

A Non-Newtonian Mathematical Model For Two Phase Hepatic Mean Blood Flow Using Herschel Bulkley Law In Hepatic Arterioles With Special Reference To Hepatitis B

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ABSTRACT: In this investigation, we are considering the two phased Mean Hepatic blood flow in arterioles, keeping in view the nature of Hepatic circulatory system in human being. P.N. Pandey and V. Upadhyay have considered that the blood flow has two phased, one of which that of red blood cells and other is plasma. They have also applied the Herschel Bulkley Non-Newtonian model in Bio- fluid mechanical setup. We have collected a clinical data in case of Hepatitis B for Hematocrit versus blood pressure. The graphical presentation for a particular parametric value is very close to the clinical observation. Using experimental values of the parameters, the flow rate for normal and diseased blood arterioles has been computed and compared with corresponding values obtained from a well known experimentally tested model in the literature. The role of Hematocrit is explicit in the determination of blood pressure in the case of Hepatic disease special reference to Hepatitis B. The graphical presentation for particular parametric value is much close to the clinical observation. The overall presentation is in tensorial form and the solution technique adopted is analytical as well as numerical.

KEYWORDS: Liver microcirculation, Hepatic Blood Flow, Hematocrit, rouleaux-structure, , Herschel Bulkley Non-Newtonian model.

I. INTRODUCTION (DESCRIPTION OF BIO- PHYSICAL PROBLEM)

The **Liver** is a most vital organ of vertebrates and some other animals.^[1] The liver is one of the largest and anatomically and functionally most complex organ of the human body. The liver constitutes 2.5% of the human body weight and is the largest organ in the body.^[2,3]

In the human it is located in the upper right quadrant of the abdomen, below the diaphragm. It is a reddish brown in the body with four lobes of unequal size and shape. These are right lobe, left lobe, quadrats and caudate lobe. A human Liver is normally weight 1.44-1.66 kg. Liver lobes are surrounded by a thick capsule, mostly overlaid with reflected periferinum^[4]

The liver has a wide range of functions, including detoxification of various metabolites and toxic matter, regulation of glycogen storage, decomposition of red blood cells, , hormone production and the production of biochemical's necessary for digestion.^[5] The liver breaks down ammonia into urea as part of the urea cycle, and the urea is excreted in the urine.^[6] The liver is the only human internal organ capable of natural regeneration of lost tissue; as little as 25% of a liver can regenerate into a whole liver.^[7]

The liver has the most complicated circulation of any organ. According to the anatomical peculiarity of the double afferent blood supply of the liver, 75% - 80% of the blood entering the liver is partially deoxygenated venous blood

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

supplied by the portal vein, which collects all the blood that leaves the spleen, stomach, small and large intestine, gallbladder and pancreas. ^[8,9]

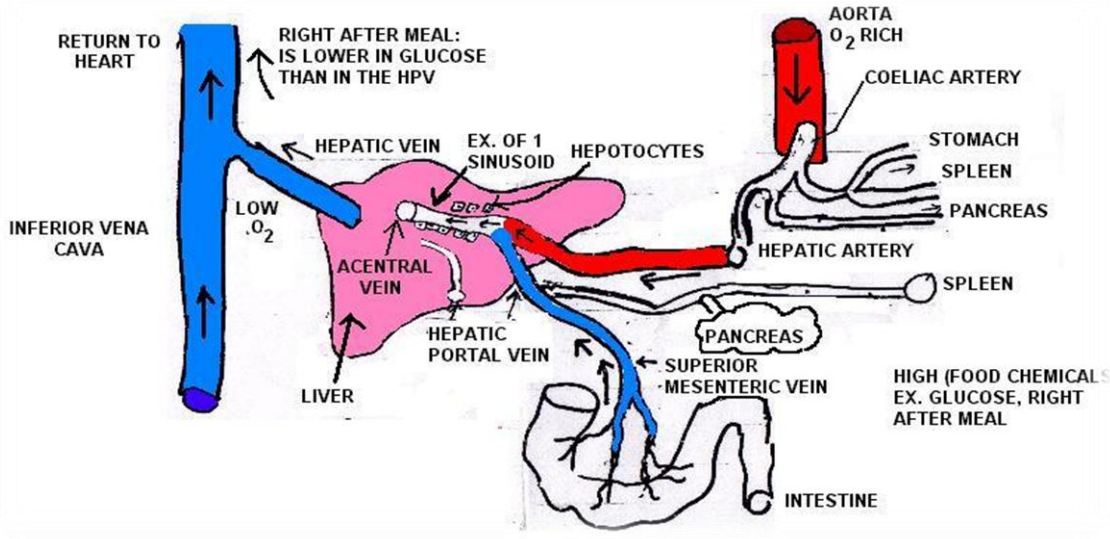


Fig.1: LIVER AND HEPATIC PORTAL SYSTEM (By D.F. Lockwood 2003)

The remaining 20-25% hepatic blood flow is delivered by the hepatic artery originating from the coeliac artery, which arises from the abdominal aorta.^[2,3] Hepatic arterial blood is well-oxygenated, while the portal vein carries partly deoxygenated, but nutrient-rich blood. Total hepatic blood flow ranges between 800 and 1200 mL/min, which is equivalent to approximately 100 mL/min per 100 g liver wet weight.^[10] Although the liver mass constitutes only 2.5% of the total body weight, the liver receives nearly 25% of the cardiac output. Liver volume and portal blood flow decreases after the age of 50.^[11]

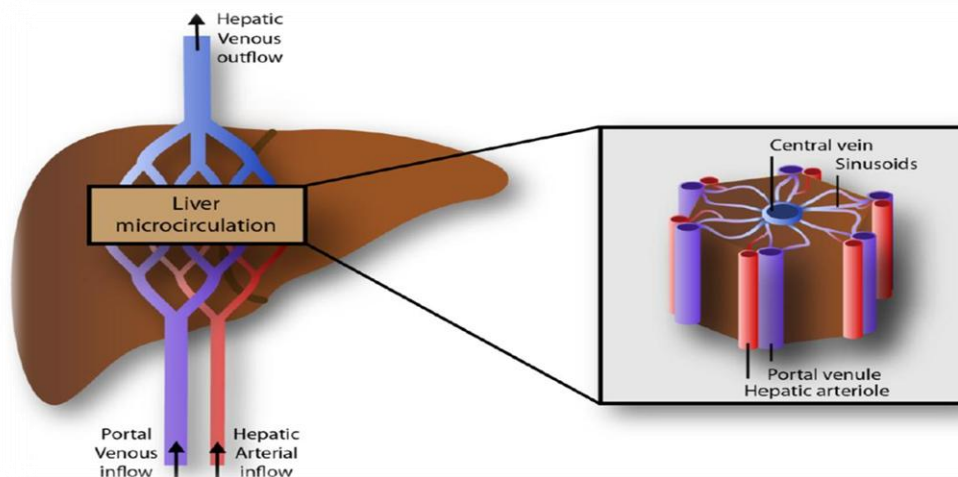


Fig. 2

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Dual blood supply of the liver with portal vein (PV), hepatic artery (HA), and venous drainage via hepatic vein (HV) (left fig). Hepatic microcirculation with portal tract, sinusoids and central vein in a classic lobule of Kiernan. Bile ducts are not shown in figure but run parallel with PV and HA(Right fig)..^[12] Liver is also prone to many diseases.^[13] One of these is Hepatitis B, Hepatitis is irritation and swelling (Inflammation) of liver due to infection with the Hepatitis B virus. Hepatitis B virus, abbreviated HBV, is a species of the genus Orthohepadnavirus, which is likewise a part of the Hepadnaviridae family of viruses.^[14] This virus causes the disease Hepatitis B.^[15] In 1947 Mac Callum classified viral Hepatitis A & viral Hepatitis B . Hepatitis B virus was discovered in 1965 by Dr. Baruch Blumberg.

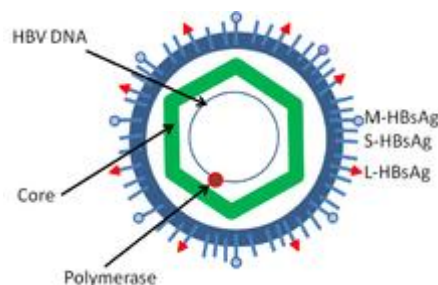


Fig. 3: The structure of hepatitis B virus

In 1981 The FDA approved sophisticated Plasma, Derived Hepatitis vaccine are human use . In 2001,FDA approved a combination Hepatitis A and Hepatitis B vaccine (Twinrix, Glaxo Smithkline). During 1990-2004, incidence of acute Hepatitis B in the United States declined 75%. The greatest decline (94%) occurred among children and adolescent. 12 March 2015 | GENEVA - WHO today issued its first-ever guidance for the treatment of chronic hepatitis B, a viral infection which is spread through blood and body fluids, attacking the liver and resulting in an estimated 650000 deaths each year – most of them in low- and middle-income countries. Worldwide, some 240 million people have chronic Hepatitis B virus with the highest rates of infection in Africa and Asia. People with chronic Hepatitis B infection are at increased risk of dying from cirrhosis and liver cancer. Many Cancer Patients at Risk for Hepatitis B Virus Reactivation.^[16] WHO report 2015: India not doing enough to tackle spread of Hepatitis B. Approximately four crore to six crore people in India are carriers of the Hepatitis B virus. According to an estimation of the World Health Organization (WHO), which says that two to five percent of India's population may be affected by the virus. Each year, one lakh patients die of viral Hepatitis (including Hepatitis B and C) in India.

Blood is a specialized body fluid in human that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those cells. It is composed of blood cells suspended in a liquid called blood plasma. Plasma which constitutes 55% of blood fluids mostly water (92% by volume).^[17] And contains dissolved proteins, glucose, minerals ions, hormones, carbon dioxide (plasma being the main medium for excretory products transportation) and blood cells themselves. Blood accounts for 7% of the human body weight.^[18-19] By volume, the red blood cells constitute about 45% of whole blood, the plasma about 54.3% and white cells about 0.7%.^[20] Whole blood (plasma and cells) exhibits non-Newtonian fluid dynamics. Red blood cells contain the blood's hemoglobin and distribute oxygen.^[21] White blood cells are part of the body's immune system. They destroy and remove old or aberrant cells and cellular debris as well as attack infectious agents.^[22] Thrombocytes also called platelets; thrombocytes are responsible for blood clotting about 55% of blood is blood plasma a fluid that is the blood's liquid medium, which by itself is straw-yellow in color.

An arteriole is a small diameter blood vessel in the microcirculation that extends and branches out from an artery and leads to capillaries.^[23]

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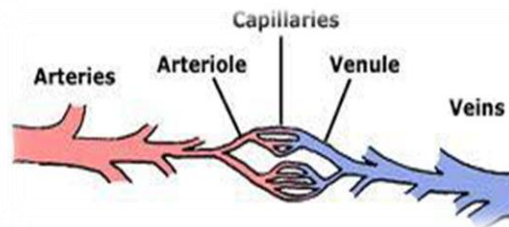


Fig. 4 : TYPICAL CIRCULATORY ROUT

Arterioles are very small arteries that deliver blood to capillaries. As arterioles branch off an artery, they have smooth muscle and a few elastic fibers in the tunica media. These gradually taper away as the arteriole becomes smaller, leaving mostly the endothelium and a few smooth muscle fibers by the time the arteriole connects to the capillaries. Arterioles play a key role in regulating blood flow into capillaries. Vasoconstriction of arterioles decreases blood flow into capillaries; vasodilatation increases flow. A change in the diameter of a large number of arterioles at once will also affect blood pressure. This work is important for human health. There are several researches, who examined the blood flow in the artery and veins. This work will focus on two phase hepatic blood flow in arterioles with special reference to Hepatitis B. The mean arterial pressure (MAP) is a term used in medicine to describe an average blood pressure in an individual. ^[24] At normal resting heart rates can be approximated using the more easily measured systolic and diastolic pressures, SP and DP. ^[25]

$$MAP \approx DP + \frac{1}{3} (SP - DP)$$

or

$$MAP \approx \frac{2(DP) + (SP)}{3}$$

At high heart rates is more closely approximated by the arithmetic mean of systolic and diastolic pressures because of the change in shape of the arterial pressure pulse. A lot of work is available, but P. N. Pandey and V. Upadhyay (2001) discussed a some phenomena in two phase blood flow gave an idea on the two phase hepatic blood flow in arterioles with a Liver disease Hepatitis B .The work of P.N. Pandey and V. Upadhyay in whole circulatory system but this work will focus on hepatic circulatory system, and hepatic circulatory system is a sub system of whole circulatory system. In this work, applied the Herschel Bulkley non-Newtonian model. We present an improvement on the previous work in the field and this is discussed separately below. The ultimate use of this model is to predict normal reference levels of two phase blood flow in arterioles for individual patients undergoing Hepatitis B disease.

II. REAL MODEL

We have to select a frame of reference for mathematical modeling of the state of a moving blood. keeping in view the difficulty and generality of the problem of blood flow, we select generalized three-dimensional orthogonal curvilinear co-ordinate system, briefly prescribed as E3, called as 3-dim Euclidean space, We interpret the quantities related to blood flow in tensorial form which is comparatively more realistic, The biophysical laws thus expressed fully hold good in any co-ordinate system, which is compulsion for the truthfulness of the law (1990). ^[26] Now, let the co-ordinate axes be OX^i where O is origin and superscript $i=1,2,3$ let X^i be the co-ordinates of any point P in space, The mathematical description of the state if a moving blood is affected by means of functions which give the distribution of the blood velocity $v^k = v^k(X^i, t)$, $k=1,2,3$ and of any two thermodynamic quantities pertaining to the blood, for instance the pressure $p = p(X^i, t)$ and the density $\rho = \rho(X^i, t)$, As is well known, all the thermodynamic quantities are determined by the values of any two of them, together with the equate of state, Hence, if we are given five quantities, namely the three components of velocity v^k , the pressure p and the density ρ , the state of moving blood is completely determined. All these quantities are, in general, functions of the co-ordinates X^i , $i=1,2,3$ and of the time t, We emphasize that $v^k(X^i, t)$ is the velocity of the blood at a given point X^i in space and at a given t, i.e. it refers to fixed

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points in space and not to fixed particles of the blood; in the course of time, the latter move about in space. The same remarks apply to p and ρ . Blood is a mixed fluid, mainly there are two-phases in blood, the first phase is plasma, while the other phase is that of blood cells. The blood cells are enclosed with a semi-permeable membrane whose density is greater than that of plasma, these blood cells are uniformly distributed in plasma, thus blood can be considered as a homogeneous mixture of two-phases. [27]

III. MATHEMATICAL MODELING

As the velocity of blood flow decreases, the viscosity of blood increases. The velocity of blood decreases successively because of the fact that arterioles, veinules and veins these vessels are relatively far enough from the heart. Hence the pumping of the heart on these vessels is relatively low. [28] Secondly these vessels relatively narrow down more rapidly. In this situation, the blood cells line up on the axis to build up rouleaux. Hence a yield stress is produced.

(a) Equation of Continuity for two phase blood flow-

According to Singh P. and Upadhyay K.S. The flow of blood is affected by the presence of blood cells. This effect is directly proportional to the volume occupied by blood cells. [29] Let the volume portion covered by blood cells in unit volume be X , this X is replaced by $H/100$, where H is the Hematocrit the volume percentage of blood cells. Then the volume portion covered by the plasma will be $1-X$. If the mass ratio of blood cells to plasma is r then clearly

$$r = \frac{X\rho_c}{(1-X)\rho_p} \quad (3.1)$$

where ρ_c and ρ_p are densities of blood cells and blood plasma respectively. Usually this mass ratio is not a constant, even then this may be supposed to constant in present context (1986)

The both phase of blood, i.e. blood cells and plasma move with the common velocity.

Campbell and Pitcher has presented a model for this situation. According to this model, we consider the two phase of blood separately (1958). Hence equation of continuity for two phase according to the principle of conservation of mass defined by J.N and Gupta R.C. as follow

$$\frac{\partial(X\rho_c)}{\partial t} + (X\rho_c v^i),_i = 0 \quad (3.2)$$

and
$$\frac{\partial(1-X)\rho_p}{\partial t} + ((1-X)\rho_p v^i),_i = 0 \quad (3.3)$$

Where v is the common velocity of two phase blood cells and plasma.

Again $(X\rho_c v^i),_i$ is co-variant derivative of $(X\rho_c v^i)$ with respect to X^i . In the same way

$(1-X)\rho_p v^i),_i$ is co-variant derivative of $((1-X)\rho_p v^i)$ w.r. to X^i .

If we define the uniform density of the blood ρ_m as follow

$$\frac{1+r}{\rho_m} = \frac{r}{\rho_c} + \frac{1}{\rho_p} \quad [30] \quad (3.4)$$

Then equation (3.2) and (3.3) can be combined together as follow

$$\frac{\partial\rho_m}{\partial t} + (\rho_m v^i),_i = 0 \quad (3.5)$$

(b) Equation of Motion for two phase blood flow-

According to Ruch, T.C. and H.D. The hydro dynamical pressure p between the two phases of blood can be supposed to be uniform because the both phases i.e. blood cells and plasma are always in equilibrium state in blood (1973). [31] Taking

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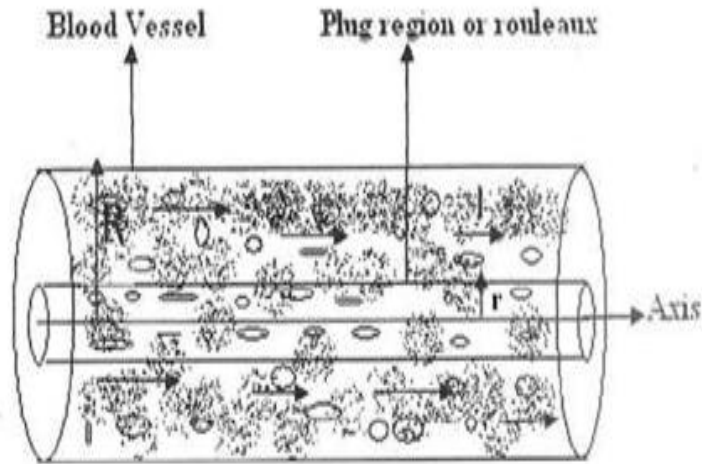


Fig.5: Herschel Bulkley blood flow model

viscosity coefficient of blood cells to be η_c and applying the principle of conservation of momentum, we get the equation of motion for two phase of blood cells as follows:

$$X\rho_c \frac{\partial v^i}{\partial t} + (X\rho_c v^j) v_j^i = -Xp_j g^{ij} + X\eta_c (g^{jk} v_{,k}^i)_j \quad (3.6)$$

Similarly, taking the viscosity coefficient of plasma to be. The equation of motion for plasma will be as follows:

$$(1 - X)\rho_p \frac{\partial v^i}{\partial t} + \{(1 - X)\rho_p v^i\} v_j^i = -(1 - X)p_j g^{ij} + (1 - X)\eta_c (g^{jk} v_{,k}^i)_j \quad (3.7)$$

Now adding equation (3.6) and (3.7) and using relation (3.4), the equation of motion for blood flow with the both phases

$$\rho_m \frac{\partial v^i}{\partial t} + (\rho_m v^j) v_j^i = -p_j g^{ij} + \eta_m (g^{jk} v_{,k}^i)_j \quad (3.8)$$

Where $\eta_m = X\eta_c + (1 - X)\eta_p$ is the viscosity coefficient of blood as a mixture of two phases.

The Herschel Bulkley law holds good on the two phase blood flow through veins arterioles, veinules and whose constitutive equation is as follows:

$$T' = \eta_m e^n + T_p \quad (T' \geq T_p) \quad \text{and} \quad e = 0 \quad (T' < T_p) \quad \text{where,} \quad T_p \text{ is the yield stress.}$$

When strain rate $e = 0$ ($T' < T_p$) a core region is formed which flows just like a plug. Let the radius of the plug be r_p .

The stress acting on the surface of plug will be T_p . Equating the forces acting on the plug, we get [fig (5)]

$$P\pi r_p^2 T_p = 2\pi r_p \tau_p \Rightarrow r_p = 2 \frac{T_p}{P} \quad (3.9)$$

The Constitutive equation for test part of the blood vessel is

$$T' = \eta_m e^n + T_p \quad \text{or} \quad T' - T_p = \eta_m e^n = T_e$$

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Where, T_e = effective Stress, whose generalized form will be as follows

$$T^{ij} = -P g^{ij} + T_e^{ij} \quad \text{where, } T_e^{ij} = \eta_m (e^{ij})^n \quad \text{while } e^{ij} = g^{jk} v_k^i$$

Where, the symbols have their usual meanings.

Now we describe the basic equations for Herschel Bulkley blood flow as follows:

(c) Equation of Continuity-

$$\frac{1}{\sqrt{g}(\sqrt{g} v^t)_{;t}} = 0$$

(d) Equation of Motion-

$$\rho_m \frac{\partial v^i}{\partial t} + \rho_m v^j v_{;j}^i = -T_{e;j}^i \tag{3.10}$$

Where all the symbols have their usual meanings.

IV. ANALYSIS (SOLUTION)

Since, the blood vessels are cylindrical; the above governing equations have to be transformed into cylindrical co-ordinates. As we know earlier:

$$X^1 = r, \quad X^2 = \theta, \quad X^3 = z,$$

Matrix of metric tensor in cylindrical co-ordinates is $[g_{ij}]$ and matrix of conjugate metric tensor is $[g^{ij}]$ whereas the Christoffel's symbols of 2nd kind are as follows :

$$\left\{ \begin{matrix} 1 \\ 2 \end{matrix} \right\} = -r, \quad \left\{ \begin{matrix} 1 \\ 2 \end{matrix} \right\} = \left\{ \begin{matrix} 1 \\ 2 \end{matrix} \right\} = \frac{1}{r} \text{ remaining others are zero.}$$

The governing tensorial equations can be transformed into cylindrical forms which are as follows: the equation of Continuity $\frac{dv}{dz} = 0$

The equation of Motion- r - component: $-\frac{dp}{dz} = 0$, θ - component: $0 = 0$ z -

component: $0 = -\frac{\partial p}{\partial z} + \frac{\eta_m}{r} [r \left(\frac{\partial v_z}{\partial r}\right)^n]$

Here, this fact has been taken in view that the blood flow is axially symmetric in arteries concerned, i.e. $v_\theta = 0$ and v_r, v_z and p do not depend upon θ .

We get $v_z = v(r)$ and $p = p(z)$ and $0 = -\frac{dp}{dz} + \frac{\eta_m}{r} [r \left(\frac{dv}{dr}\right)^n]$ (4.1)

Since, pressure gradient $-\frac{dp}{dz} = P$

$$r \left(\frac{dv}{dr}\right)^n = -\frac{Pr}{2\eta_m} + A, \quad \text{we apply boundary condition: at } r = 0, v = v_0. \text{ then } A = 0.$$

Then $-\frac{dv}{dr} = \left(\frac{Pr}{2\eta_m}\right)^{\frac{1}{n}}$ Replace r from $r - r_p$, for non- plug region

$$\frac{dv}{dr} = -\left(\frac{\frac{1}{2}Pr - \frac{1}{2}Pr_p}{\eta_m}\right)^{\frac{1}{n}} \quad \text{i.e.} \quad \frac{dv}{dr} = -\left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} (r - r_p)^{\frac{1}{n}} \tag{4.2}$$

Integrating above equation (4.2) under the no slip boundary condition: $v = 0$ at $r = R$, so we get:

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$$v = \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} \frac{n}{n+1} \left[(R - r_p)^{\frac{1}{n}+1} - (r - r_p)^{\frac{1}{n}+1} \right] \quad (4.3)$$

This is the formula for velocity of blood flow in arterioles, veinules and veins.

Putting $r = r_p$ to get the velocity v_p of plug flow as follows

$$v_p = \frac{n}{n+1} \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} (R - r_p)^{\frac{1}{n}+1} \quad (4.4)$$

Where the value of r_p is taken from (3.7).

V. RESULT & DISCUSSION (BIO-PHYSICAL INTERPRETATION)

Observations: Hematocrit Vs. Blood pressure is taken from Lala Lajpat Rai and Associated Hospital, Kanpur by **Dr. Richa Giri**.

Patient Name: - Mr. Sanjay Sharma

Annual No. 16527 / 2013

Diagnosis: - Hepatitis B

DATE	Hemoglobin (Hb)	B.P. Systolic/Diastolic(In mmhg)	Hematocrit (3 × Hb)	B.P. (In Pascal)
16.06.13	4.0	80/50	12.0	10665.6/6666.0
17.06.13	4.5	108/84	13.5	14398.56/11198.88
18.06.13	5.8	90/50	17.4	11998.8/6666.0
19.06.13	6.0	100/74	18.0	13332.0/9865.68
20.06.13	6.8	94/60	20.4	12532.08/7999.2
26.06.13	6.0	100/70	18.0	13332.0/9332.4

'According to Berkow, Robert, The hematocrit (expressed as percentage points) is normally about three times the hemoglobin concentration (reported as per deciliter) .^[32]

The flow flux of two phased blood flow in arterioles, veinules and veins is

$$Q = \int_0^{r_p} 2\pi r v_p dr + \int_{r_p}^R 2\pi r v dr$$

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$$= \int_0^{r_p} 2\pi r \frac{n}{n+1} \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} (R - r_p)^{\frac{1}{n}+1} dr + \int_0^{r_p} 2\pi r \frac{n}{n+1} \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} [(R - r_p)^{\frac{1}{n}+1} - (r - r_p)^{\frac{1}{n}+1}] dr$$

Using (4.2) and (4.4) , we get

$$Q = \frac{2\pi n}{(n+1)} \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} (R - r_p)^{\frac{1}{n}+1} \left[\frac{r^2}{2} \right]_0^{r_p} + \frac{2\pi n}{(n+1)} \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} \left[\frac{r^2}{2} (R - r_p)^{\frac{1}{n}+1} - \frac{r(r-r_p)^{\frac{1}{n}}}{\frac{1}{n}+2} + \frac{(r-r_p)^{\frac{1}{n}+3}}{(\frac{1}{n}+2)(\frac{1}{n}+3)} \right]_{r_p}^R$$

$$= \frac{\pi n}{(n+1)} \left(\frac{P}{2\eta_m}\right)^{\frac{1}{n}} R^{\frac{1}{n}+3} \left[\frac{r_p^2}{R^2} \left(1 - \frac{r_p^2}{R}\right)^{\frac{1}{n}+1} + \left(1 + \frac{r_p}{R}\right) \left(1 - \frac{r_p}{R}\right)^{\frac{1}{n}+2} - \frac{2\left(1 - \frac{r_p}{R}\right)^{\frac{1}{n}+2}}{(\frac{1}{n}+2)} + \frac{2\left(1 - \frac{r_p}{R}\right)^{\frac{1}{n}+3}}{(\frac{1}{n}+2)(\frac{1}{n}+3)} \right]$$

$Q = 1000 \text{ ml. /min} = 0.1666 \text{ l./sec.}, \quad R=1, \quad r_p = \frac{1}{3}$ [33] According to Gustafson, Daniel R. (1980)

$\eta_p = 0.0015 \text{ (Pascal-sec.)}$ [34] According to Glenn Elert (2010)

$\eta_m = 0.035 \text{ (pascal-sec.)} \quad H = 12.00 \quad P = 8665.80$

Terminal hepatic arterioles length = $50 \mu\text{m}$ [35] $\Rightarrow Z_f - Z_i = 0.00005 \text{ meter}$

By using relation $\eta_m = \eta_c X + \eta_p (1-X)$ where, $X = \frac{H}{100}$, We get

$\eta_c = 0.2806$, and again using same above relation , We get

$\eta_m = 0.0015 + 0.00279 H$ (5.1)

Substituting the values of, r_p and R in equation(4.1), we get

$$Q = \frac{2}{27} \pi \left(\frac{P}{3\eta_m}\right)^{\frac{1}{n}} \left[\frac{26n^3+33n^2+9n}{6n^3+11n^2+6n+1} \right] \Rightarrow \frac{27 \times Q}{2\pi} = \left(\frac{P}{3\eta_m}\right)^{\frac{1}{n}} \left[\frac{26n^3+33n^2+9n}{6n^3+11n^2+6n+1} \right]$$

Let $A = \frac{26n^3+33n^2+9n}{6n^3+11n^2+6n+1}$

$$\frac{P}{3\eta_m} = \left(\frac{27Q}{2\pi A}\right)^n \Rightarrow P = \left(\frac{27Q}{2\pi A}\right)^n \times 3\eta_m$$

$$P = - \frac{dP}{dz} \Rightarrow dP = - P dz \Rightarrow \int_{p_f}^{p_i} dP = - \int_{Z_i}^{Z_f} \left(\frac{27Q}{2\pi A}\right)^n \times 3\eta_m dz$$

Where, Pressure drop = $p_i - p_f$, Length of hepatic arterioles = $Z_f - Z_i$

$$\Rightarrow p_i - p_f = \left(\frac{27Q}{2\pi A}\right)^n \times 3\eta_m (Z_f - Z_i) \quad (5.2)$$

Substituting the values of Q , p_i , p_f , η_m in equation (5.2), and solve by Numerical method

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We get $n = -10.6525$

Again from equation (5.2), we have

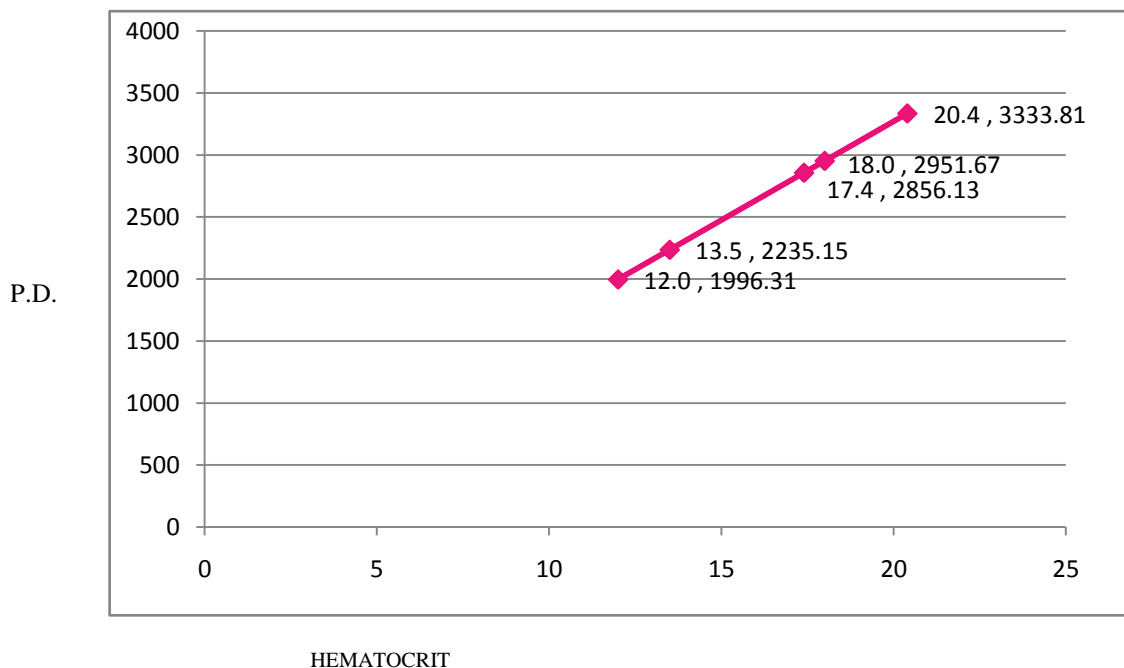
$$p_i - p_f = \left(\frac{27Q}{2\pi A}\right)^n \times 3\eta_m (Z_f - Z_i) \text{ and substituting the value of } \eta_m, \eta_c, Q \text{ and } n, \text{ we get}$$

$$p_i - p_f = 159.2256 H + 85.6052$$

We get, values of Blood Pressure drop if hematocrit known by using above equation

(Relation between Blood Pressure Drop and Hematocrit)

Hematocrit	Mean Blood Pressure	Weighted Mean Blood Pressure	Blood Pressure Drop (P.D.)
12.0	8665.8	7999.2	1996.31
13.5	12798.72	12265.44	2235.15
17.4	9332.4	8443.6	2856.13
18.0	11598.84	11021.12	2951.67
20.4	10265.64	9510.16	3333.81



GRAPH:1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

VI. CONCLUSION

A simple survey of the graph between blood pressure drop and hematocrit in Hepatitis B patient shows that when hematocrit increased then Blood pressure is also increased, That is the hematocrit is proportional to blood pressure drop.

Acknowledgement:

I give my sincere thanks to **Dr. Richa Giri**, physician of Lala Lajpat Rai and Associated Hospital, Kanpur (U.P.).

Remark: If this would have been possible to get blood Pressure on the particular tissue (Liver) during operation of Hepatitis B patient then the relation between blood pressure drop and hemoglobin has been measured more accurately.

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