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EFFECT OF LASER RADIATION ON ELECTRICAL CONDUCTIVITY OF HUMAN BLOOD

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Abstract: The aim of this paper is to study the effect of He Ne Laser radiation on electrical conductivity of human blood. Interaction of laser radiation with biological tissue has wide applications in clinical pathology starting from diagnosis of the disease to the treatment. Choice of blood is taken as an object for investigating the effect of laser radiation on electrical parameter of blood as blood is a component of nearly all biological tissue. The numerical value of conductivity is assumed to be varying with several factors. These are concentration of erythrocytes, hematocrit volume and moreover the liquid composition of blood (plasma) which conducts electricity due the presence of ions (salt and proteins) [1]. During the interaction of laser radiation with biological tissue the light rays get scattered and at the same time an amount of light can get absorbed by the tissue [2]. To understand the process of scattering and absorption it is necessary to understand the microscopic behavior of blood as blood is a suspension of cells of different shapes and size. The main centers of interaction are erythrocytes as they are sufficiently large in number as compared to other constituents of blood. Therefore it is important to know the number of erythrocytes which is also determined by hematocrit volume (number of erythrocytes per unit volume of the blood), to understand the behavior of whole blood. The paper discusses the structure and composition of blood and effect of these components on conducting behavior of blood.

Keywords: Conductivity, laser radiation, plasma, whole blood.

INTRODUCTION

An understanding of conductivity of blood is essential parameter for determination of interfacial potentials during the flow of blood. A thorough study of electrical conductivity of human blood has been done with respect to the effect of laser radiation. Literature shows that the erythrocytes almost behave like a perfect nonconductor of direct current [3]. Later studies showed that the only the surface layer of the erythrocytes is nonconductive which offers the resistance to flow of blood while the inner structure of the erythrocyte had a conducting medium which is almost half of the conductivity of the plasma [4,5]. Literature also revels the fact that erythrocyte does not conduct direct current and act as a dielectric medium at sufficiently high frequency.

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Subsequent investigations in last two decades further explain the electro physical characteristics of red blood cells. It should also be noted here that resistance offered by the blood is proportional to the hematocrit volume which means that red blood cell count has direct impact on the conductivity of blood. Conductivity of plasma depends upon electrolyte contents and concentrations (salt and proteins).

MATERIALS AND METHODS

For measurement of conductivity a digital conductivity meter 909, (Digisun Electronics) has been used. It consists of a PDMS chamber and two electrodes which are separated with a small gap of the order of micrometer. Before measuring the conductivity of the given sample the digital meter has to be calibrated by using 0.01 N KCl solutions. After calibration the electrodes should be removed from KCl and washed with distilled water. The meter is now ready to measure the conductivity of the given sample. The conductivity is measured both for whole blood and plasma at room temperature and after effect of radiation for specific time duration. For effect of radiation He-Ne Laser with the radiation wavelength 632.8 nm, power density 100 mW, beam diameter 5mm was used as a source of interaction with human blood because of the following characteristics:

1. Small angular divergence and high specific power density of laser beam can have advantage to restrict the interaction to relatively small volume of blood in the investigation.
2. Mono chromaticity (single wavelength) of the source plays an important role and simplifies theoretical calculations for comparison of experimental results with the theory.

The blood samples have been collected from the normal healthy people those who were not on any medication. The samples were mixed with EDTA as an anticoagulant to prevent the coagulation and all the experiments were performed within two hours of collection of blood.

Biological fluids generally contain ions. In the presence of an electric field these ions give rise to an electric current within the fluid. The movement or mobility or ionic conductivity of these ions is influenced by several chemical and physical parameters. Some of the parameters restrict the flow of ions while others impel the flow. The chemical complexity of the biological fluids imposes the restrictions and makes it difficult to give an accurate theoretical analysis of the electrical conductivity.

However, microscopic study of the fluid will give rise to an understanding of overall behavior of the fluid. Once these factors are known it is then essential to relate them to the morphological and biochemical structure of the biological fluids. The parameters which influence the electrical conductivity of the whole blood are: erythrocyte sedimentation rate (ESR), red blood cell count, hematocrit volume, plasma constituents (salt, proteins etc). With the knowledge of the chemical compositions of the blood, the possible changes of these chemical compositions are also required when the biological fluid is subjected to radiation.

RESULTS AND DISCUSSION

In vitro study of biological fluid, the measurement of electrical conductivity or settling of the erythrocytes strongly depends on the position of the conductivity cell. Because of the process of settling down of erythrocytes the measurements of electrical conductivity should be performed immediately after a uniformly dispersed sample is placed in the conductivity cell. Electrical conductivity of whole blood shows a significant increase after radiating the sample with a He-Ne laser of output power 100 mW as shown in Figure 1. Data on effect of low level laser radiation on the electrical conductivity of human blood has been presented in table 1.

Sample Code	Before radiation (millimho)	After Radiation (millimho)	% Increase
S1	1.96	2.32	18.40
S2	1.72	2.30	33.70
S3	2.61	3.01	15.30
S4	1.36	1.62	19.10
S5	2.72	3.31	21.70
S6	2.81	3.75	33.50
S7	2.86	3.39	18.50
S8	3.30	3.90	18.20
S9	2.03	2.42	19.20
S10	3.29	4.38	33.10

Table 1. Data on electrical conductivity of whole blood before and after radiation

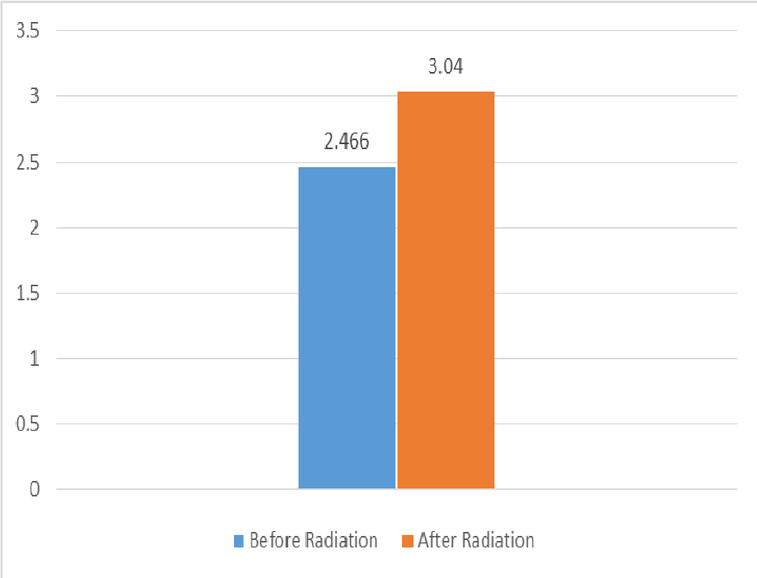

Figure 1. Average Electrical Conductivity (in millimho) of whole blood before and after radiation

The reason for such variation is understandable as various activities take place during the interaction of laser radiation with blood. The first activity is based on photodynamic action of laser radiation where the energy is transferred to oxygen present in the whole blood. Than with respect to the time duration of irradiation, photo dissociation starts, this indicates interaction of radiation with hemoglobin. And finally a part of radiation converted into heat that is referred as local heating of cell which causes change in temperature at local site [6,7]. However because of intensive blood circulation, there is not significant change in the temperature of the whole blood but the conductivity of whole blood changes. A significant increase in controlled and irradiated blood samples is found. The laser radiation increases the conductivity of whole blood by 15 to 35 %.

CONCLUSION

The present study investigated the effect of Low Level Laser Radiation (LLLR) on electrical conductivity of the human blood. Laser tissue interaction is of great interest because it permits not only the information about the optical characteristics of the biological tissue but also provide the information about change in the electrical and optical parameters. Electrical conductivity is one of the important parameter associated with the overall rheology of the blood. Results of present investigations indicate that laser radiation act both at tissue level and molecular level which results in change in conductivity of whole blood. This study uses the digital conducting meter for measurement of electrical conductivity. He-Ne laser (100 mW output power, 632.8 nm wavelength and 5 mm beam diameter) was used for irradiating the samples. Experimental results provide useful information about change in biophysical parameter with effect of laser radiation.

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