Long Term Exposure to Cell Phone Radiation and Stress

Ahmadi Tameh A*, Ahmadi R, and Gohari A

***Abstract*—**The studies show that many factors including electromagnetic radiation may result in stress leading to changes in serum level of cortisol. The main aim of this study was to determine the effects of cell phone radiation on serum levels of cortisol –as indicator of stress- in male rats. In our study male Wistar rats were randomly divided into control and groups exposed to cell phone radiation for 1, 3 or 6h/day of 5 rats in each group. After 8 weeks, blood samples were obtained using cardiac puncture method. Following serum preparation, level of cortisol was measured using immunoassay method. Data were statistically analyzed and compared between groups using ANOVA. The results indicated that serum level of cortisol increased in rats exposed to cell phone radiation for 6h/day compared to control rats ($P<0.001$). Our findings show that long term exposure to cell phone radiation enhances serum cortisol level which may indicate the existing of stress in animals.

***Keywords*—** Cell Phone Radiation, Cortisol, Male Rat.

I. Introduction

CELL phones emit radiofrequency electromagnetic waves (RF-EMW) to nearby relay base stations or antennas. Our bodies act as antennas that absorb the radiation and convert it into alternating eddy currents. The frequencies of these radio waves fall in the low frequency microwave range (800- 2200 MHz[1], therefore, this radiation is of non- ionizing type as the energy emitted is too low to break chemical bonds in biological system. On the other hand, the energy carried in extremely high frequencies (1,000,000 MHz) electrom- agnetic waves such as x-rays is so intense that the electro magnetic particles have sufficient power to break chemical bonds and cause serious damage to human tissue; this type of radiation is known as ionizing radiation [2].

When speaking into a cell phone, the sound wave from the speaker goes through a transmitter that converts the sound into a sine wave. The transmitter then sends the signal to the antenna, which then sends it out into space in all directions[3]. The transmitter in cell phone operates on about 0.75 to 1 watt of power, with 2 W at peak usage. This electric sine wave current running through the transmitter circuit also creates an electromagnetic field around it. As the electric current moves back and forth, the fields continue to build and collapse, forming electromagnetic radiation. Thus, cell phone radiation is generated in the transmitter, and is emitted through the antenna in the form of a radio wave [4].

This value depends on multiple factors such as proximity to a cell site, the proximity of the wireless device to the body while in use, the mode of usage of the device (talk versus standby mode), and the use of hands-free (Bluetooth) devices [5].

The exact underlying pathophysiologic mechanism of cell phone related health impacts is not entirely known. However, there are two proposed cell phone related biological effects on the human body. The first is termed a "thermal effect" which occurs at particularly high frequencies where the radio-frequency radiation has heating properties which may lead to an increase in tissue or body temperature. Thermal effects may cause disruption of cell function and development [6]. The inflicted tissue damage in humans could occur due to the body's inability to dissipate the excessive heat. The eye and the testes are particularly vulnerable due to relative lack of blood flow to dissipate the excessive heat load [7]. The second is the "non-thermal effect" which is manifested by disruption of cell membrane integrity due to passage of electrically shaking eddy current formed from body absorption of EMW, endothelial dysfunction and alterations in the blood-brain barrier, cellular signal transduction effects, immune system effects and nervous system excitability defects [3]. More realistically, the mode of action of RF-EMW is probably a combination of the thermal and nonthermal effects.

Furthermore, usage of cell phones has been associated with difficulty in concentration, fatigue, and headache [1]. Cell phone exposure has also been shown to increase resting blood pressure [8]. Also, EMW radiation may alter hormone secretion, such as follicle-stimulating hormone, due to deformation of Leydig and Sertoli cells, which may lead to altered cell proliferation [9]. Although it is not completely clear how the EMWs cause these changes, there is substantial evidence pointing towards a decrease in normal body function. Usage of cellular phones is associated with alterations in various body systems including the central nervous system, cardiovascular system, and male reproductive system[3].

However, there is some evidence of potential adverse effects including headaches [1], increased resting blood pressure [1], and disturbances to electroencephalographic (EEG) activity during sleep[10]. It has also been suggested that mobile phones, and other electromagnetic devices that emit RF-EMR radiation, are detrimental to human fertility [11].

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Cortisol, the predominant glucocorticoid produced by humans, is secreted by the adrenal glands as the final product of the hypothalamus– pituitary–adrenal (HPA) axis [12]. In typical individuals, cortisol secretion follows a particular pattern across the day. This circadian rhythm consists of a spike in cortisol approximately 30 min after awakening in the morning, called the cortisol awakening response (CAR), followed by decreasing levels across the day and a slight rise throughout th night tomoderate levels bymorning [13]. Thus, cortisol levels are generally at their lowest overnight and increase across the early morning hours[14]. It is produced by the cortex of adrenal glands, follows a circadian rhythm and mediates many metabolic processes, such as energymobilization, increasing of cerebral perfusion, enhancing cardiovascular output, redistributing blood flow and modulating the immune system[15].Glucocorticoids (GCs; cortisol in humans) are produced in response to stress [14].

Sustained chronic exposure to high GCs through stress or exogenous administration has deleterious effects on brain structure and function in animals [16]. A similar effect is observed in Cushing disease in humans, a disease whose hallmark is chronically elevated cortisol [17]. In some animals and humans, aging is accompanied by flatter diurnal slopes, lower GC levels on waking [18], and increased GC levels in reaction to stress [19]. Its acute release by an absolute or relative stressor inhibits further release by negative feedback [15]. The activation of the HPA axis can be considered a basic adaptive mechanism in response to change. However, prolonged activation of this system is a risk to the organism's health [20]. Chronic cortisol rising in response to a continued stress has been related to various chronic diseases and metabolic changes, including diabetes, hypertension, dyslipidemia and immunosuppression [15].

Cortisol can easily cross the blood–brain barrier, where it can influence learning and memory by binding to brain receptors involved with these cognitive domains in specific areas, such as the hippocampus, the amygdala and frontal lobes [21]. Changes in its concentrations can also cause impairments in attention and perception [22]. High concentrations of cortisol have been observed in individuals with hippocampal atrophy, cognitive decline [12].

II. Material And Methods

A. Animals

Adult Wistar rats weighting 200±30g were purchased and raised in our colony from an original stock of Pasteur institute (Tehran, Iran).The temperature was at 23±-2 ^{0}C and animals kept under a schedule of 12h light:12h darkness (light on at: 08: 00 a.m.) with free access to water and standard laboratory chow. This study was performed according to ethical guidelines relating to working with laboratory animals].

B. Protocol of Study

Male Wistar rats were randomly divided into control and groups exposed to cell phone radiation for 1, 3 or 6h/day of 5 rats in each group. After 8 weeks, blood samples were obtained using cardiac puncture method. Following serum preparation, level of cortisol was measured using immunoassay method..

C. Statistical Analysis

All values are presented as mean ± S.E.M. Statistical significance was evaluated by one-way analysis of variance (ANOVA) using SPSS 19. Differences with $P<0.05$ were considered significant.

III. Results

Table I and Figure I show the serum levels of cortisol in male rats. The results indicated that serum level of cortisol increased in rats exposed to cell phone radiation for 6h/day compared to control rats ($P<0.001$); however, serum cortisol level decreased in rats exposed to cell phone radiation for 1h/day compared with control animals and there was no significant difference in serum cortisol level between rats exposed to cell phone radiation for 1 or 3h/day and control animals.

TABLE I
SERUM LEVEL OF CORTISOL IN CONTROL ANIMALS AND RATS EXPOSED TO CELL PHONE RADIATION FOR 1, 3 AND 6H/DAY. P VALUES ARE VERSUS CONTROL GROUP. NS INDICATES NONSIGNIFICANT DIFFERENCE COMPARED TO CONTROL GROUP.

Group	Cortisol (Microgram/dl)	P
Control	1.16±0.3	-
1h/day	0.87±0.1	NS
3h/day	1.81±0.2	<0.01
6h/day	2.95±0.4	<0.05

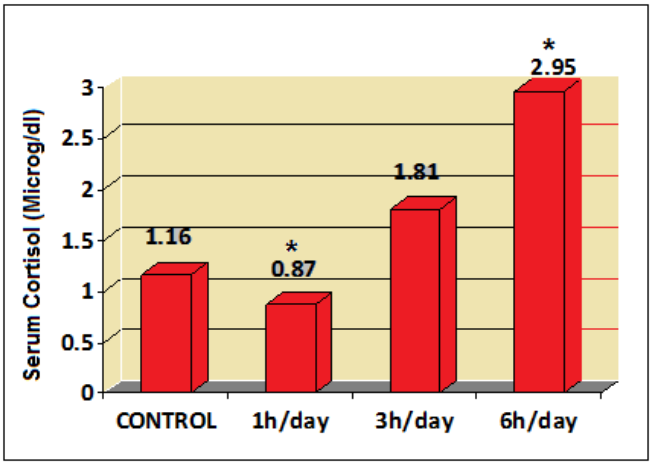

Fig. 1 Serum level of cortisol in control animals and rats exposed to cell phone radiation for 1, 3 and 6h/day. * represents significant difference compared to control animals.

IV. Discussion

Our study indicated that long term exposure to cell phone radiation results in enhanced serum levels of cortisol indicating the existing of stress in rats exposed to cell phone radiation. Another study shown that it may be concluded that deleterious effects of mobile microwaves can effect on hypothalamic-pituitary-thyroid axis[23]. Tian-Yong conclude that there is adequate epidemiologic evidence to suggest a link between prolonged cell phone usage and the development of an

ipsilateral brain tumor [24]. Serkan et al in their study show that even relatively short-term exposure to cell phone radiofrequency emissions can up-regulate elements of apoptotic pathways in cells derived from the brain, and that neurons appear to be more sensitive to this effect than astrocytes[25].

But some studies have shown although the cells that had been exposed to long-term, low-dose EMF did not present any findings that were contrary to the control conditions, the changes observed during ultrastructural examination gave the impression that significant changes may occur if the study period were to be extended[26].

V. Conclusion

Our findings show that long term exposure to cell phone radiation enhances serum cortisol level which may indicate the existing of stress in animals.

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