A Study on Viscosity of Normal Human Blood and Diseased Blood (Tuberculosis)

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Abstract- Blood viscosity is a basic biological parameter that affects blood flow both at large arteries and in microcirculation. Since blood is viscous by nature, the thickness and stickiness of an individual's blood is associated with many risk factors of health of a human being. In this study a simple technique is used to find out the viscosity of blood at different flow rates by using normal capillary tubes, The tool is developed based on Poiseuille's theory to measure the coefficient of viscosity and volume flow rate at different radii. The coefficient of viscosity is considerably high in Tuberculosis blood when compared to normal blood. The data is presented and findings and conclusions are drawn from the data.

Indexed Terms- Tuberculosis, Viscosity, Flow rate

I. INTRODUCTION

Tuberculosis (TB) is a highly contagious and infectious disease, that usually attacks the lungs. It can also spread to other parts of body like brain and spine. Mycobacterium tuberculosis, a type of bacteria is main cause for it. TB spread from person to person through the air. When people with lung TB cough, sneeze or split, they propel the TB germs into the air. A person needs to inhale only a few of these germs to become infected.

Blood viscosity is a basic biological parameter that affects blood flow both at large arteries and in microcirculation. Since blood is viscous by nature, the thickness and stickiness of an individual's blood is associated with many risk factors of health of a human being. Under normal physiological conditions viscosity of blood varies because of many factors like gender, geography and heredity and other important factor that influences the blood viscosity is temperature. As temperature increases the viscosity decreases. Under pathological conditions the change in blood viscosity is mainly due to changes in the shear stress imparted by blood flow due to which the circulatory system and related tissues and organs damage. Plasma viscosity is determined by the concentration of Plasma proteins, but the erythrocytes deformability and aggregation vary with different blood shear rates. Therefore, erythrocytes with high shear rates is a major determination of viscosity of blood.

II. MATERIALS AND METHODS

To study the rheological behaviour of blood, a simple capillary technique is used. Though Capillary viscometry is the most traditional method for measuring the viscosity of the viscous materials, here in the present study, an open-end capillary viscometer is used and a theory is developed based on the Poiseuille's theory for the dynamics of a liquid column in an open capillary tube. No external pressure is applied on the liquid column. The pressure at the two ends of the capillary tube is the atmospheric pressure.
The simple capillary viscometry technique, which is employed in this study, is used to measure both viscosity and volume flow rate. The blood samples were collected from the patients suffering from diabetes mellitus. The samples are collected in siliconised bottles with EDTA (Ethylene Diamine Tetra Acetic) anticoagulant in the powder form. Plasma was separated from blood by centrifuging the blood at the rate of 1500 rmp about 10 to 15 minutes. By taking out the plasma, RBC (90% packed erythrocytes) were separated. Blood samples were prepared by mixing an equal amount of plasma and erythrocytes. By this process, Haematocrit of sample is maintained to be constant. In the case of Tuberculosis, samples collected from the patients are below 50 and above 30 years of age. All the samples belong to chest TB only.

III. RESULT AND DISCUSSION

Table 1 indicates the data on coefficient of viscosity of water. Four capillary tubes of different radii i.e. 0.029cm, 0.040cm, 0.045cm and 0.055cm were taken to find out the coefficient of viscosity of water. Five samples of water were taken for different capillary tubes and found the viscosity. It is found that there is no change in the coefficient of viscosity of water with different radii of capillary tubes.

Table 1: Data on coefficient of Viscosity of Water

CT=Capillary Tube
CT1= 0.029cm; CT2= 0.040cm; CT3= 0.045cm; CT5= 0.055cm

Sample Code	Viscosity, η (poise)			
	CT1	CT2	CT3	CT4
W1	0.012	0.012	0.012	0.012
W2	0.012	0.012	0.012	0.012
W3	0.013	0.013	0.013	0.013
W4	0.013	0.013	0.013	0.013
W5	0.012	0.012	0.012	0.012

Mean**:** 0.012 Mean**:** 0.012 Mean**:**0.012 Mean**:** 0.012
S.D= ±0.0005 S.D= ± 0.0005 S.D= ±0.0005 S.D= ± 0.0005

Table 2 shows the data on coefficient of viscosity of human blood. The fresh samples of blood were collected and found the viscosity for four different radii i.e. 0.029cm, 0.040cm, 0.045cm and 0.055cm of capillary tubes. It is observed from the table that as the radius of the capillary tube increases, the coefficient of viscosity also increases.

Table 2: Data on coefficient of Viscosity of Human Blood

Sample Code	Viscosity, η (poise)			
	CT1	CT2	CT3	CT4
HB1	0.02427	0.02663	0.02889	0.03927
HB2	0.02126	0.02399	0.03393	0.0434
HB3	0.02184	0.02308	0.03009	0.04825
HB4	0.02663	0.03055	0.03505	0.04849
HB5	0.02951	0.03062	0.03551	0.05101
HB6	0.02569	0.039	0.03924	0.04541
HB7	0.02569	0.02926	0.03414	0.04732
HB8	0.02539	0.02968	0.03414	0.04014
HB9	0.03765	0.03405	0.04045	0.04243
HB10	0.02951	0.03582	0.03984	0.04043
HB11	0.03368	0.03516	0.03804	0.04227
HB12	0.02968	0.03057	0.0364	0.03889
HB13	0.02473	0.03595	0.03677	0.04611
HB14	0.02299	0.02971	0.03553	0.04237
HB15	0.02698	0.02873	0.03286	0.04732
HB16	0.02299	0.02846	0.03553	0.0479
mean	0.027	0.031	0.035	0.044
S.D=±	0.0044	0.0044	0.0032	0.0038

Table 3 shows the data on volume flow rate of water. For five samples of water four different radii of i.e.0.029cm, 0.040cm, 0.045cm and 0.055cm of capillary tubes were taken to find out the volume flow rate. It is observed from the given table that the flow is continuous when the length is infinite.

Table 3: Data on Volume flow rate of water

Sample Code	Volume flow rate, Q (cm3 sec-1)			
	CT1	CT2	CT3	CT4
W1	0.035	0.06757	0.08552	0.12775
W2	0.033	0.06406	0.08107	0.12111
W3	0.031	0.06029	0.076302	0.113982
W4	0.035	0.066819	0.084568	0.126335
W5	0.032	0.061041	0.077255	0.115406
Mean	0.034	0.064	0.081	0.121
S.D= ±	0.0017	0.0033	0.0042	0.0062

Table 4. gives the data on volume flow rate of human blood. Here also four capillaries with different radii i.e.0.029cm, 0.040cm, 0.045cm and 0.055cm were used respectively for different samples of blood and the flow rate was found. It is seen clearly from the table that the flow rate increases with the increases of the radii of capillary tubes.

Table 4: Data on Volume flow rate of Human Blood

Sample Code	Volume flow rate, Q (cm3 sec-1)			
	CT1	CT2	CT3	CT4
HB1	0.01188	0.03918	0.05786	0.06498
HB2	0.01188	0.03173	0.04955	0.06082
HB3	0.0132	0.04521	0.0561	0.07844
HB4	0.01082	0.03416	0.04768	0.07693
HB5	0.01293	0.0371	0.05086	0.07313
HB6	0.01199	0.04069	0.04924	0.08216
HB7	0.01122	0.03567	0.04896	0.07883
HB8	0.01135	0.035	0.04896	0.06319
HB9	0.01165	0.03064	0.04133	0.06174
HB10	0.00977	0.0305	0.04433	0.06174
HB11	0.01101	0.0331	0.04289	0.0617
HB12	0.01147	0.03516	0.04942	0.07313
HB13	0.01103	0.0331	0.04673	0.06648
HB14	0.01154	0.0376	0.04705	0.07123
HB15	0.01158	0.0301	0.04005	0.07218
HB16	0.01154	0.03667	0.04705	0.07788
Mean	0.012	0.035	0.048	0.070
S.D= ±	0.0008	0.0041	0.0047	0.0073

Table 5: Data on coefficient of viscosity of Tuberculosis Blood

Sample Code	Viscosity, η (poise)			
	CT1	CT2	CT3	CT4
TBB1	0.034	0.043	0.052	0.066
TBB1	0.028	0.041	0.054	0.089
TBB1	0.025	0.034	0.041	0.048
TBB1	0.035	0.037	0.041	0.048
Mean	0.031	0.039	0.046	0.0630.
SDV ±	0.0048	0.0040	0.0083	0.0194

TBB= Tuberculosis Blood

Table 6: Data on Volume flow rate of Tuberculosis Blood

Sample Code	Volume flow rate, Q (cm3 sec-1)			
	CT1	CT2	CT3	CT4
TBB1	0.009	0.027	0.035	0.062
TBB1	0.008	0.02	0.041	0.075
TBB1	0.009	0.045	0.045	0.084
TBB1	0.009	0.31	0.05	0.085
Mean	0.009	0.031	0.043	0.077
SDV±	0.0005	0.0105	0.0063	0.0107

Fig.1. A plot between Volume flow rate on x-axis coefficient of viscosity on y-axis of water.

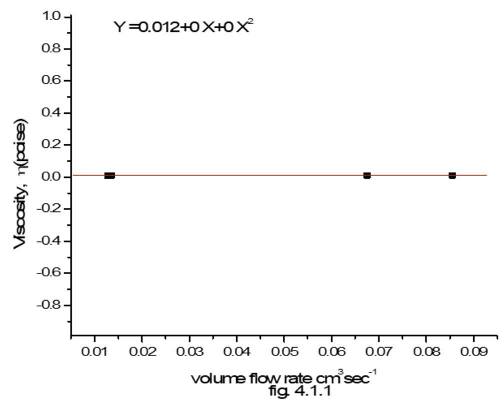


Fig.2. A plot between volume flow rate on x-axis and coefficient of viscosity on y-axis for human blood.

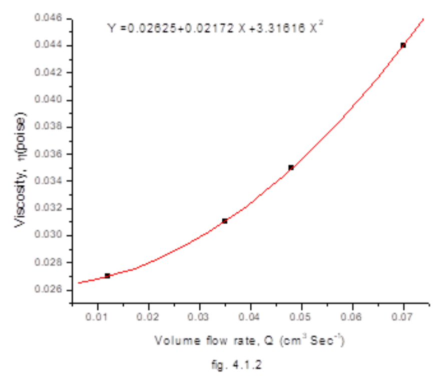


Fig.3: A plot between Radius-R(Cm) on X-Axis and coefficient of viscosity on y-axis of water.

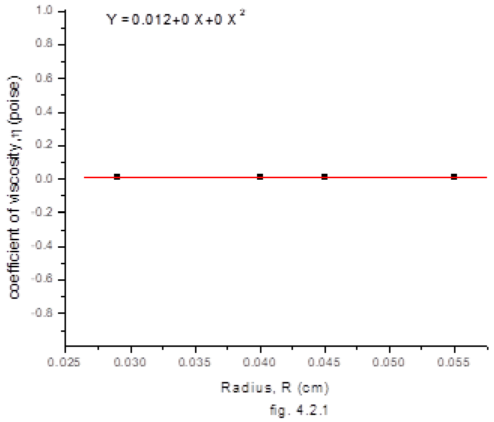


Fig. 4: A plot between Radius on x-axis and Coefficient of viscosity on y-axis of human blood

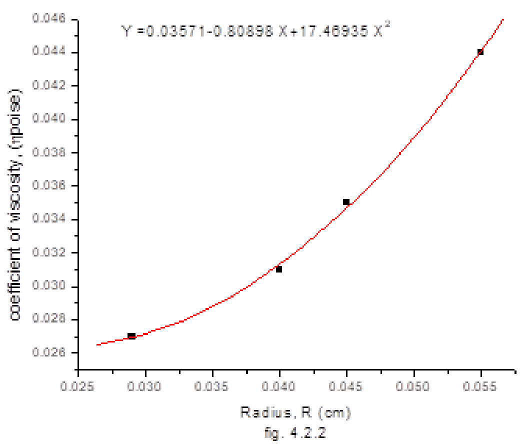


Fig.5: A plot between Radius on X-axis and Volume flow rate on Y-axis for water.

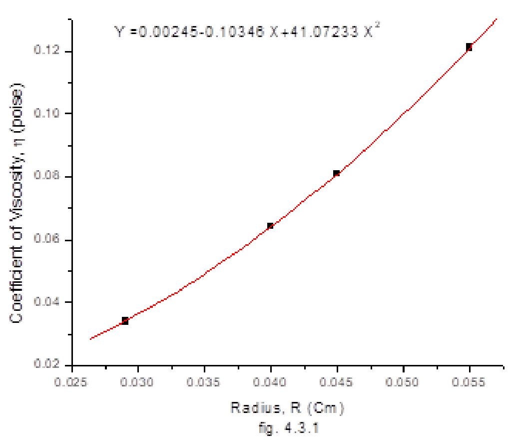
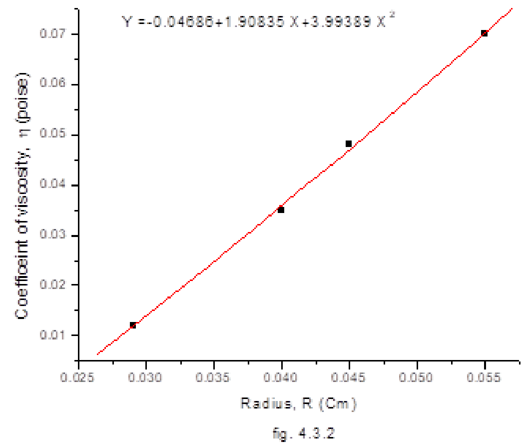


Fig.6: A plot between Radius on X-axis and Volume flow rate on Y-axis for human blood.



In the present study, it is observed that the coefficient of viscosity of blood increases nonlinearly with increase of radius of capillary tube (Tables 2). But in the case of water, the coefficient of viscosity remains constant (Table1). As it is known, in Newtonian fluids the viscosity is independent of resistance and the stress, strain relation is linear (Fig.1), where as in a non-Newtonian fluids viscosity increases non linearly with the radius of a capillary tube (Fig.2). The volume flow rate of blood also increases with the increase of radius (Table 4). It is interesting to know that the coefficient of viscosity and volume flow rate both are proportionally increasing with the radius. In other words, it can be stated that the coefficient of viscosity increases as the flow rate increases.

CONCLUSION

The coefficient of Viscosity is high in the case of Tuberculosis blood. There are many factors that contribute for high viscosity. This may be due to the confirmational changes in Plasma proteins and the interaction between erythrocytes and plasma. When the size of the erythrocytes increase, haemoglobin content is decreased and the increase in the concentration of the clotting protein fibrinogen are also responsible for high value of viscosity.

The present study suggests that viscosity serves as a potential parameter to assess the degree of disease. By measuring the parameters like viscosity and volume flow rate, the chronic disease can be predicted in advance.

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