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Effects of the Wireless (2.45 GHz) Electromagnetic Fields on Blood Cells in Rat

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ABSTRACT

The study aims to investigate hematological parameters, blood cell diameters and shapes of rats exposed to 2.45 GHz wave frequency EMF. All of the subjects were divided in three groups as cage control group (n = 30), pseudo-exposure group (n = 30) and 2.45 GHz EMF exposed group (n = 30). The rats in the magnetic field group were exposed to a frequency of 2.45 GHz wave EMF power of 1 mW/cm2 for 120 minutes a day for 2 weeks. The effects of the electromagnetic field on blood levels in rats exposed to 2.45 GHz were compared. The mean lymphocyte count of 2.45 GHz group was lower than in the control group, the number of monocytes in the 2.45 GHz group was higher than the control group. The mean platelet count in the experimental group exposed 2.45 GHz was observed more intense than the control group. Exposure conditions of EMF emitted from wireless devices should be examined and in accordance with these terms the necessary corrections are being made and national standards should be determined. To continue research on this subject is important in terms of scientific and public health.

1. INTRODUCTION

Today, cell phones, radars, TV and radio transmitters, microwave ovens, wireless networks, bluetooth, etc. can be counted as the sources constituting the electromagnetic field [1]. Radiofrequency waves emitted from wireless networks which are in the sources of EMF, increasingly affect the large communities [2]. As a consequence, there has been increased interest in studies of electromagnetic contamination at this frequency and of related thermal and non-thermal effects in biological systems[3].

EM waves have two main effects on the tissues. The first is a thermal effect; the latter is also known as non-thermal or chemical effects. The thermal effect takes place formally accepted or higher values, the chemical effect occurs at low doses below the limits of danger. Long-term low-dose exposure is considered to be a more risky short-term high-dose[4].

Today we are informed that these waves are harmful to human health in the light of publications, it is possible that this issue may become an important health problem shows. Neuronal electrical activity, energy metabolism, genomics responses, neurotransmitter balance, blood brain barrier permeability, cognitive related to function, sleep and its effects on various brain-related diseases many publications have been made[5].In many studies related to exposure to EMF; weights, morphology and histology of organs, hematological parameters, biochemical parameters, hormones, immune system and blood electrolyte their effects on their levels were examined and different results were found [6].

Electromagnetic waves can cause a great deal of confusion in the human organism. For example, the balance between the molecules and atoms of the body may be lost, biochemical activities may be affected, and most importantly, the electrical structure that is important in the functioning of the cell, and therefore the tissues, may be impaired. Correlated disorders may occur in the cardiovascular system, immune system and nervous system. One of the issues that have been brought to the agenda is that the constant weakening of the body's immune system will increase the formation of cancer or have an effect that initiates or triggers cancer [7,8].

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Matausic and et al., rats were exposed to 2.45 GHz with an average power density of 10 mW/cm2, five days a week for 30 days. The results showed that in total erythrocytes a negligible [9]. Black and Heynick have reported that exposure to radiofrequency electromagnetic fields can turn lymphocytes into lymphoblasts (active cells undergoing mitosis). Although current findings indicate a significant increase in the number of blood cells following microwave radiation, the mechanism, and pathology of this increase need to be confirmed before making any meaningful conclusions [10].

Various studies were performed in order to show the effects of radiofrequency radiation on peripheral blood and bone marrow cells. Vijayalaxmi et al. have not found any effect when they have analyzed peripheral blood and bone marrow cells of rats exposed to 2.45 GHz RF radiation for 24 hours. In long-term animal studies, it has been reported that the increase in the frequency of micronuclei in eukaryotic cells may be important in order to show the effect of RF radiation [11]. Juutilainen et al. have not demonstrated any effect in erythrocyte precursor cells of transgenic rats after 52 and 78 weeks of exposure to RF radiation [12].

Robert et al. did not find a significant difference between the groups of human mononuclear leukocyte cultures exposed to 2.45 GHz RF-EMF; 4 W/kg for 2 hours. Similar results were obtained for 0.5 W/kg and medium SAR. Significant differences between the total groups were found for DNA, RNA and protein synthesis [13].

Olcest was observed as a result of the test performed on rabbit blood with hemoglobin level and the number of red blood cells which were the logical effects of 2.45 GHz frequency and SAR that, hemoglobin did not decrease and Na+ and Rb+ increased [14]. Galvin did a similar test; different hematological values were observed in hemoglobin level and the number of red blood cells for a period of eight hours, using a 2.45 GHz continuous wave by increasing 2 mW/cm2 to 10.00 mW/cm2 [15].

In this study, it has been aimed to investigate hematological parameters, blood cell diameters and shapes of rats exposed to 2.45 GHz wave frequency EMF.

2. MATERIALS AND METHODS

2.1. Working Groups

In this study, weighing 200-250 grams, 10-12 weeks 90 healthy male Wistar Albino rats were used as test subjects. This study was performed at Suleyman Demirel University, Laboratory of Department of Bioengineeering. The experiments are suitable for the directive of the Suleyman Demirel University Ethics Committee. All subjects were obtained from Suleyman Demirel University School of Medicine Animal Laboratory production under standard laboratory conditions Subjects during the study (2 days) were held in the plastic cages, in each cage was used for maximum a five of them.

During this period, they could drink water and feed as much as they want (ad libitum). The room was arranged to be 12-hour light and 12-hour dark. In addition, the experimental ambient temperature was held a range of 22- 23 ° C during the study. All of the subjects were divided into three groups as cage control group (n = 30), pseudo-exposure group (n = 30) and 2.45 GHz EMF exposed group (n = 30).

I. Group: Cage control group (n=30):

This group of rats was fed with a standard diet (pellet feed) for 2 weeks. A restricted diet has not been given. Like drinking water, tap water was given for 2 weeks. They were kept in a cage far away from the magnetic field.

II. Group: Pseudo-exposure group (n=30):

This group of rats was fed with a standard diet (pellet feed) for 2 weeks. A restricted diet has not been given. Like drinking water, tap water was given for 2 weeks. During the exposure of the magnetic field to other groups of rats, due to thinking they may experience stress because of putting a narrow cage, the rats in control group also were kept in a far environment from the magnetic field putting in the same system at the same time and for the same duration.

III. Group: 2.45 GHz EMF exposed group (n=30):

They were fed for 2 weeks with standard rat pellet feed. Like drinking water, tap water was given for 2 weeks. To provide exposure to the magnetic field, monopole antenna and a system have been established that only one rat can fit into and provide exposure for 6 rats at the same time. These group rats were exposed to radiation which is the lowest level that can be arranged (max. 1 W). They were subjected to a 2.45 GHz frequency magnetic field from the same distance 120 minutes a day, every day for 2 weeks.

2.2. Experimental Design

Rats were put in plastic tubes of 5.5 cm diameter and 12 cm long. For rats placed into the tube, a system was organized that to be an equal distance from the monopole antenna. With 2.45 GHz half-wave monopole antenna used as a source of EMF, rats were exposed to radiation of maximum 1 W/kg power density. Changes in the close field of the power density of the monopole antenna were measured by Suleyman Demirel University Electrical and Electronics Engineering Research Laboratory of Electromagnetic Pollution. In Fig. 1, Fig. 2, and Fig.3 it has been shown that the rats were exposed to the 2.45 GHz electromagnetic field.

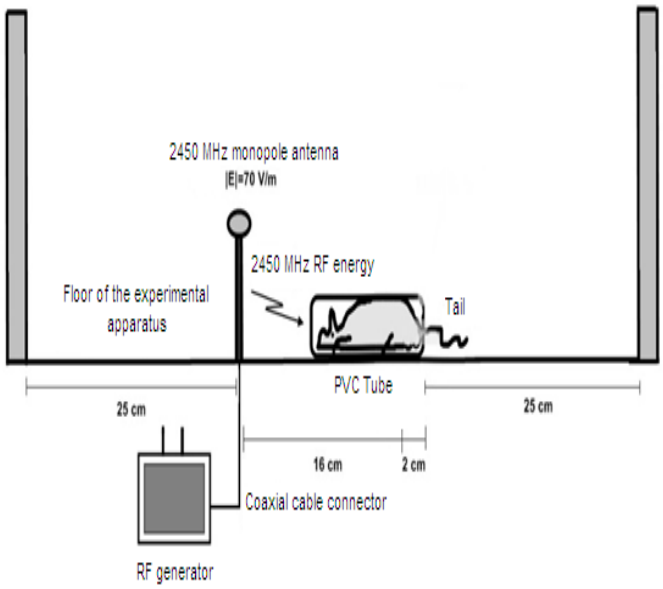

Fig 1. The Appearance of the Experimental Setup

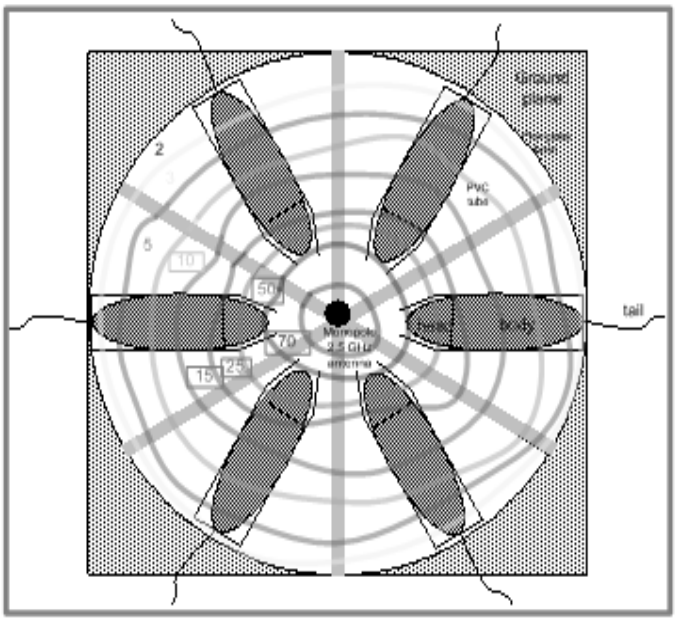

Fig 2. Schematic View of the 2.45 GHz Electromagnetic Field Application Setup

Fig 3. Plastic Tube and Monopole Antenna Assembly in which the Rats are Placed

At the end of the experimental period, the animals were anesthetized with the combination ketamine (50 mg/kg) and xylazine (5 mg/kg) by intraperitoneal injection. Immediately peripheral blood smears were made with the blood from vein of each rat. Samples were stained with MayGrünwald and Giemsa stain. Photographs of preparations were taken under Olympus CX-41 type light microscope from preparations.

2.3. Statistical Analysis

The values in the table represent the mean ± standard deviation (X ± SD) of the least squares. The lymphocyte, monocyte, neutrophil, eosinophil, basophil and erythrocyte levels in the three rat groups were analyzed using a one-way ANOVA, thus satisfying the assumptions of normality and equality of variance. Then a significant relationship with the groups followed, followed by the HSD test for multiple-pair comparisons of Tukey. The significance level was accepted as $p<0.05$. The study was conducted using post-hoc Power PASS 2008 software (NCSS, Utah 84037, USA).

3. RESULTS

The hematological parameters and the blood cell diameter of each rat in their groups in the study (control, pseudo-exposure and test group) were given in Tab. 1 and Tab. 2.

Table. 1. Rate of blood cells

	Control Group (%)	Pseudo-Exposure Group (%)	2.45 GHz EMF Exposed group (%)	p values
Lymphocyte	92.63±7.78	81.38±6.58	80±6.30	p<0.05
Monocyte	7.4±0.29	7.79±0.32	10.9±0.46	p<0.05
Neutrophil	18.71±1.98	20.8±2.04	18.74±1.56	p<0.05
Eosinophil	0.35±0.01	1.5±0.05	3.35±0.24	p<0.05
Basophils	0.35±0.01	0±0.00	0±0.00	p<0.05

The values in the table represent in least-squares mean ± standard deviation (X ± SD).
Calculated from n=30 in each group.
*p<0.05 compared to control (one way ANOVA test)

Table 2. The diameter of blood cell

	Control Group (%)	Pseudo-Exposure Group (%)	2.45 GHz EMF Exposed group (%)	p values
Lymphocyte	8.89±0.42	8.07±0.38	8.94±0.45	p<0.05
Monocyte	11.75±0.59	10.61±0.49	11.83±0.64	p<0.05
Neutrophil	11.43±0.60	11.63±0.72	11.39±0.61	p<0.05
Erythrocyte	6.71±0.18	6.41±0.11	6.55±0.16	p<0.05

The values in the table represent in least -squares mean ± standard deviation (X ± SD).
Calculated from n=30 in each group.
*p<0.05 compared to control (one way ANOVA test)

Some changes in blood cell shapes of the rats in the experimental group exposed to 2.45 GHz were observed. Especially the changes observed in neutrophil cells, neutrophil abnormalities such as metamyelocyte (Fig. 4), hiyper segmented neutrophil (Fig. 5) were determined. In addition, in peripheral red blood cells of test group rats, the presence of acanthocytes known as abnormality of erythrocytes was determined (Fig. 6).The blood cells of rats in pseudo- exposure (Fig. 7) and the control group (Fig. 8) were determined as normal shape.

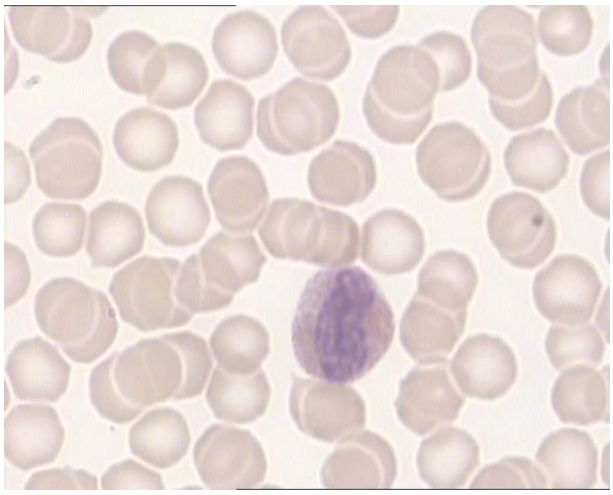

Fig 4. Metamyelocytes cell observing due to lack of neutrophil in the rats of test group exposing 2.45 GHz. May Grünwald-Giemsa. 1000x

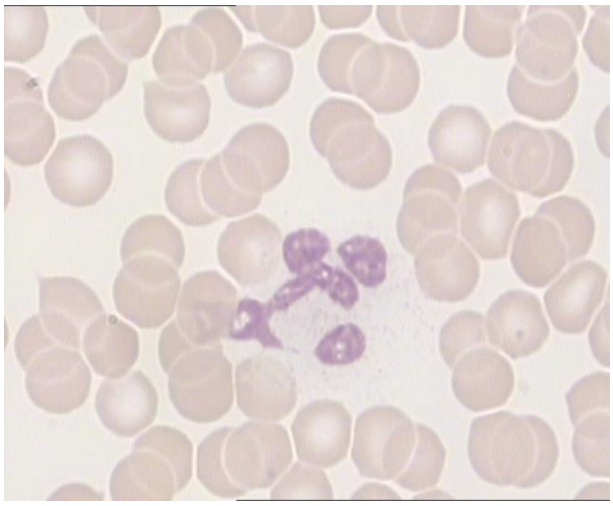

Fig 5. Hypersegmented neutrophil in blood smears of rats in the test group exposing 2.45 GHz. May Grünwald-Giemsa. 1000x

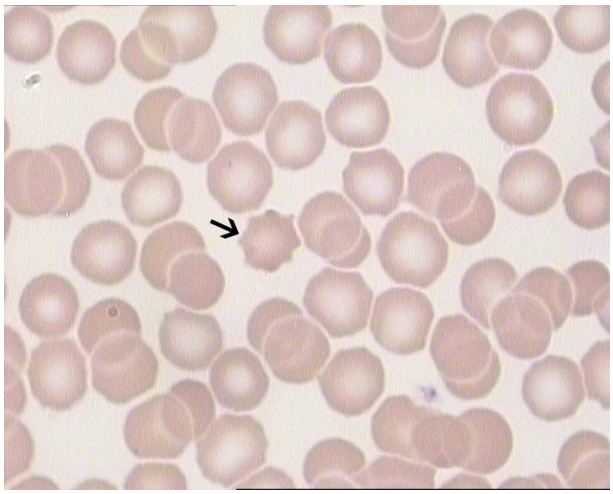

Fig 6. Acanthocytes (ok) in blood smears of rats in the test group exposing 2.45 GHz. May Grünwald-Giemsa. 1000x

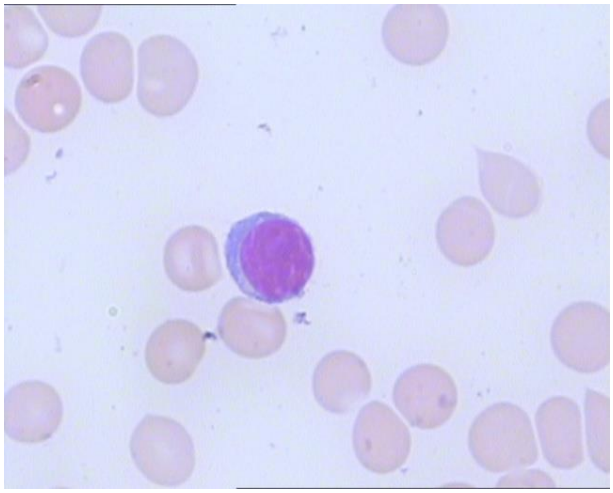

Fig 7. Lymphocyte cell in blood smears of rats in the control group. May Grünwald-Giemsa. 1000x

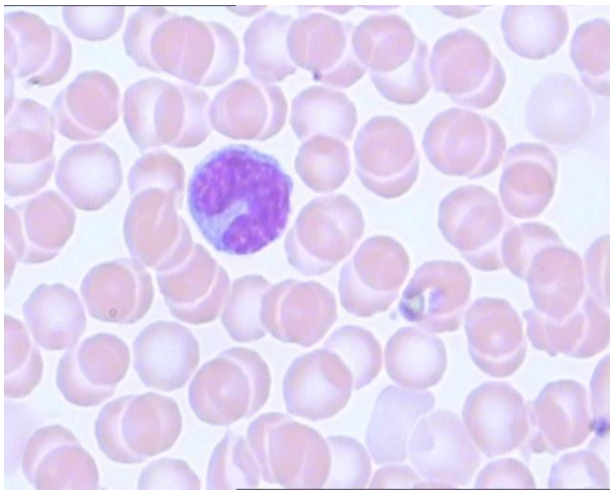

Fig 8. Monocyte cell in blood smears of rats in the pseudo-exposure. May Grünwald-Giemsa. 1000x

4. DISCUSSION

The widespread use of mobile communication devices all over the world as a result of the process of globalization resulted in an increase in the number of people affected by electromagnetic fields sourced from these communication systems. So far, a number of researches have been done about the effects of these EMF on biological systems. With this study, the effects of the electromagnetic field on blood levels in rats exposed to 2.45 GHz were compared.

As shown in Tab. 1, the mean lymphocyte count was lower in 2.45 GHz group than the control group. The mean number of monocytes was determined to be higher in 2.45 GHz group than the control group. Mean platelet count was observed in the experimental group more intense than the control group. Values of other parameters were found to be normal. In the results obtained in Tab. 2, the diameter of the blood cells did not differ significantly between the groups studied.

Some changes in blood cell shapes in the rats in the experimental group exposed 2.45 GHz were observed. Especially the changes observed in neutrophil cells, neutrophil abnormalities such as metamyelocyte, hipper segmented neutrophil were determined. In addition, in peripheral red blood cells of test group rats, the presence of acanthocytes known as abnormality of erythrocytes was determined. The blood cells of rats in pseudo- exposure and the control group were determined as normal shape.

A 2.45 GHz microwave has been demonstrated in rabbits exposed to changes in the amount and functionality of circulating white blood cells and a marked increase in the myeloid/erythroid ratio [16]. A decrease in the number of leukocytes intact in the bone marrow cell after exposure to police radar frequencies, and the percentage of granulocytes in the peripheral blood of mice, Rotkovska et al. Additionally, impairments in both cellular and humoral immunological parameters were found in their workers exposed to TV signals [17].

Maes et al. in a study that they performed with human peripheral blood lymphocytes have reported that, 2.45 GHz radio frequency waves caused significant increase in chromosome defects and the frequency of micronucleus formation [18]. Magnetic fields, except their effects on DNA, leads to many harmful effects on the level of organelle, cell and organ level. Somosy has reported that radiation affected negatively many cell organelles [19]. Allis and Sinha-Robinson in a study performed with human erythrocytes have reported that 2.45 GHz microwave radiation inhibited Na+/K+ ATPase activity [20].

In the scientific literature, there are studies in which the interaction of blood cells with electromagnetic energy will be different due to their special shape. It is known from magneto-hydrodynamics that when a stationary, transverse magnetic field is applied to an electrically conductive fluid in motion, electric currents are induced in the fluid. The interaction-induced currents and the applied magnetic field produce a body force (Lorentz force) that tends to retard the movement of blood [21]. Considering this study, it can be said that these molecules, which should circulate freely in the blood fluid, are exposed to an extra spin moment and the possible results depend on this.

5. CONCLUSION

In the research, it is known that the human body cannot tolerate even the temperature rise of 1° C. In this process, proximity and duration of exposure of the source of the magnetic field must be taken into account. During the use of the wireless network, it is necessary to study as far as possible from the source and to keep the source in closed position except for use. The prevention of temperature increase which is one of the possible effects can be minimized damage to the tissue due to take care of the proximity to the source of the magnetic field and length of use. These further histopathological and molecular studies about this topic are needed.

The macroscopic and microscopic effects of magnetic field at the level of cell and tissue will be understood when the exact mechanism is made clear with scientific data. It will be possible to minimize the damage of this technological convenience. Avoid influencing the biological tissues, but also by making these devices can be used easily and efficiently due to developing technology; to minimize detrimental effects may be possible.

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