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A study on effect of LASER radiation on hemodynamic parameters of human blood

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Abstract

The present study proposed a method for measurement of three important parameters involved in hemodynamics of human blood: coefficient of viscosity, surface tension and volume flow rate. These parameters contribute effectively the physiological condition of a human being. Although the viscous behavior of whole blood is due to the presence of large number of cells, the proteins present in plasma also contribute to the hemorhelogical behavior of blood at tissue level and at molecular level. The aim of the present investigation is to see the impact of laser radiation on viscosity, surface tension and volume flow rate of whole blood and plasma separately.

Keywords: *Viscosity, Surface Tension, Volume Flow Rate, Laser, Human blood, Plasma.*

1. Introduction

Viscosity of blood is an important biophysical parameter which ties blood pressure, cholesterol, Erythrocyte Sedimentation Rate (ESR) and hematocrit volume all together. The amount of hemoglobin present in whole blood is primary determinant of blood viscosity. For more complex fluids, such as blood which is a suspension of cells in liquid called plasma, viscosity depends upon complexity of the fluid and influenced by additional number of parameters, such as type of solvent, their molecular weight and conformation of solutes. Primary determinants of whole blood viscosity are hematocrit, erythrocyte deformability, plasma viscosity and erythrocyte aggregation.

Variation in viscosity reflects in case of any circulatory disorder and contributes effectively to physiological condition of a human being. Blood viscosity is measurement of the thickness of blood and is associated with various diseases either as a contributor or an effect. Viscosity is a characteristic property of a fluid and typically is a constant for a given liquid at a given temperature and pressure for a Newtonian fluid (Johnson, et al. 2010). The property of viscosity can be exhibited only under dynamic conditions. Low-viscosity samples flow more easily than those with high viscosity (Barbee, 1993) (B Turezynski, 2005).

It also becomes important to mention here that blood is microscopically defined as a two phase biological fluid. It is regarded as solid liquid suspension or more interestingly liquid-liquid emulation. The transition between suspension and emulation during the flow is one of the main reasons for the special rheological behavior of blood (Rubinov 2003).

In addition to viscosity, surface tension is also a key parameter which holds mass of blood together to form a drop. Surface tension is responsible for size of the blood cells which tries to keep the drop as small as possible.

The present study proposed a method for measurement of three important parameters involved in hemodynamics of human blood: coefficient of viscosity; surface tension and volume flow rate. In the present work all the three hemodynamic parameters were measured both for whole blood and plasma separately.

2. Expeimental Arrangement

Different types of viscometers are available to study the viscometric parameters of biological and non-biological fluids, which measure the viscosity in a unique way depending upon the type of fluid and conditions to flow. These are Dead load, capillary tube, Counter pressure, Glass, Rotational, falling ball and falling cylinder viscometers.

In the present investigation, a capillary tube viscometer was used which measure coefficient of viscosity, surface tension and volume flow rate of human blood at a stretch. The pathological samples of normal human blood were obtained from healthy people those who were not on any

ISSN 2348 – 7968

medication and were mixed with EDTA (Ethylene Diamine Tetra Acetic Acid) as an anticoagulant. Each sample was divided into two parts for irradiation and control. The measurements were taken within two hours after collecting the blood. Viscosity for whole blood and plasma has been measured at room temperature and after irradiating the sample. The duration for irradiation was 30 minutes. For separating the plasma from the whole blood, the samples have been centrifuged at 4000 rpm at room temperature for 15 minutes. Capillary tube viscometer is shown in Fig. (1), both the ends of capillary tube are open to the atmosphere and liquid column of the fluid is allowed to flow freely along the length of the capillary tube. As per fluid mechanics, there are various force acts on liquid column of a capillary tube. These are - Viscous force, Gravitational force, Surface tension force and Inertial force (Rao 2011).

Fig.1.Capillary tube viscometer

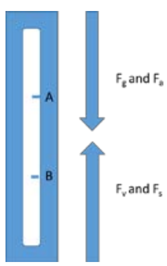

Fig.2. Free body diagram

The liquid column in the vertical capillary tube has upper and lower surfaces. When the liquid column is in motion, surface tension of the liquid causes the force on the upper surface but the lower surface does not experience the same force. Further, In the presence of external pressure, accelerated motion of the liquid also generates inertial force on the liquid column.

As mentioned in the Fig. 2 the forces Fv and Fs works in one direction (upwards) while Fg and Fa works in opposite (downwards) direction. Table 1 describes the various forces and formulae to calculate them.

Table 1. Various forces acting on free body flow

Forces	Parameters
Viscous Force – $F_v = 8\pi\eta L v$	*η - fluid viscosity coefficient* *v - velocity of the fluid column* *L - fluid column length*
Gravitational Force – $F_g = \pi R^2 L\rho g$	*ρ – fluid density* *R - capillary tube radius* *g - acceleration because of gravity*
Surface Tension Force – $F_s = 2\pi RT \cos\theta$	*T - surface tension of the liquid* *θ - angle of liquid contact*
The Inertial Force – $F_a = \pi R^2 L \rho (d^2 L / d t^2)$	$d^2 L / d t^2$ - *liquid column acceleration*

Resultant vertical force (F) applied on free flow liquid in a capillary tube will be summation of upward and downward forces and can be presented as

$$F = [F_g] + [-(F_v + F_s)] = F_a \quad \ldots(1)$$

Here values of F_v and F_s are mentioned as negative because they work in opposite direction to F_g

In the experimental arrangement, the flow time was measured for blood sample by using stopwatch manually. The tube length was selected typically as 30 centimeters with radius of 0.05 centimeters. The tube was held vertically and two points are marked on the capillary tube (A and B) at the center with a minimum separation of 10 cm. The time for flow of biological fluid for a fixed distance is measured with an accuracy of 0.01 second. The capillary tube viscometer can be used for obtaining the

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surface tension, viscosity coefficient and volume flow rate of liquid at a stretch.

The minimum length of the blood column was taken as 2 cm and it was filled initially till point A marked on the tube. The flow time was measured for movement of blood from point A to point B. the experiment was repeated for different length of the column (maximum 5 cm) for the same blood sample. The same procedure is followed for measurement of all three parameters together for plasma as well.

Result:

The study of hemorheology has been of great interest in the fields of biomedical engineering and medical research for many years. Hemorheological parameters in clinical studies are generally concerned with the individual components of blood (erythrocytes, leucocytes, platelets and plasma) which collectively influence the behavior of blood. The parameters measured under this aspect are: coefficient of viscosity, dynamic surface tension and volume flow rate of whole blood and plasma.

Coefficient of viscosity, surface tension and volume flow rate of laser irradiated blood decrease considerably, when compared with that of normal blood Fig.4(a), and Fig. 4(b) while an increase is observed in the case of plasma.

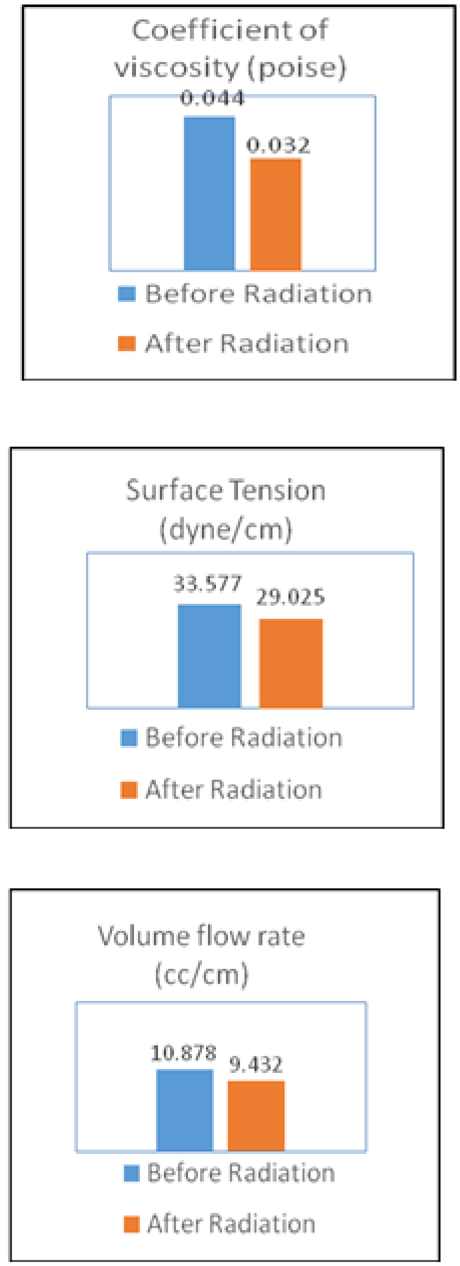
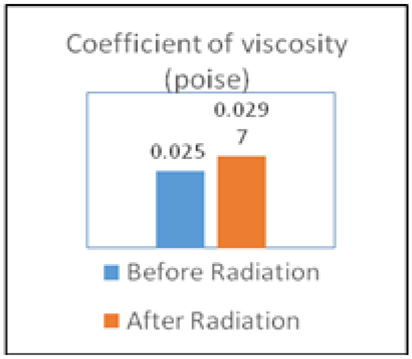
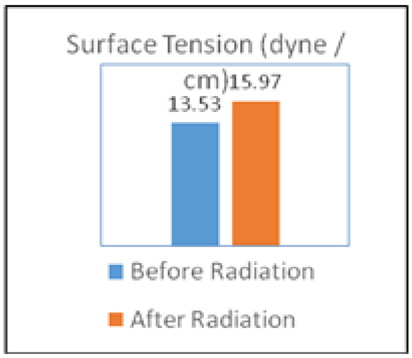


Fig. 4(a). Coefficient of viscosity, surface tension and volume flow rate of blood.

ISSN 2348 – 7968





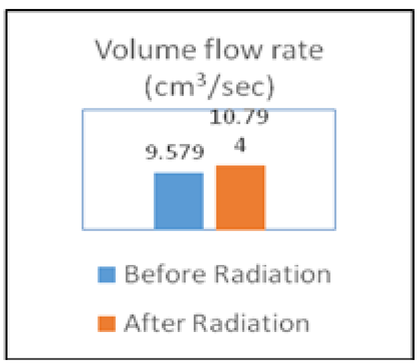


Fig. 4(b). Coefficient of viscosity, surface tension and volume flow rate of plasma.

4. Conclusions

The decrease in viscosity, surface tension and volume flow rate of laser irradiated blood may perhaps be attributed to the following factors:

1. The conformational changes in plasma proteins.
2. The interaction between erythrocytes and plasma.
3. Decrease in the size of erythrocytes.
4. Aggregation or roulex formation of erythrocytes.

The increase in viscosity, surface tension and volume flow rate of laser irradiated plasma can be due to the fibrinogen present in plasma which is regarded as an important determinant of hemorhelology at molecular level.

References

[1] Barbee, James H. 1993. "The effect of temperature on the relative viscosity of human blood." Biorheology 10 (1): 1.

[2] Johnson, S. A., B. M. Stinson, M. S. Go, L. M. Carmona, J. I. Reminick, X. Fang, and T. Baumgart. 2010. "Temperature-dependent phase behavior and protein partitioning in giant plasma membrane vesicles." BiochimicaetBiophysicaActa (BBA)-Biomembranes 1798 (7): 1427-1435.

[3]Rao, C. Ramakrishna. 2011. " Biophysical investigations on blood of cancer patients."

[4] B Turezynski, Michalska Malecka, L Slowniska and Szezesny S ,Romaniuk, (2005) J.Diabetes complication, Vol.19, pp.128.

[5] Pries, A. R., D. Neuhaus, and P. Gaehtgens. 1992. "Blood viscosity in tube flow: dependence on diameter and hematocrit." American Journal of Physiology-Heart and Circulatory Physiology 263 (6): H1770-H1778.

[6] Rubinov, A. N. 2003. "Physical grounds for biological effect of laser radiation." Journal of Physics D: Applied Physics (36) 19: 2317.