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Hemorheological parameters of Blood of patients suffering from pulmonary Tuberculosis

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ABSTRACT

The paper presents the data on hemorhelogical parameters of blood of patients suffering from pulmonary tuberculosis. These parameters are the crucial parameters, which adversely affect many vital functions of human body. A simple open capillary tube method is employed for the determination of characteristic velocity, volume flow rate, viscosity and surface tension. The coefficient of viscosity is considerably high in TB blood when compared to normal blood values and there is no significant change in surface tension when compared with that of normal. It is observed that volume flow rate and characteristic velocity decrease considerably. This method can be the complementary method for the diagnosis, monitoring and administration of drug of TB patients.

Key words: Tuberculosis, opened tube viscometer, viscosity, surface tension.

INTRODUCTION

Tuberculosis is a highly prevalent chronic infectious disease, caused by Mycobacterium tuberculosis, an aerobic intracellular binding *bacterium* (bacillus); because of this characteristic property it prefers tissues which are always in contact with high oxygen levels as in the lung. After inhaling the *bacillus*, transmitted by tiny droplets of saliva, the infected individual may develop the diseased depending on his immunological state [1,2]. After taking up residence in the lung, *M. Tuberculosis* can disseminate to any part of the organism [2].

Globally *M. Tuberculosis* infection remains at epidemic levels [3]. One third of the world's population is infected and approximately 3 million people die annually from pulmonary tuberculosis, overtaking the number of deaths due to acquired - immune deficiency syndrome (AIDS), malaria, diarrhea, leprosy and other tropical diseases combined [4]. Tuberculosis diseases and even though treatment is performed on an outpatient basis. It is the 9th highest cause of hospitalization from infectious diseases and the 7th highest in cost from these hospitalizations [5].

It is estimated that 95% cases occur in under developed world where diagnostic and treatment facilities are rudimentary or non existent [6]. Tuberculosis is caused by several species of mycobacterium often described as

mycobacterium tuberculosis complex which include; M. Tuberculosis, M. microti, M. africanum, M. bovis and BCG. Out of them mycobacterium tuberculosis is the most frequent of this complex are rare causes of TB [7].

Around 10% tuberculosis cases are in the under 20's,with the most affected age group being the 20-49 year-old, accounting for 70% of all those affected. It affects three times as many men as women [8]. The common methods used for the early detection of tuberculosis cases are (1) X-Ray (2) Sputum examination and (3) Tuberculin test. Primary billiary tuberculosis is an extremely rare entity in Pediatric age group from reported cases; this rare entity has scarcely been found in Pediatric age group [9-15].Currently 1/3 of the world's population are infected with tuberculosis bacillus with 8 million new cases and 3 million deaths due to tuberculosis estimated annually [16-21]. For better fighting against this disease, knowledge of pathogenic mechanisms and immune response provoked against this disease are essential [21-23].

MATERIALS AND METHODS

In the present investigation, a capillary viscometer technique is employed. This technique can measure volume flow rate, characteristic velocity, surface tension and viscosity. The quantity of sample required for the study is about 0.5 ml. About 40 patients suffering from Pulmonary T. B (all males) were selected to study hemorheological parameters of blood. Samples of volume 5 ml were drawn in the anticoagulant - EDTA at A.P. Chest Hospital, Hyderabad and brought to the laboratory in siliconised bottles and stored at 4˚c until use. The experimental investigations were completed within three hours after the collection. Plasma was separated from blood samples by centrifuging the blood at the rate of 1500 rpm about 15 minutes and the blood samples were prepared by mixing equal amount of plasma and erythrocytes. By this process hematocrit of sample is maintained to be constant.

2.1 Experimental

In the present investigation an open capillary viscometer was developed, based on the theory proposed, in order to study viscosity and surface tension, volume flow rate and characteristic velocity of blood and plasma (Fig). . The viscometer is nothing but a simple capillary tube of length of about 30cm with a inner radius of 0.05cm. The glass capillary tube was marked with two preset points.

Fig. 1. Viscometer

A and B and the distance between them is 10cm. A blood or plasma column of about 2 to 8cm in length sample of blood (or plasma) was sucked into the capillary tube by means of a rubber tube attached to one of the ends of capillary tube, through a pinchcock. The capillary tube was clamped vertically to a stand. The pinch cock arrangement controls the movement flow of liquid column between the preset terminals. The vertical clamping of the capillary tune with sample will set the liquid column into one-dimensional motion (Fig. 2.10). At the beginning

of the experiment, meniscus of column was set above the marked point A (upper mark). The timer was switched on the moment the meniscus of the liquid column passed the mark A, when the pinch cock was released. The timer was switched off at the moment the meniscus passed off mark B (lower mark). The timer records the time of the sample which traveled 10cm distance. The velocity was calculated from the ratio of the preset distance (10cm) and time. For different lengths of the liquid column the time of travel was recorded and velocity was calculated.

The velocity V of the blood column of length L is calculated as V = l/t.

Here

l = length of a fixed distance of 10 cm
L = length of blood column
t= time of flow of blood column to travel at a distance l.

A plot was drawn between L^{-1} on X - axis and V on Y- axis. The plot is a straight line with an intercept on Y-axis which confirms the theory. The intercept and slope of the straight line were measured. Viscosity and surface tension of the sample were calculated from the intercept and slope of the straight line, respectively, knowing radius of the capillary tube (R) and angle of contact (θ) of the sample with the capillary wall. Hence, radius of the capillary tube (R) was measured using a traveling microscope of L.C 0.001 cm. The angle of contact was measured by keeping a circular scale marked in degrees behind the capillary tube and viewing the meniscus of the sample through traveling microscope. It is not possible to measure angle of contact very accurately and hence if is approximated to 30^0 for both plasma and blood.

For ready assessment of the results, a computer program was written in C^{++} language. The experimental parameters length of sample column L, and flow time t, can directly be fed, to obtain viscosity and surface tension of the samples. Thus, the values of viscosity and surface tension of the sample can be obtained at a stretch with the simple technique. To examine the validity of the proposed technique, the parameters - viscosity and surface tension were determined for alcohol, benzene, carbon tetra chloride, whose values are available in literature. For further verification of surface tension of blood, capillary rise method was employed.

The following precautions were taken during experimentation:
(1) Care was taken to see that the capillary tube should be ultra clean, free from water because the presence of water leads to hemolysis of blood, which badly effects the viscosity measurements. Therefore, saline was used in the cleaning process of tube.
(2) No air bubbles should be present in the sample otherwise the flow of the sample may be decelerated.
(3) Ends of the capillary tube shouldn't posses sample molecules because surface tension acting decelerates the fluid motion. Therefore, proper care must be taken to eliminate the traces of the sample after the sample is sucked into the capillary.
(4) The capillary tube was held vertically; otherwise gravitational force would be affected.
The following conclusions are drawn from the present investigation.
(1) The capillary viscometer, developed in the laboratory, is simple, elegant and inexpensive.
(2) It is more advantageous with respect to the quantity of sample. Two of three drops of sample are sufficient for the viscometric analysis of the sample.
(3) It is the only technique which can measure viscosity and surface tension of a sample at a stretch.
(4) This technique may serve as a potential tool in the medical discipline, for diagnosis, drug administration and monitoring health of a patient suffering from any disease, in general, and thrombosis and cancer, in particular.
(5) This simple capillary viscometric techniques aided with computer program for data processing, may help a physician for diagnosis of a disease.
(6) The viscometric parameters such as viscosity and surface tension may be helpful, to some extent, for assessing the physiological fitness of a person.
(7) Biochemical and biophysical alterations in plasma proteins and environmental perturbations in cell physiology can be mirrored in viscometric data.

The expressions for coefficient of viscosity (η) and surface tension (T) are:

$\eta = (R\text{^}2\ \rho g)/8V$
$T = 4\eta\ \tan\alpha/R\ \cos\theta$

Volumetric flow rate (Q) is calculated using the relation

$$Q = V \pi R^2$$

Where V = Velocity of blood column obtained from the Y-intercept of the plot between 1/L on X-axis and velocity V on Y-axis.

RESULTS AND DISCUSSION

The below table shows that the hemodynamical data of blood ofpatients suffering from tuberculosis patients. The hemodynamical parameters studied are characteristic velocity, volume flow rate, coefficient of viscosity and surface tension.

Table 1: Data on hemodynamical parameters of blood of pulmonary tuberculosis of patients

Sample Code	Tan θ	V_0 ($cm.sec^{-1}$)	η (poise)	T ($dynecm^{-1}$)	Q (cm^3sec^{-1})
Normal		7.20	0.028	58	0.133
HB01	12.82	7.40	0.045	.53.88	0.058
HB02	12.12	7.50	0.044	49.26	0.059
HB03	15.38	10.1	0.033	46.88	0.079
HB04	20.0	10.0	0.033	62.07	0.078
HB05	11.76	7.75	0.043	47.14	0.061
HB06	13.13	8.60	0.039	47.42	0.067
HB07	11.11	7.55	0.044	45.15	0.059
HB08	08.00	5.70	0.058	42.86	0.045
HB09	15.15	9.50	0.034	47.58	0.074
HB10	20.83	11.0	0.030	58.88	0.086
HB11	17.85	9.40	0.036	60.02	0.074
HB12	12.00	6.95	0.050	55.42	0.054
HB13	16.66	9.65	0.036	56.02	0.076
HB14	09.75	6.15	0.057	51.51	0.048
HB15	17.64	10.7	0.031	51.00	0.084
HB16	20.00	11.4	0.032	59.12	0.090
HB17	20.0	9.05	0.037	68.72	0.071
HB18	11.42	6.75	0.051	54.54	0.053
HB19	13.33	7.05	0.049	60.95	0.055
HB20	19.23	11.0	0.032	58.26	0.086
HB21	13.79	8.20	0.043	55.66	0.064
HB22	19.04	9.70	0.039	68.77	0.076
HB23	30.00	14.7	0.024	68.45	0.115
HB24	12.12	7.50	0.047	53.40	0.059
HB25	22.58	11.7	0.031	64.66	0.092
HB26	15.38	8.00	0.046	65.21	0.063
HB27	14.28	8.10	0.045	59.36	0.069
HB28	24.00	13.4	0.026	58.75	0.105
HB29	14.28	7.10	0.050	66.48	0.060
HB30	18.18	9.55	0.039	64.99	0.075
HB31	13.79	7.50	0.047	59.74	0.059
HB32	12.9	6.45	0.056	67.21	0.050
HB33	12.0	7.50	0.048	53.76	0.059
HB34	15.38	8.55	0.041	58.96	0.067
HB35	15.78	9.60	0.036	53.35	0.075
HB36	11.42	7.15	0.052	54.85	0.056
HB37	14.28	8.20	0.044	57.77	0.064
HB38	13.51	8.10	0.044	54.66	0.063
HB39	18.75	11.4	0.030	52.65	0.089
HB40	11.11	6.75	0.053	54.60	0.053
HB41	12.19	7.80	0.046	52.47	0.061
HB42	11.42	6.66	0.053	56.44	0.052
HB43	11.42	7.80	0.046	48.45	0.061
HB44	16.66	9.30	0.036	56.32	0.073

It is observed from the data that the values of viscosity of blood (0.024 – 0.057 poise) are significantly high, when compared to that of normal blood (normal blood viscosity 0.028poise). The high viscosity of blood of patients

suffering from tuberculosis can be attributed to the interaction between erythrocytes and fibrinogen and other plasma proteins. No significant variation is observed in the case of surface tension of blood drawn from the patients suffering from pulmonary tuberculosis

Fig. 2

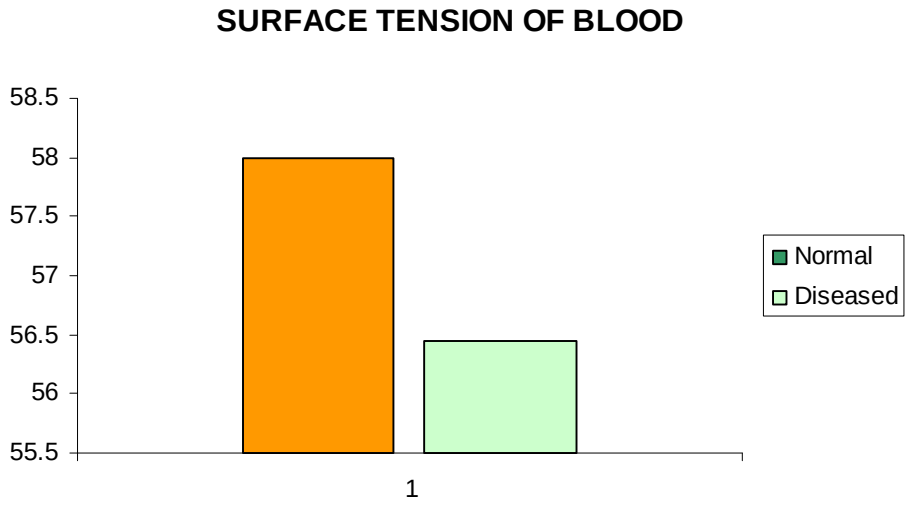

Fig. 3

In the present investigation on tuberculosis patients' blood and its plasma, it is observed that volume flow rate and characteristic velocity decrease considerably.

The study reveals the fact that any abnormality in human system at molecular, cellular, tissue and organ levels due to the influence of Tuberculosis can be mirrored in the viscosity of blood and its plasma. The increase in viscosity of blood of tuberculosis patients can be attributed to the following factors:

1. The conformational changes in plasma proteins
2. The interaction between erythrocytes and plasma.
3. Increase in the size of erythrocytes

4. Decrease in the hemoglobin content
5. Increase in the concentration of the clotting protein *fibrinogen* (N.manohar reddy etal.JPAP, 2009).
6. Aggregation of rouleaux formation of erythrocytes.

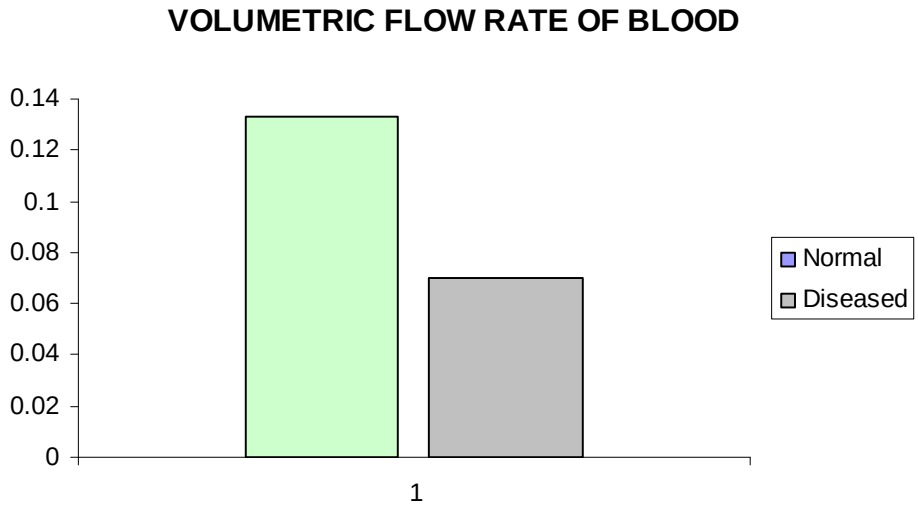

Fig. 4

The present study suggests that viscosity serves as a potential parameter to asses the degree of disease, because of the fact that the increase in viscosity is the main cause for the diseases such as cardio vascular, pulmonary, renal etc. by measuring the parameters *viscosity* and *surface tension* of blood, the chronic disease can be predicted in advance. All these days' hemodynamical parameters could not draw the attention of medical discipline for diagnosis of chronic disease due to the lack of availability of proper instrumentation and conceptual understanding.

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