameter such as Z_0 stands for charge balance, e_0 stands for electric charge, n_+ *and* n_- stands for cation and anion respectively. The Boltzmann distribution when no electric double layer overlaps are expressed as

$$n_{\pm} = n_0 \exp\left(\mp \frac{\overline{Z}_0 \overline{e}_0 \overline{\psi}}{T_0 K_b} \right) \quad (14)$$

Where T_0 is the mean temperature, K_b is the Boltzmann constant and n_0 is the density of ions in the electrolytes. The poison equation which holds the relation between the potential distribution (ψ) and net volume charge (ρ_e) is expressed as

$$\nabla^2 \overline{\psi} = \frac{\partial^2 \overline{\psi}}{\partial \overline{x}^2} + \frac{\partial^2 \overline{\psi}}{\partial \overline{y}^2} = \frac{-\rho_e}{\varepsilon_1} \quad (15)$$

Where ε_1 is the dielectric constant. Hence, the Boltzmann equation together with the boundary condition and the net charge density.

$$\left.\begin{aligned} \psi = \psi_w \ \ at \ \ y = H \\ \frac{\partial \overline{\psi}}{\partial y} = 0 \quad at \quad y = 0 \end{aligned}\right\} \tag{16}$$

By linearizing the Boltzmann and using the Debye-Huckell parameter or by Debye-Huckel linearization principle, the poison Boltzmann equation is expressed as

$$\frac{\partial^2 \overline{\psi}}{\partial \overline{y}^2} = \frac{-\rho_e}{\varepsilon_1} = \frac{\overline{K} e^2 \overline{\psi}}{\varepsilon_1} \tag{17}$$

From equation (17), We have

$$\frac{\partial^2 \overline{\psi}}{\partial \overline{y}^2} = \frac{2Z_0 e_0 n_0}{\varepsilon_1} \sinh\left(\mp \frac{Z_0 e_0 \overline{\psi}}{T_0 K_b} \right) \tag{18}$$

$$\Rightarrow \frac{\partial^2 \overline{\psi}}{\partial \overline{y}^2} = \frac{2Z_0^2 e_0^2 n_0}{\varepsilon_1 T_0 K_b} \tag{19}$$

The Debye length parameter (λD) is use to define the characteristics thickness of the electric double layer (EDL) and it is given as

$$\lambda D = \sqrt{\frac{\varepsilon_1 T_0 K_b}{2Z_0^2 e_0^2 \overline{n}_0}} = (K)^{-1} \tag{20}$$

$$\Rightarrow \frac{\varepsilon_1 T_0 K_b}{2Z_0^2 e_0^2 \overline{n}_0} = \frac{1}{K^2} \tag{21}$$

$$\Rightarrow K^2 = \frac{2Z_0^2 e_0^2 \overline{n}_0}{\varepsilon_1 T_0 K_b} \tag{22}$$

$$\Rightarrow \frac{\partial^2 \overline{\psi}}{\partial \overline{y}^2} = K^2 \psi \tag{23}$$

Considering the boundary conditions as follows

$$\left.\begin{aligned} \psi &= \psi_w \ \ at \ \ y = H \\ \frac{\partial \psi}{\partial y} &= 0 \quad at \quad y = 0 \end{aligned}\right\} \tag{24}$$

Where ψ_w represents the zeta potential of the vessel wall. The nondimensional parameter of Debye-Huckel is expressed as $Ke = R_0 K$. The distributions of electrical potential may be systematically expressed as $\psi' = \frac{\overline{\psi}}{\psi_w}$

The simplified poison-Boltzmann equation is simplified using Debye- Huckell approximation under the assumption that potential energy is minimal in comparison to the thermal energy. We therefore in this work apply the electric field of small intensity and use the Debye-Huckell linearization $\left(\sinh\left(\frac{Z_0 e_0 \psi}{T_0 K_b}\right) \cong \frac{Z_0 e_0 \psi}{T_0 K_b}\right)$, assuming that, the electric potential energy is low in comparison to the thermal energy that is $\left|Z_0 e_0 \psi\right| \le \left|T_0 K_b\right|$. Thus, the transformed poison-Boltzmann equation in dimensionless forms along with the boundary conditions are

Subject to the boundary conditions

$$\therefore \frac{\partial^2 \psi}{\partial y^2} = K_e^2 \psi \tag{25}$$

$$\text{Hence, } \psi(y) = \psi_w \frac{\cosh(ky)}{\cosh(kH)} \tag{26}$$

$Ke = \frac{R_0}{\lambda D}$ establishes the relationship between artery radius and the diffusion layer which influences electrokinetic effects.

Method of solution

Due to the complications of the model equations, we intend to obtain the solution of these equations via Numerical technique, implicit finite difference scheme forward in time and central in space which is reliable and easy to implement. Implicit method offers great advantage on the stability of the finite difference scheme equations since most are unconditionally stable, a larger step size in time is permitted. However, the selection of larger time step is limited due to accuracy consideration because an increase in time step will increase the truncation error of the finite difference equation. Therefore, the partial differential equations would be addressed numerically using implicit finite difference scheme using known values of U, θ and ϕ at grid point $t = 0$ and reducing the solution to tri-diagonal matrix, we shall obtain temperature and concentration fields at time $t_{i+1} = t_i + \delta t$ using the known values of the previous time $t = t_i \ \forall i = 1, 2, ..., M-1$. Then the velocity field is evaluated using the already known value of temperature and concentration field obtained at $t_{i+1} = t_i + \delta t$. This continues repeatedly until the required solution for U, θ and ϕ converges. See (Hoof-Man and Chiang, 2000; Yabo et al. 2016; Hamza et al. 2022).

$$\frac{\partial U}{\partial y} = \frac{U_{i+1}^{j} - U_{i-1}^{j}}{2\delta y} \tag{13}$$

$$\frac{\partial^2 U}{\partial y^2} = \frac{U_{i+1}^{j+1} - 2U_i^{j+1} + U_{i-1}^{j+1}}{(\delta y)^2} \tag{14}$$

$$\frac{\partial U}{\partial t} = \frac{U_i^{j+1} - U_i^{j}}{\delta t} \tag{15}$$

Validation of Numerical Results

To validate the accuracy and reliability of the numerical scheme employed in the present study, the obtained results from the implicit finite difference scheme (IFDS) are compared with the numerical findings reported by Kumar et al. (2021). The comparison is carried out for the axial velocity profile relaxing all the incorporated parameters to zero and other parameter constant, which proven to have an element of agreement in comparison with the based paper. This has shown the correctness and efficiency of the method employed and the code adopted.

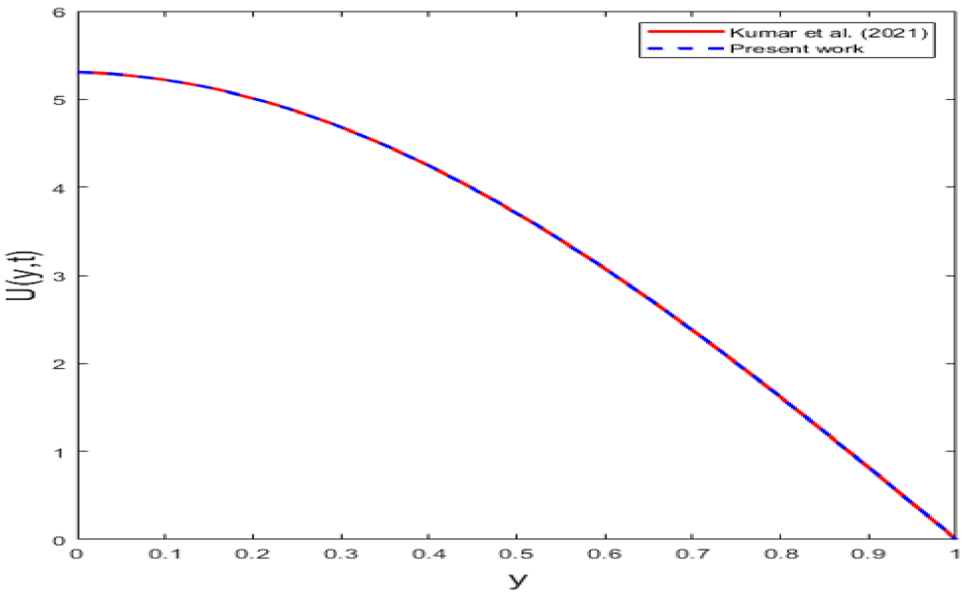

Figure 2; Graph validation against Kumar et al. (2021)

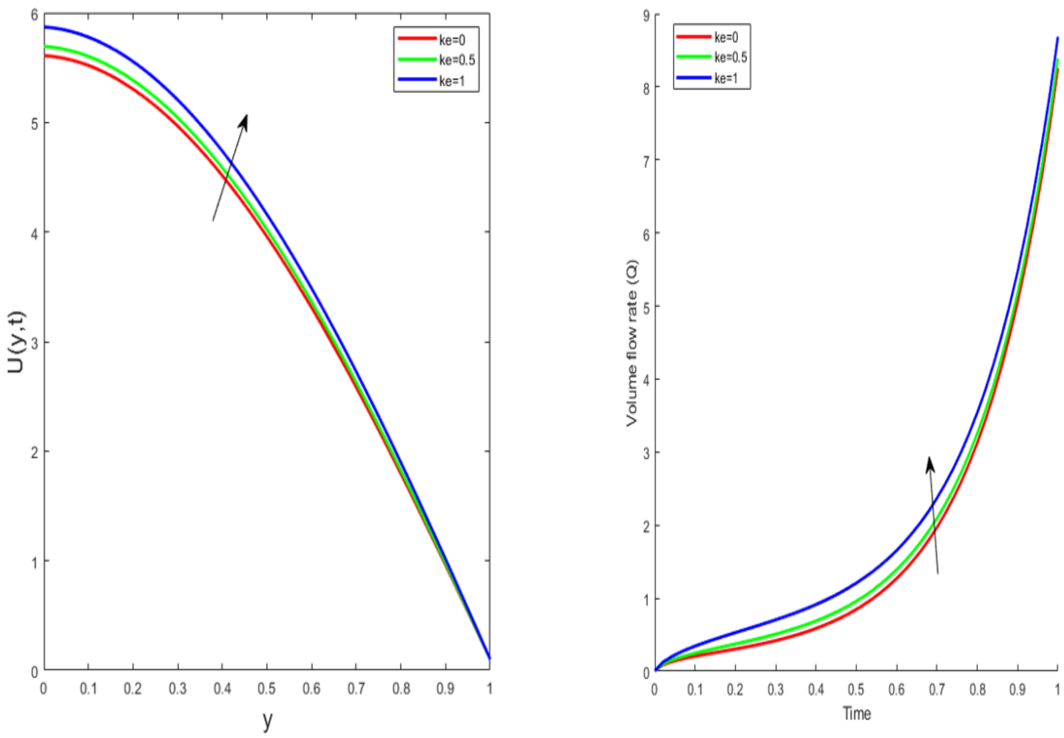

Figure 3: electric field effect on axial velocity and volumetric flow rate

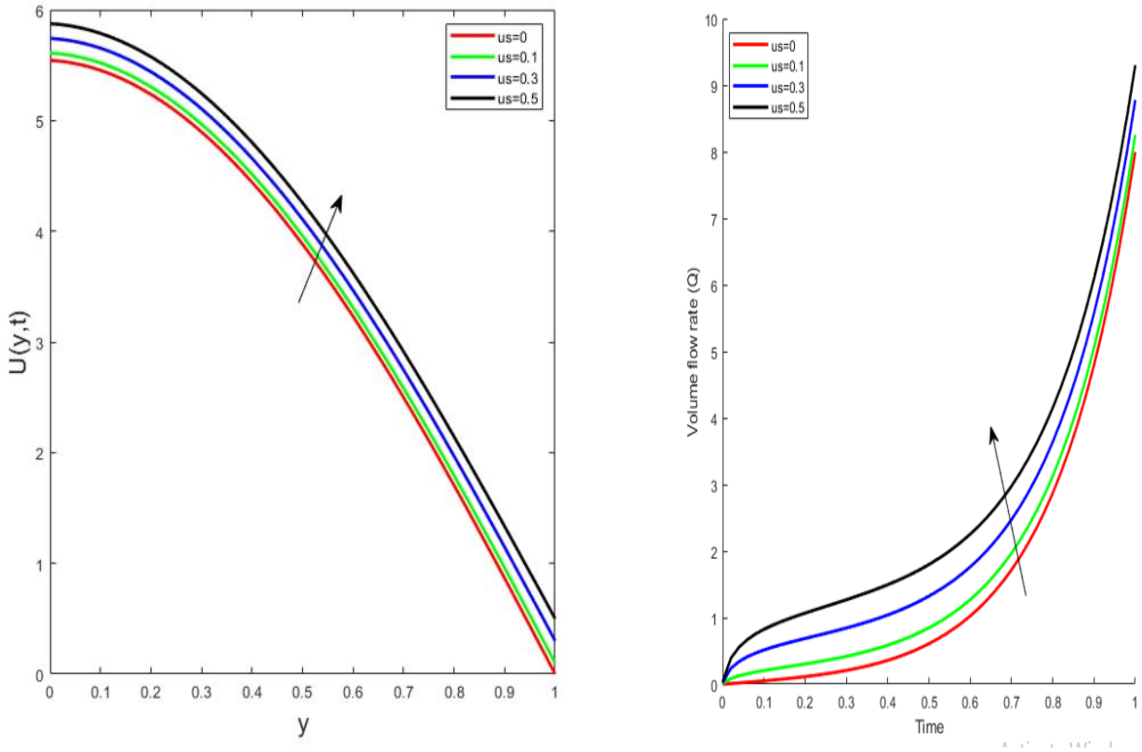

Figure 4; effect of slip parameter on axial velocity and volume flow rate

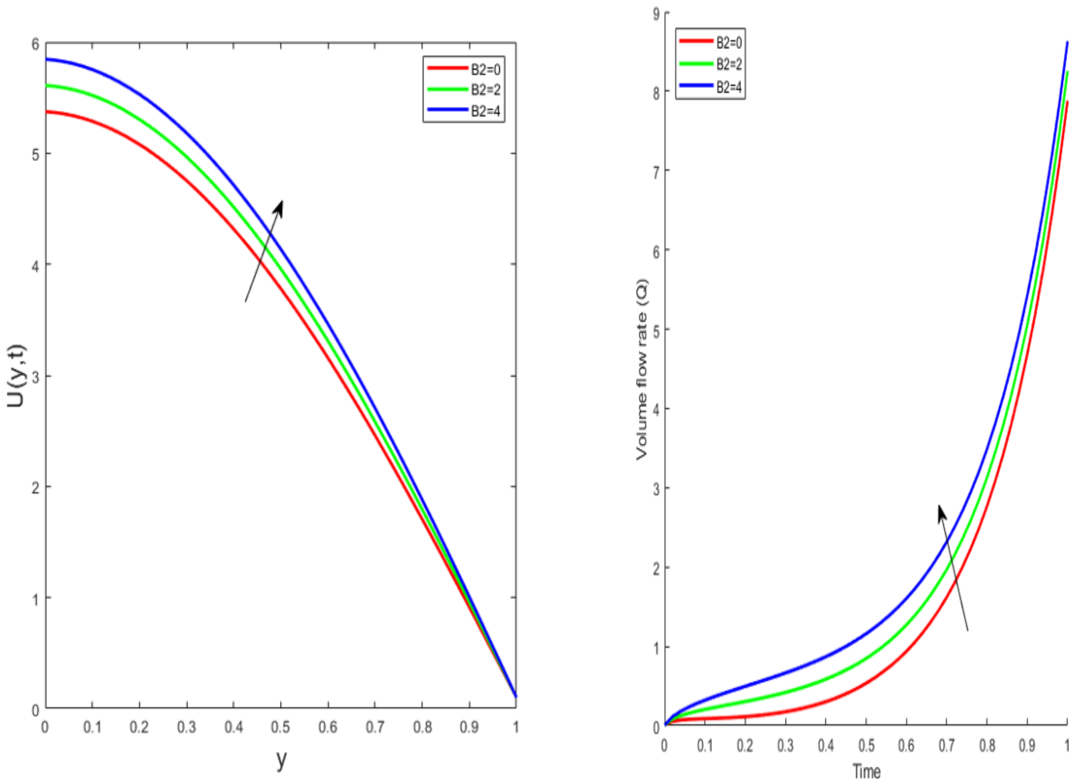

Figure 5; impact of body acceleration on axial velocity and volume flow rate

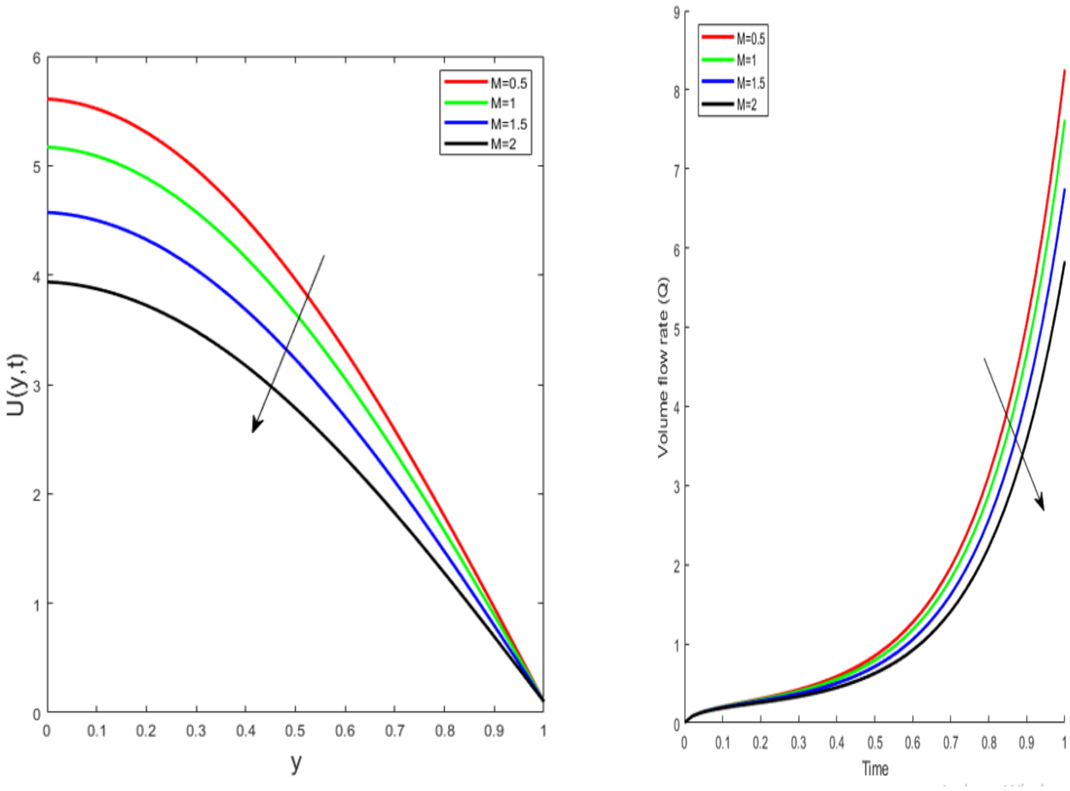

Figure 6; role of magnetic field on axial velocity and volume flow rate

Results and Discussions

The present work has been caried out to delineate on combine administration of some impacts of blood flow behavior flowing through a carotid artery, which responsible for tumor treatments and blood pressure problems. Several researchers studied numerical results for axial velocity, normal velocity, skin friction, temperature field and concentration profile. Hence, the results for different parameters are obtained for slip parameter and body acceleration effect on axial velocity and volumetric flow rate in the presence of an inclined magnetic field.

Figure 3: increase in electric field parameter increases both axial velocity and volume flow rate. The velocity outline upsurges as a result of the decrease in EDL thickness or the growing value of electric field parameter. This reaction is caused by the decline in the electric double layer width, which increases electroosmotic powers and decreases fluid drag leading to a significant amount of fluid flow quickly at the channel axis with respect to the charged surface

Figure 4, explored on the effect of slip parameter on axial velocity and volume flow which exhibits that on increasing these parameters it increases both axial velocity and volume flow rate due to a decrease frictions, resistance flow and shear-stress at the blood vessel wall.

Figure 5: increase in body acceleration parameter increases both axial velocity and volume flow rate because its increase alters pressure gradient which significantly upsurges the flow behavior.

Figure 6: demonstrates that a stronger magnetic field (M), associated with an increased Lorentz drag force, significantly retards blood flow. This phenomenon has applications in surgical blood control and treating arterial diseases like atherosclerosis and cancer treatment. The effect arises because hemoglobin contains ferrous ions (Fe2+) that interact with the Lorentz force opposing the flow direction, effectively increasing blood viscosity and slowing its velocity and volume flow rate.

Conclusion

The present study focuses on the impact of electric field parameter in the presence of slip parameter and body acceleration which serve as a yardstick for cancer treatment. In biomedical engineering and computational fluid dynamics (CFD) simulations of cancer therapies, the slip parameter and body acceleration are critical variables used to model and optimize targeted drug delivery and thermal treatments (such as hyperthermia)

Increasing electric filed parameter increases both axial velocity and volumetric flow rate. The Slip Parameter (Velocity Slip), blood at the vessel wall is modeled using a "no-slip" condition (velocity is zero at the wall). However, micro vessels feeding a tumor are highly abnormal, porous, and lined with leaky endothelial gaps. To reflect this reality, researchers introduce a velocity slip parameter at the boundary due to its wide applications in biomedical engineering.

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