Original Article
Toxicology International, *May-Aug 2017 / Vol-24 / Issue-2, 150-156*
ISSN (Print) : 0971-6580
ISSN (Online) : 0976-5131
DOI: 10.22506/ti/2017/v24/i2/162412

Exploring the impact of 900 and 1800 MHz radio frequency electromagnetic radiation on blood pressure and haematological parameters

Karan Devasani* **and Rema Razdan**

Department of Pharmacology, Al-Ameen College of Pharmacy, Bangalore, India
*karandeva2@gmail.com

Abstract

Today there is an unprecedented growth of wireless technology and upsurge in the public about potential health risk factors. Communication using cell phone in a pool of radio frequency electromagnetic radiation is a precarious apprehension in our society. Effect on blood pressure and blood profile is one of the utmost area of research interest. The current study was aimed to evaluate the possible implications on blood pressure and haematological parameters on chronic exposure to radio frequency electromagnetic radiation (RF-EMR) in male and female wistar rats at 900 MHz and 1800 MHz frequencies for 2 h per day for 3 months. In this study 36 rats were evenly categorised into 3 groups, each group consists of male and female rats: group 1 (sham exposed); group 2 (1800 MHz (exposed); group 3 (900 MHz exposed). Non-invasive blood pressure was recorded using tail cuff and haematological parameters was measured at the end of experiment. In our study, results obtained did not showed any significant differences in the haemoglobin (%), RBC count, Total W.B.C count, eosinophils (%) when compared to sham exposed rats. Surprisingly, male and female rats exposed to 900 MHz was found to be decrease in their blood pressure while male and female rats exposed to 1800 MHz was not found to be significant difference as compared to sham exposed. Whereas platelet count was found to be significantly increased in male rats exposed to 1800 MHz and 900 MHz. According to our perspective there has been no conclusive evidence that using a mobile phone could bring changes in BP and haematology.

Keywords: RF-EMR, blood pressure, Haematology, 900 MHz and 1800 MHz

Received: 19-01-2017 **Revised:** 22-03-2017 **Accepted:** 02-04-2017

Introduction

Radiation is the type of energy that is travelling through space in the form of waves or particles and it occurs naturally where we are bombarded with it in one form or another, every day of our lives - from the earth, from space and even within our own bodies. The type of radiation emitted from mobile phones is electromagnetic radiation. It is present in mobiles because they use radio frequency (RF) waves to make and receive calls. Although we are not always aware of their presence, electromagnetic radiation permeate our environment in the form of visible light, infrared radiation, microwaves that cook our food or radar frequency wave, used in radar communication systems[1].

Electromagnetic radiation consists of electric and magnetic fields, which propagates through vacuum (unlike mechanical waves which require a medium to propagate) and do not require moving charges or currents. The biological effects of exposure to RF-EMR from mobile phones were reported to be variable, depending on many factors including duration of exposure, distance from the various sources, species and tissues as well as the conditions of exposure[2]. Electromagnetic fields induce an electric field and a current into the body. A strong electric field, depending on its frequency, might warm up tissues or disturb the cellular functions. Thermal effects are based on energy absorption from the field to the tissue, which causes the oscillation of molecules. These types of effects are nowadays well known, and guidelines to limit

* *Author for correspondence*

human exposure to EMF are based on them. However, it is unclear whether RF-EMR might cause other non-thermal effects at low exposure levels[3].Virtually every living cell is a seething mass of electric currents and electrical and biochemical amplifiers that are essential for their sham exposed function[4].

The alternating fields generate alternating electric currents that flow through cells and tissues and remove structurally-important calcium ions from cell membranes, which then makes them leak. Most of them involve the inward leakage of free calcium ions down an enormous electrochemical gradient to affect calcium-sensitive enzyme systems. This is the sham exposed mechanism by which cells sense mechanical membrane damage. Thesham exposed respond by triggering mechanisms that stimulate growth and repair, including the MAP-kinase cascades, which amplify the signal[5]. If the damage is not too severe or prolonged, we see a stimulation of growth and the effect seems beneficial, but if the exposure is prolonged, these mechanisms are overcome and the result is ultimately harmful. It was reported that RF radiation from mobile phones could alter intracellular signalling pathways through changes in Ca2+ permeability across cell membranes and cellular calcium levels[6].

It has also been reported that exposure to RF-EMR can provoke production of free radicals [7], cause hemolysis[8], decrease in the hemoglobin [9], increased the incidence of leukemia in children [10]and changes in brain neurotransmitter levels[11]. Conversely, other studies have indicated that at the current exposure level, no indications of mutagenic effect on human lymphocyte was observed[12] and indeed a few studies even seem to suggest that the exposure to the low level RF radiation seem to have protective effects[13]. Tahvanainen et al has shown that cell phone use does not acutely affect blood pressure or heart rate in humans[14].It was also reported that Radio frequency radiation does not induce stress response in human T-lymphocytes and rat primary astrocytes [15].

Therefore, it is generally agreed that information on the potential effects of RF radiations especially effects that can arise as a result of long term exposure to non-ionizing radiations from mobile phone base stations. As a result, more studies on effects of RF radiations on a wide variety of parameters spanning over several generations in exposed organisms will be required to elucidate the potential long-term effects of these RF devices. Therefore, in our study, we have investigated the effect of simulated GSM 900 and 1800 MHz on blood pressure and haematological profile of male and female wistar rats.

Materials and methods

Experimental animals

Inbred healthy mail albino Wistar rats (aged 6–8 weeks old) were used in this experiment. The rats were housed in polypropylene cages inside a temperature- and humidity-controlled environment with free access to food and water *ad libitum*, with a 12 h light and 12 h dark cycle. All the experiments were carried out with prior approval from the institutional animal ethics committee. Car was taken to handle the rats in a human manner, and all precautions were taken to use the minimum number of animals required to generate significant data.

Animals were categorized into three groups: Each group had 6 male and 6 female wistar rats (Table 1).

Table 1. Grouping of experimental animals for exploring the impact of 900 and 1800 MHz radio frequency electromagnetic radiation

Sl.no	Group name	Dose (RF-EMR)	Duration
1	Group 1 (sham exposed)	Sham exposure to radiations	2 hrs for 3 months
2	Group 2	1800 MHz	2 hrs for 3 months
3	Group 3	900 MHz	2 hrs for 3 months

The radio frequency electromagnetic radiation generator (manufactured by AND Solutions, India) was used to emit 900MHz and 1800MHz frequencies, SAR set at 1.6 W/kg and power density was 0.9 watt/m^2(which was fixed statically by manufacturer as per IEEE guidelines) via monopoly antenna that directed the signal to the cages. The antenna generated uniform RF radiations as a genuine GSM mobile phone. The length of the monopole antenna was set so that the antenna resonant at the operating frequency. The antenna had an Omni-directional pattern in the azimuth plane through which the rats were to be uniformly distributed. Male and female Wistar rats were placed individually in an hexagonal acrylic plastic cage (40 cm in diameter) which was divided into six compartments and exposed to RF-EMR daily 2 h for 3 months. The cage was designed in such a way that the animals were not restrained and ventilated by drilling holes. The animals were left for 3 days for acclimatization. Sham exposed animal's underwent the

same transportation, habituation and handling procedure without switching on the signal generator i.e. no RF-EMR exposure. The antenna was placed 30 cm above the ground. At the end of the exposure non-invasive measurement of blood pressure was measured and blood was collected to study the haematological parameters. (Figure 1)

Measurement of non-invasive blood pressure

Non-invasive blood pressure was performed by tail cuff using MLT125 NIBP Controller (AD Instruments, Australia). Animals were trained for 2 to 3 sessions to acclimatize the condition and placed in the perspex cylinder restraint cage comfortably. Rats were kept under constant temperature between 28 to 30°C to improve the blood circulation in the tail and the signal to noise ratio in the recording. The tail cuff was positioned at the proximal end of the tail which was used to occlude blood flow in the tail and thereby interrupt the pulse that is measurable in the caudal artery. The active site of the pulse transducer was placed on the ventral surface of the tail, directly below the caudal artery. The transducer was positioned directly following the tail cuff. Maximum sensitivity was achieved when the artery was positioned above the most sensitive position on the transducer. Movement from this position can reduce the amplitude of the measured pulses. The transducer which is used to make the pulse measurements is very sensitive and subject to vibrations. So, it was ensured that mechanical vibrations from other laboratory devices do not affect the transducer.

The basic signals recorded by the MLT125 NIBP system are the cuff pressure and the caudal artery. Systolic blood pressure (SBP) occurs when the cuff pressure corresponds to the restoration of the first caudal artery pulse. Each measurement was repeated five to six times to ensure reproducible results. Although direct observation of the pulse is usually sufficient to determine the systolic blood pressure point, alternative methods of detecting is the onset of the pulse[16]. (Figure 2)

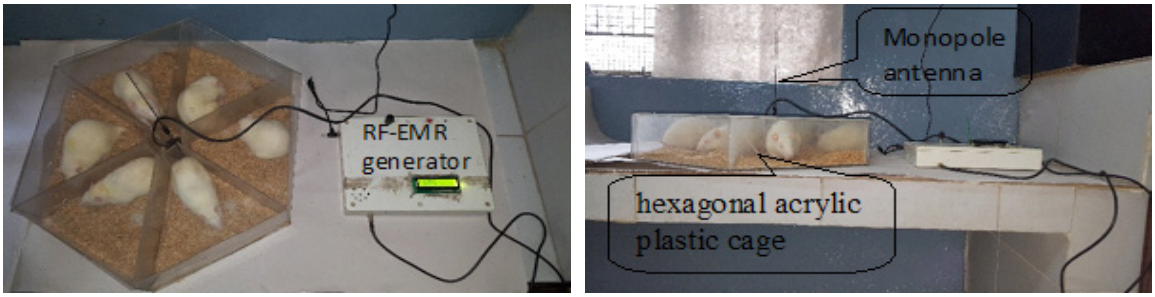


Figure 1. Example of Measured blood pressure signals through BIOAMP MLT125 NIBP Controller using tail cuff pressure and tail pulse rate using the rate function of cyclic measurements.

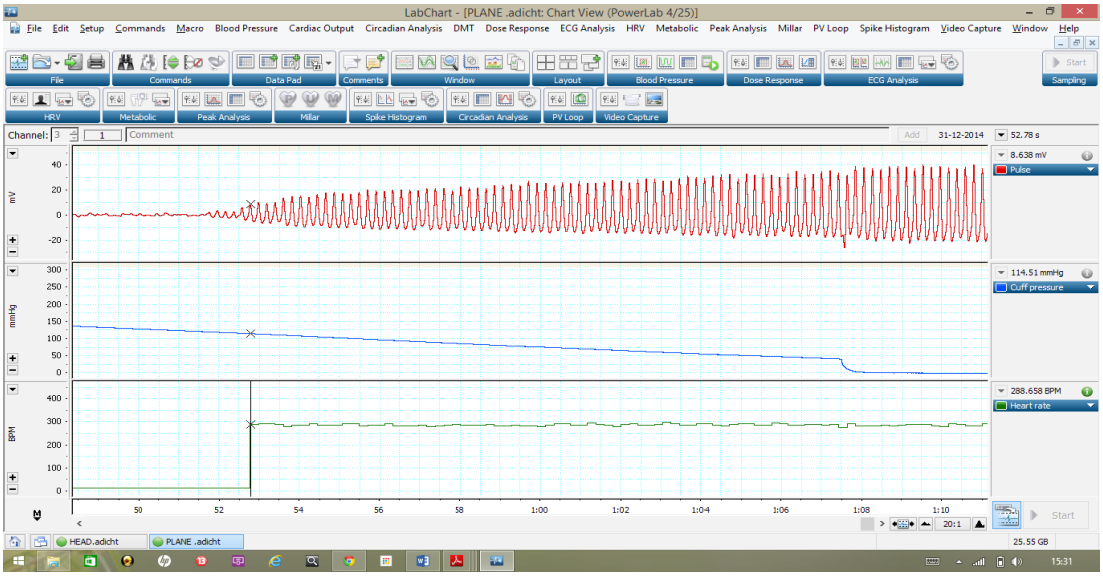


Figure 2. Basic signals recorded by the MLT125 NIBP system.

Hematological parameters

Blood samples were taken at the end of the experiment. The blood samples were collected in EDTA coated vacutainer and these samples were used in assessment of blood profile: Haemoglobin concentration was performed using Sahli's haemoglobinometer[17], RBC count,Total W.B.C count and platelet countwas performed using Neubauer's Haemocytometer[18], Differential leucocyte count using Leishman`s stain and examined under oil immersion power to count the percentage of each type of W.B.C.[17].

Statistical analysis

All data were expressed as mean ± SEM and analyzed with one-way analysis of variance (ANOVA) between the groups and followed by Tukeys Multiple Comparison Test to assess differences between the groups using graph pad prism (Ver. 5). Probability values $p < 0.05$, $p < 0.01$ and $p < 0.001$ were considered significant.

Results

Effect of exposure to RF-EMR on blood pressure in rats.

Male and female rats exposed to RF-EMR at 1800 MHz frequency had blood pressure of 109.70 ± 1.86 mmHg and 97.37 ± 2.43 mmHg and found to be non-significant as compared to sham exposed rats. Whereas male and female rats exposed to 900MHz frequency had B.P of 97.22 ± 0.93 mmHg and 96.73 ± 1.20 mmHg respectively, that was found to be significantly lower than that of sham exposed rats (108.4 ± 2.49 mmHg), (Table 2.).

Effect of RF-EMR on Haematological parameters

No statistical significant differences were observed on haemoglobin concentration, RBC count, WBC count and eosinophil count in both Male and Female rats exposed to RF-EMR at 1800 MHz and 900 MHz frequency, when compared with sham exposed rats. (Table 3 and 4)

Male rats exposed to RF-EMR at 1800 MHz and 900 MHz frequency, had lymphocytes of 66.00 ± 3.12 % and 55.50 ± 2.41 % respectively of which 900 MHz was found to be significantly lower than that of sham male rats (67.50 ± 1.52 %), while female rats exposed to 1800 MHz and 900 MHz frequency, had lymphocytes of 58.67 ± 1.38 % and 67.17 ± 2.04 % respectively of which 1800 MHz was found to be significantly lower than that of sham female rats (69.67 ± 2.17 %). (Table 4)

Male rats exposed to RF-EMR at 1800 MHz and 900 MHz frequency, had neutrophils of 21.50 ± 2.91% and 31.50 ± 2.15 % respectively of which 900 MHz was found to be significantly higher than that of sham exposed male rats (19.00 ± 2.70 %). Whereas there were no significant differences was observed in female rats exposed to 1800 MHz and 900 MHz frequency as compared to sham exposed female rats. (Table 4)

Male rats were exposed to RF-EMR at 1800 MHz and 900 MHz frequency, had platelet of 7.585 ± 0.299 lakhs/cumm and 7.955 ± 0.631 lakhs/cumm respectively was significantly higher than that of sham male rats (4.933 ± 0.353 lakhs/cumm), Whereas there was no significant differences was observed in female rats exposed to 1800 MHz and 900 MHz frequency as compared to sham exposed female rats. (Table 4)

Table 2. Impact of 900 and 1800 MHz radio frequency electromagnetic radiation on blood pressure. Values are expressed as Mean ± SEM; n= 6. * $p<0.05$, ** $p<0.01$ when compared with sham exposure by using one way ANOVA followed by Tukeys multiple comparison test

Sl.no	Group name	sex	NIBP (mmHg)
1	Group 1 (Sham exposure)	Male	108.4±2.49
		Female	108.0±4.38
2	Group 2 (1800 MHz)	Male	109.70±1.86
		Female	97.37±2.43
3	Group 3 (900 MHz)	Male	97.22±0.93**
		Female	96.73±1.20*

Table 3. Impact of 900 and 1800 MHz radio frequency electromagnetic radiation on haemoglobin, RBC and WBC count. Values are expressed as Mean ± SEM; n= 6. P > 0.05 when compared with sham exposure by using one way ANOVA followed by Tukeys multiple comparison test

Sl.no	Group name	sex	Haemoglobin (g %)	RBC count (mill/cumm)	Total W.B.C count (cells/cumm)
1	Group 1 (Sham exposure)	Male	14.57± 0.260	6.232± 0.199	5850 ±488.4
		Female	14.52± 0.419	6.198± 0.193	5517 ±729.6
2	Group 2 (1800 MHz)	Male	13.53± 0.304	6.082± 0.157	6383 ±955.1
		Female	15.50± 0.511	6.705± 0.278	6217 ±481.3
3	Group 3 (900 MHz)	Male	13.55± 0.403	6.083± 0.159	8417 ±1998.0
		Female	15.15± 0.331	6.645± 0.154	6350 ±397.3

Table 4. Impact of 900 and 1800 MHz radio frequency electromagnetic radiation on lymphocytes, neutrophils, platelet count and eosinophils. Values are expressed as Mean ± SEM; n= 6. P > 0.05 when compared with sham exposure by using one way ANOVA followed by Tukeys multiple comparison test. Values are expressed as Mean ± SEM; n= 6. * p<0.05, ** p<0.01, ***p<0.001, P > 0.05 when compared with sham exposure by using one way ANOVA followed by Tukeys multiple comparison test

Sl.no	Group name	sex	Lymphocytes (%)	Neutrophils (%)	Platelet count (lakhs/cumm)	Eosinophils (%)
1	Group 1 (Sham exposure)	Male	69.67± 2.17	19.00± 2.70	4.933± 0.353	11.33± 1.38
		Female	67.50± 1.52	22.33± 1.58	5.120± 0.971	10.17± 0.79
2	Group 2 (1800 MHz)	Male	66.00± 3.12	21.50± 2.91	7.585± 0.299**	12.50± 0.50
		Female	58.67± 1.38**	27.33± 1.99	6.572± 0.348	12.67± 0.71
3	Group 3 (900 MHz)	Male	55.50± 2.41**	31.50± 2.15*	7.955± 0.631***	13.00± 0.85
		Female	67.17± 2.04	20.50± 1.68	5.473± 0.507	12.67± 0.55

Discussion

There has been an upsurge and unprecedented growth in the cell phone technologies and offers a diverse service to users and contributing to social and economic benefits. But there are still some issues as it is not clear whether this technology has any hazardous effect on the body. There has been substantial development into the understanding of how cell phone radiation may alter sham exposed bodily functions because mobile radiations are non-ionising radiations. Many studies have looked at various body tissues reaction to the radiation exposure. But it has been reported that EMF increases free radical activity in cells [19] and the EMF radiating from mobile phone gives rise to the development of ROS. However, based on current knowledge, it seems that weak fields are quite unlikely to generate significant effects in their interactions. Thus, no generally accepted mechanism for the potential non-thermal mobile phone radiation-based effects has so far been established.

Our investigations on Blood pressure and haematological profile have not shown much disastrous outcome rather the effect of radiations on male and female were found not consistent and males were more affected than females. This may depend upon the amount of movement of the animal, the energy absorption pattern in its body could become either more complex and unpredictable or more uniform. The pattern of energy absorption inside an irradiated body is non-uniform, and biological responses are dependent on distribution of energy and the body part that is affected. Astonishingly, we observed that male and female rats exposed to 900 MHz was found to be decrease in their blood pressure i.e. there seems to be hypotension. While Colak et al found that no significant differences in the BP values among the groups However, in the evaluation of HR values were significantly lower[20], whereas Soviet researchers reported indications that long term RFEMF may cause hypotension and bradycardia or tachycardia [21]. This foresight is also in accordance with the previous studies reporting no significant changes in BP exposure to 900 MHz or 1800 MHz Mobile Phones[14].

Measurements of blood parameters are most important means by which to determine the health status of experimental animals. These measurements are diagnostic for certain diseases such as anaemia, leukaemia, to detect the presence of the inflammation and decrease in numbers of red blood cells indicates anaemia while increase indicates Polycythaemia. After investigating effects on haematological parameter, there were no

consistent evidence that RF fields may cause adverse outcomes. In the earlier investigation by A.D. Usman et al, it was suggested that long term exposure to 1800 MHz and 900 MHz RF fields showed that haematological parameters of the exposed mice were within the sham exposed range of the mice in the control[22].

Haemoglobin (%), RBC count, Total W.B.C count, eosinophils (%) did not showed significant differences when compared to sham exposed rats. But, surprisingly platelet count was found to be significantly increased in male rats exposed to 1800 MHz and 900 MHz, compared to sham exposed rats while female was found to be non-significant. High platelets are accompanied by a persistent headache, difficulty in breathing, dizziness and seizures or loss of consciousness for even a moment. Percentage of neutrophils in male rats exposed to 900 MHz was found to be significantly lower than that of sham exposed male rats while female rats exposed to 1800 MHz was found to be significantly lower than that of sham exposed female rats. Whereas, percentage of neutrophils in male rats exposed to 900 MHz frequency was found to be significantly higher than that of sham exposed male rats. There were no significant differences was observed in female rats exposed to 1800 MHz and 900 MHz frequency as compared to sham exposed female rats. But all the parameters were in sham exposed range. These differences and inconsistency in results may be due to the energy absorption pattern in its body and movement as it was mentioned earlier. In most of the studies, the mechanisms for the effects were not investigated, and many of the results were not consistent with one another. Infact an earlier study conducted by Guy and co-workers at the University of Washington, one group of 100 male rats was exposed unrestrained to 2.45 GHz RFEMF at an average power density about 0.48 mW/cm^2 in individual cylindrical waveguides under controlled environmental and specific pathogen free conditions. Another group of 100 male rats was similarly sham exposed. Exposures were begun at age 8 weeks and continued for 25 months (whole body SAR, 0.15–0.4 W/kg). One of the endpoints investigated was whether such exposures would affect the immune system of the rats. There were no overall significant differences between RFEMF exposed and sham exposed rats in the hematologic parameters.

Studies conducted on T-lymphocytes [23], B-lymphocytes[24], neutrophils[25] has showed no significances on haematological profiles. Exposure on cultured human peripheral blood lymphocytes at 380, 900 and 1800 MHz showed no significant changes in cell cycle[26]. The present study had investigated, in a comprehensive manner, on the effects of RF-EMR 900/1800 MHz on blood pressure and blood components. But the study is not asserted by our research and it must be endorsed by doing further research and more findings.

Conclusion

Despite of extensive research on the subject, there has been no conclusive evidence that using a mobile phone can cause long term harmful effects in humans. Our investigations show that results of blood pressure and haematological parameters were in a sham exposed range although blood pressure and platelets was found to be decreased and increased respectively. The pace of mobile phone technology is advancing at a far quicker pace than the research required into the potential harm that they can cause. So, much more research is needed for standardization of such an assumption.

Conflict of Interest: None Declared

References

1. Serway R, Jewett J. Electric Potential and Capacitance. *Princ Phys A Calc Text, Vol 2* 2012; 671–672.
2. Ahlbom A, Bridges J, de Seze R, et al. Possible effects of electromagnetic fields (EMF) on human health--opinion of the scientific committee on emerging and newly identified health risks (SCENIHR). *Toxicology* 2008; 246: 248–250.
3. Adair ER, Black DR. Thermoregulatory Responses to RF Energy Absorption. In: *Bioelectromagnetics*. 2003, pp. 17–38.
4. Chatterjee I, Wu D, Gandhi OP. Human body impedance and threshold currents for perception and pain for contact hazard analysis in the VLF-MF band. *IEEE Trans Biomed Eng* 1986; 33: 486–94.
5. Goldsworthy A, Whitney H, Morris E. Biological effects of physically conditioned water. *Water Res* 1999; 33: 1618–1626.
6. Maskey D, Kim M, Aryal B, et al. Effect of 835 MHz radiofrequency radiation exposure on calcium binding proteins in the hippocampus of the mouse brain. *Brain Res* 2010; 1313: 232–241.
7. Aweda MA, Meindinyo ROK GS. Effects of 2.45 GHz microwave exposures on the peroxidation status in Wistar rats. *Niger J Heal Biomed Sci* 2003; 10: 243–246.
8. Aweda MA, Gbenebitse SO KM. Effects of 2.45 GHz Radiofrequency Radiation Exposures on Normal and Sickle Erythrocytes. *Niger J Heal Biomed Sci* 2004; 3: 56–59.

9. Karel M, Jan M HT. *Biological effects of electromagnetic waves and their Mechanism*. San Francisco, 1971.
10. Michelozzi P, Capon A, Kirchmayer U, et al. Adult and childhood leukemia near a high-power radio station in Rome, Italy. *Am J Epidemiol* 2002; 155: 1096–1103.
11. Devasani K, Razdan R, Chaithanya K, et al. Exploring the Effect of Chronic Exposure to Radio-Frequency Electromagnetic Radiation on Neurotransmitters and Acetylcholinesterase activity in rat Brain. *Toxicol Int*; 23. Epub ahead of print 2016. DOI: 10.22506/ti/2016/v23/i3/.
12. Maes A, Collier M, Verschaeve L. Cytogenetic effects of 900 MHz (GSM) microwaves on human lymphocytes. *Bioelectromagnetics* 2001; 22: 91–96.
13. Phillips JL, Ivaschuk O, Ishida-Jones T, et al. DNA damage in molt-4 T-lymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro. *Bioelectrochemistry Bioenerg* 1998; 45: 103–110.
14. Tahvanainen K, Niño J, Halonen P, et al. Cellular Phone Use Does Not Acutely Affect Blood Pressure or Heart Rate of Humans. *Bioelectromagnetics* 2004; 25: 73–83.
15. Lee JS, Huang TQ, Kim TH, et al. Radiofrequency radiation does not induce stress response in human T-lymphocytes and rat primary astrocytes. *Bioelectromagnetics* 2006; 27: 578–588.
16. AD Instruments. *NIBP Controller Owner's Guide*. U-ML125-OG-003C, Bella vista, Australia, 2014.
17. Sood R. *Hematology for students and practitioners*. 4th ed. India: Jaypee brothers Medical Publishers, 1996.
18. Stanley DE. Tietz Textbook of Clinical Chemistry. *JAMA J Am Med Assoc* 1999; 282: 283–283.
19. Grundler W, Kaiser F, Keilmann F, et al. Mechanisms of electromagnetic interaction with cellular systems. *Naturwissenschaften* 1992; 79: 551–559.
20. Colak C, Parlakpinar H, Ermis N, et al. Effects of electromagnetic radiation from 3G mobile phone on heart rate, blood pressure and ECG parameters in rats. *Toxicol Ind Health* 2012; 28: 629–638.
21. Jauchem JR, Frei MR, Ryan KL, Merritt JH MM. Lack of effects on heart rate and blood pressure in ketamine-anesthetized rats briefly exposed to ultra-wideband electromagnetic pulses. *IEEE Trans Biomed Eng* 1999; 46: 117–120.
22. Usman AD, Ahmad WFW, Kadir MZ a A, et al. Effect of Radiofrequency Electromagnetic Field Exposure on Hematological Parameters of Mice. *World Appl Sci J* 2012; 16: 656–664.
23. Lyle DB, Schechter P, Adey WR, et al. Suppression of T-lymphocyte cytotoxicity following exposure to sinusoidally amplitude-modulated fields. *Bioelectromagnetics* 1983; 4: 281–292.
24. Sultan MF, Cain CA, Tompkins WAF. Effects of microwaves and hyperthermia on capping of antigen-antibody complexes on the surface of normal mouse B lymphocytes. *Bioelectromagnetics* 1983; 4: 157–165.
25. Cleary SF, Liu L, Garber F. Viability and Phagocytosis of Neutrophils Exposed In Vitro to 100-MHz Radiofrequency Radiation. *Bioelectrornagnetics* 1985; 60: 53–60.
26. Antonopoulos A, Eisenbrandt H, Obe G. Effects of high-frequency electromagnetic fields on human lymphocytes in vitro. *Mutat Res* 1997; 395: 209–14.