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Effects of Mobile Phone Radiation on Surface Tension and Volume Flow Rate of Human Blood groups

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ABSTRACT

Introduction: The great use of electrical appliances in different life applications is one of the most obvious concerns because of its possible health drawbacks. These investigation reports results of electromagnetic field effect emitted from mobile phones on some biophysical parameters of human blood belonging to blood groups A, B, AB & O collected from the normal persons. The parameters observed are surface tension, volume flow rate of blood. This article displays a comparative data of the above parameters for control group and test group.

Materials and Methods: The blood samples were collected from healthy persons and stored in heparin as anticoagulant. The test samples were exposed with mobile phone up to 1 hour with the interval of 15 min. The parameters such as surface tension and volume flow rate of normal and irradiated blood samples were measured using capillary viscometer, developed at Biophysics Laboratory, Nizam College, Osmania University, Hyderabad, India.

Results: It is interesting to note that surface tension of blood, irrespective of blood group, is increased significantly, when blood exposed to radiation produced by mobile phone. Volume flow rate decreases significantly in A, B and AB blood groups, and increases in blood group O, when blood exposed to radiation produced by mobile phone.

Conclusion: Mobile phone radiation has significant effect on surface tension and volume flow rate of human blood of different blood groups.

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Introduction

Mobile phones are now an integral part of modern telecommunications. In many countries, over half the population use mobile phones and the market is growing rapidly. In 2014, there is an estimated 6.9 billion subscriptions globally. In some parts of the world, mobile phones are the most reliable or the only phones available. Given the large number of mobile phone users, it is important to investigate, understand and monitor any potential public health impact [1].

Blood is the liquid connective tissue that is the transport medium of the circulatory system. The two main functions of blood are to transport nutrients and oxygen to the cells and to carry CO_2, urea and other wastes away from the cells. Blood also transfers heat to the body surface and plays a role in defending the body against disease [2].The tendency of a liquid is to minimize the area of its surface by contracting. This property causes liquids to rise in a capillary tube, affects the exchange of gases in the pulmonary alveoli, and alters the ability of various liquids to wet another surface. Volume flow rate and surface tension are the crucial blood parameters and affect many vital functions of human body.

World Health Organization (WHO), in 1996, has started an international project that called electromagnetic fields project (EMF project) [3]. It has collected evidence relevant to the effects of electromagnetic filed on human health. So far, no strong evidence has been found for the health effects of mobile phone [4 -5- 6]. However, sometimes cancer symptoms and tumors signs were suspected because of the long time (a few decades) and continuous use of mobile phone. But researchers could not clearly reject or confirm the role of mobile radiation on tumors or cancer [7].

Many studies reported that radiation from mobile phones absorbed by the human body turns into heat. This biological effect leads to the continuation of the existence of many damage risks caused to human and their vital organs [8]. These findings have confirmed the report of the Australian Radiation Protection in 2005, where 70% of the waves emitted by mobile phone is absorbed in the user's head which leads to increase the speed of nerve impulses; blood pressure; heart rate that exposure to

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electromagnetic waves leads to an imbalance in the circulatory system; increase in blood flow; disruption in blood pressure [9,10];and decrease in the hemoglobin content [11];altered in two proteins in skin cell of volunteers[12];and next investigation reports significant change in viscosity of human blood[13];hematological blood cell factors[14]; size and shape of red blood cells of human blood[15]; tympanic temperature[16].With this background in mind, the aim of the present investigation was to determine effects of mobile phone electromagnetic radiation on surface tension and volume flow rate of human blood.

Materials and Methods

Blood samples of groups A, B, AB & O of volume 5 ml each were collected from 20 healthy male volunteers aged 18 to 60 years and were stored in heparin as anticoagulant. Each sample was divided into 2 parts. First part was control sample of volume 1 ml. Second part was test sample of volume 4 ml, which was again divided into 4 equal parts. The test samples were exposed to EM field produced from mobile phone for an hour with an interval of 15 min (distance between mobile phone and sample is 10 cm). The first test sample was exposed for 15 min. Similarly, second, third and fourth samples were exposed for 30 min, 45 min and 60 min respectively. The mobile phone used is Nokia X2-02. The network technology is GSM (Global system for mobile communication) 900/1800 MHz. The Specific Absorption Rate (SAR) is 0.91 W/kg.

The parameters such as surface tension and volume flow rate of normal and irradiated blood samples were measured using capillary flow meter, developed at Biophysics Laboratory, Nizam College, Osmania University, Hyderabad, India.

Figure 1 Shows experimental setup, which is a simple capillary tube of length of about 30cm with an inner radius of 0.075cm, marked with two preset points A and B at the distance between them is 10 cm. The capillary tube is held vertically as shown in Figure 1.

A column of about 2 to 8cm in length of blood sample was sucked into the capillary tube. Vertically holding the capillary tube with sample will set the blood column into one-dimensional motion.

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 blood column passed the mark A. 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.

Figure 1. A simple Capillary flow meter

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. Surface tension and volume flow rate 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 at a distance through cathetometer [17]. 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 found, to obtain viscosity, surface tension and volume flow rate of the samples. Thus, the values of viscosity, surface tension and volume flow rate of the sample can be obtained at a stretch with the simple technique. The formulae used to calculate surface tension (T) and volume flow rate (Q) are [18]:

$T = (R\rho g \tan\alpha) / (2v_0 \cos\theta)$

$Q = v_o \pi R^2$

Where v_o: Velocity of blood column obtained from the Y-intercept of the plot; between L^{-1}on X-axis and velocity (v) on Y-axis ($cm.sec^{-1}$); R: Inner radius of the capillary tube (cm); ρ : Density of blood ($gm.cm^{-3}$); g : Acceleration due to gravity: 980 $cm.sec^{-2}$ θ :Angle of contact of the sample with the capillary wall: 30^0; α: Slope of the plot between L^{-1} on X-axis and velocity (v) on Y-axis.

Results

Table 1 and Figure 2 show data on average values along with SD of surface tension of normal and exposed blood of groups A, B, AB and O for the time of exposure up to 1 hour with an interval of 15 min.

Table 1. Data on Average values of Surface Tension of normal and exposed human blood

Blood Group	Average values of Surface Tension, T (dyne.cm^{-1}) for Exposure time of					
	0 min	15 min	30 min	45 min	60 min	% Change for 60 min
A	61.09±4.01	63.77±10.75	69.32± 8.58	71.03± 5.51	76.29±6.20	24.83±4.71
B	60.47±4.58	65.18± 5.47	69.45± 4.55	72.12± 1.73	76.48±3.85	21.72±3.59
AB	61.72±2.87	66.70±3.57	69.58±3.88	73.40±5.77	80.10±3.08	29.86±3.94
O	61.44±4.45	64.52± 4.15	67.45± 5.75	76.68± 8.87	79.75±5.83	29.82±1.42

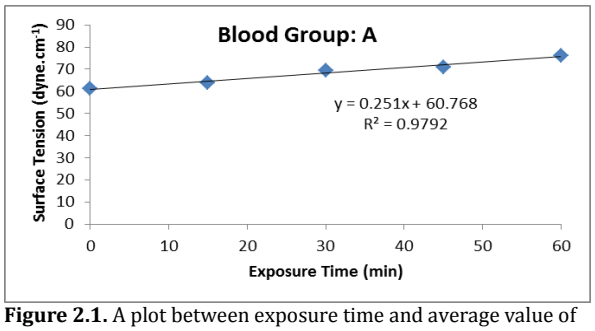

Figure 2.1. A plot between exposure time and average value of Surface Tension of blood of group A

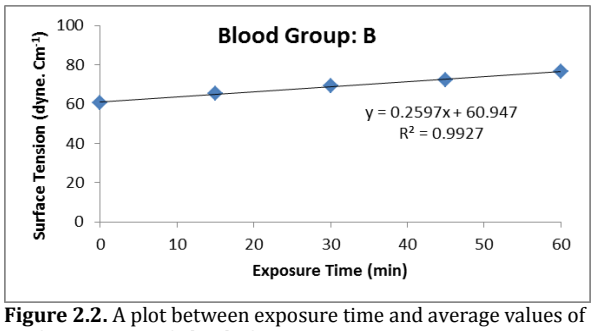

Figure 2.2. A plot between exposure time and average values of Surface Tension of Blood of group B

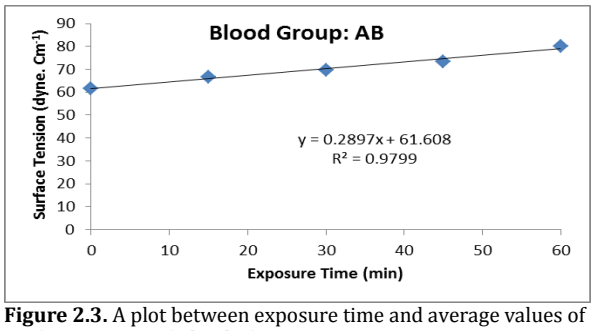

Figure 2.3. A plot between exposure time and average values of Surface Tension of Blood of group AB

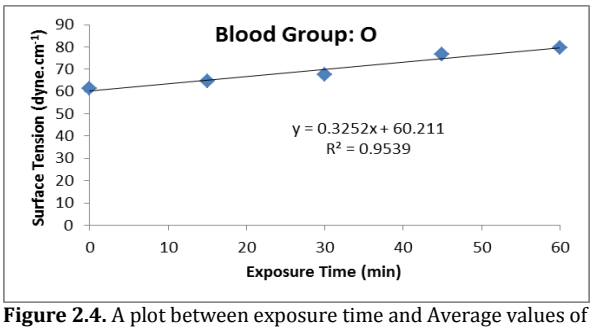

Figure 2.4. A plot between exposure time and Average values of Surface Tension of Blood of group O

Also table shows percentage change in average value of surface tension, when blood samples are irradiated with mobile phone for 1 hour duration. It is evident from the table that surface tension of blood, irrespective of blood group, is increased significantly, when blood exposed to radiation produced by mobile phone. Here, exposure time of zero min means normal (unexposed) blood.

Table 2 and Figure 3 show data on average values along with SD of volume flow rate of human blood of groups A, B, AB and O of normal and also exposed to EM radiation produced by mobile phone up to 1 hour with an interval of 15 min. The table also shows percentage change in average values of volume flow rate, when blood samples are exposed to mobile phone radiation for 1 hour duration. Here, exposure time of zero min means normal (unexposed) blood. It is evident from the table that volume flow rate decreases significantly in A, B and AB blood groups, and increases in blood group O, when blood exposed to radiation produced by mobile phone.

Table 2. Data on Average values Volume Flow Rate of normal and exposed human blood

Blood Group	Average values of Volume Flow Rate, Q (cc/sec) for Exposure time of					
	0 min	15 min	30 min	45 min	60 min	% Change for 60 min
A	0.300±0.038	0.276±0.031	0.272±0.040	0.259±0.043	0.244±0.029	-18.55 ± 2.89
B	0.289±0.020	0.275±0.030	0.276±0.025	0.250±0.017	0.244±0.022	-15.60± 2.43
AB	0.284±0.062	0.250±0.056	0.242±0.043	0.237±0.056	0.222±0.057	-22.24± 3.90
O	0.257±0.037	0.274±0.055	0.272±0.028	0.292±0.039	0.313±0.044	21.94± 3.73

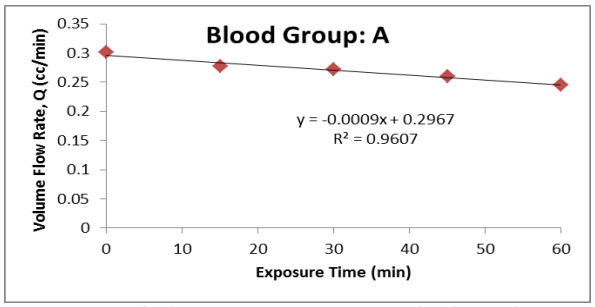

Figure 3.1. A plot between exposure time and Volume Flow Rate of blood of group A

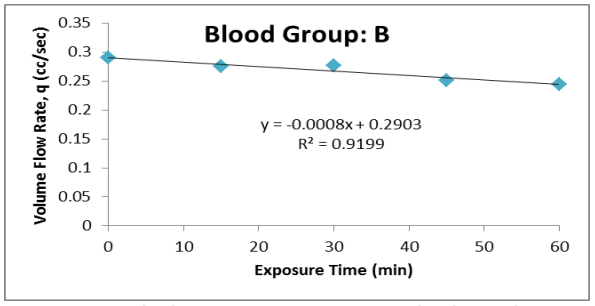

Figure 3.2. A plot between exposure time and Volume Flow Rate of blood of group B

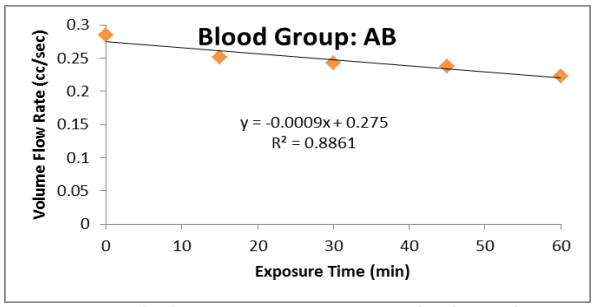

Figure 3.3. A plot between exposure time and Volume Flow Rate of blood of group AB

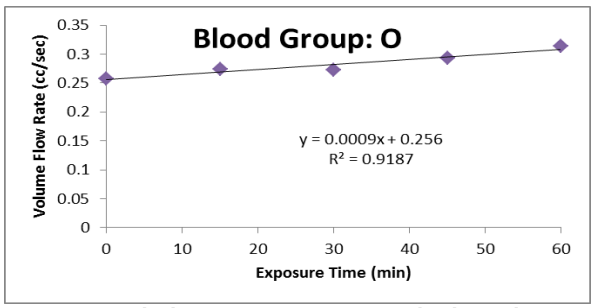

Figure 3.4. A plot between exposure time and Volume Flow Rate of blood of group O

Discussion

Surface tension is exclusively a molecular phenomenon. Hence, one should take into account various forces that act between the molecules of liquid. There are two types of intermolecular forces:

1. Force of attraction between the molecules of two different materials known as *adhesive force*.
2. Force of attraction between the molecules of same liquid known as *cohesive force*.

If a film of liquid is considered, the molecules inside will experience a resultant downward force. Work has to be done against the downward cohesive force in order to bring a molecule from within the liquid to the free surface. Consequently potential energy of the molecule increases. This means potential energy of the free surface is greater than that of any other layer of the liquid, since any mechanical system tries to come back to a state of minimum potential energy. The free surface of the liquid also tries to the same and in the process, a contraction in the area takes place. As a result, the free surface always experiences a tension, which is nothing but *surface tension* of the liquid. The surface tension of a liquid depends on the nature of media in contact with the surface.

In this study, surface tension which biophysical parameters of the blood increases linearly with the increase in time of exposure of EM field generated by mobile phone, irrespective of blood group. However, the percent change in surface tension is more in blood group O than that of other blood groups (Figure 2.5.)

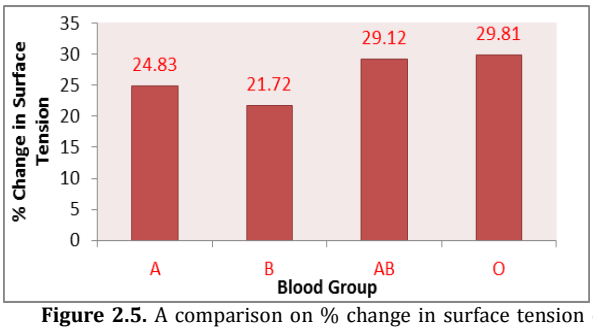

Figure 2.5. A comparison on % change in surface tension of exposed human blood of different Blood groups

Volume flow rate of blood is inversely proportional to the viscosity. Interestingly, volume flow rate linearly decreases in A, B and AB blood groups and increases in O blood group with the time of exposure of mobile phone EM field. It is evident a significant effect in volume flow rate of blood due to the exposure to mobile phone radiation. The volume flow rate decreases linearly with the increase in exposure time in the case of blood groups A, B and AB. Further, percent change in volume flow rate of blood of group AB is low when compared to other groups. The decrease in volume flow rate may perhaps be due to the aggregation of erythrocytes and can be attributed to the presence of antigens (A & B) in the erythrocyte membrane. It is interesting to note that rheological behavior of blood of group O is different to other blood groups. In this case, volume flow rate increases with the increase in exposure time. It may be the fact that erythrocyte membrane of exposed blood of O group, having no antigen A or B, becomes more fragile and hemolysis takes place. Further, the percent decrease in volume flow rate of

blood of group AB, exposed to mobile phone radiation for 1 hour, is more than that of blood of A and B groups. However, volume flow rate of irradiated blood of groups A, B and AB is less and more for O group than that of normal (unexposed) blood (Fig. 3.5.).

The present study suggests that the effect of EM radiation, produced by mobile phone, is blood group dependent and sensitive to the antigens (A and B) present in erythrocyte membrane.

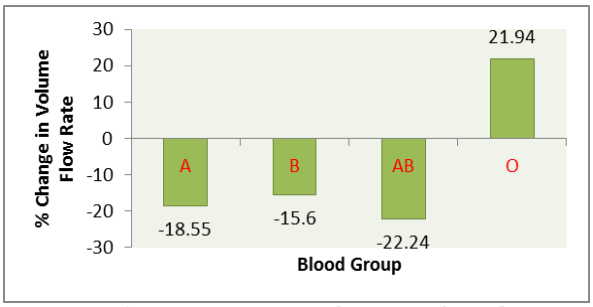

Figure 3.5. A comparison on % change in volume flow rate of exposed human blood of different blood groups

Some previous studies have also investigated the possible effects of mobile phone electromagnetic waves on biophysical parameters of the blood, however there are few articles related to the surface tension and even fewer to the surface tension of human blood and also about volume flow rate of blood. In addition we did not find any paper about the effect of mobile phone radiation on blood surface tension and volume flow rate. In this regard, similar to the present study, Somayeh Arian Rad (2015) investigated the influence of electromagnetic radiation produced by mobile phone on viscosity of human blood, The viscosity increases linearly with the increase in exposure time in the case of blood groups A, B and AB, however rheological behavior of blood of group O is different to other blood groups. In this case, viscosity decreases with the increase in exposure time. This study suggested that the effect of EM radiation, produced by mobile phone, is blood group dependent and sensitive to the antigens (A and B) present in erythrocyte membrane [13]. There is inverse relationship between volume flow rate and viscosity of blood. So these results were perfectly consistent with the findings of the present study in the case of volume flow rate of blood. When human blood is exposed to mobile radiation, erythrocytes aggregate in A, B and AB blood groups and hemolyse in blood group O [13]. But in these two different situations for surface tension of blood and viscosity of blood, surface tension of blood increases. Hence, this clearly shows that plasma may perhaps be playing the role in increasing surface tension of exposed blood, but not the erythrocytes.

There is relation between osmotic fragility and volume flow rate, in the other words increased hemolysis of RBC increases the volume rate of blood. Our results of volume flow rate of blood are in good agreement with previous studies which were about electromagnetic field effect by mobile phone on osmotic fragility of blood which the percent hemolysis of blood was altered in exposure groups [19-20].

Conclusion

From the present investigation, the following conclusion can be drawn:

Mobile phone radiation has significant effect on surface tension and volume flow rate of human blood of different blood groups. These parameters have blood group specificity.

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