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Journal of Stem Cells
Volume 10, Number 4

ISSN: 1556-8539

Effect of Mobile Phone-Induced Electromagnetic Field on Brain Hemodynamics and Human Stem Cell Functioning: Possible Mechanistic Link to Cancer Risk and Early Diagnostic Value of Electronphotonic Imaging

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Abstract

The mobile phones (MP) are low power radio devices which work on electromagnetic fields (EMFs), in the frequency range of 900-1800 MHz. Exposure to MPEMFs may affect brain physiology and lead to various health hazards including brain tumors. Earlier studies with positron emission tomography (PET) have found alterations in cerebral blood flow (CBF) after acute exposure to MPEMFs.

It is widely accepted that DNA double-strand breaks (DSBs) and their misrepair in stem cells are critical events in the multistage origination of various leukemia and tumors, including brain tumors such as gliomas. Both significant misbalance in DSB repair and severe stress response have been triggered by MPEMFs and EMFs from cell towers. It has been shown that stem cells are most sensitive to microwave exposure and react to more frequencies than do differentiated cells. This may be important for cancer risk assessment and indicates that stem cells are the most relevant cellular model for validating safe mobile communication signals.

Recently developed technology for recording the human bio-electromagnetic (BEM) field using Electron photonic Imaging (EPI) or Gas Discharge Visualisation (GDV) technique provides useful information about the human BEM. Studies have recorded acute effects of Mobile Phone Electromagnetic Fields (MPEMFs) using EPI and found quantifiable effects on human BEM field.

Present manuscript reviews evidences of altered brain physiology and stem cell functioning due to mobile phone/cell tower radiations, its association with increased cancer risk and explores early diagnostic value of EPI imaging in detecting EMF induced changes on human BEM.

Keywords: eletromagnetic field, mobile phone radiations, stem cells, cancer, CAM therapies

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Introduction

The Mobile Phones (MP) are radio devices which work on electromagnetic fields (EMFs), in the frequency range of 900-1800 MHz, signal pulsed at 217 Hz with pulse width of 577 μs [1]. The steady increase of mobile phone usage has led to a rising concern regarding possible adverse health effects of mobile phone electromagnetic field (MPEMF) exposure at intensities even below the existing safety limits; common health hazards after long term exposure may possibly include hypersensivity syndromes, cognitive declines, autonomic dysfunctions and brain tumors [2, 3]. The World Health Organization INTERPHONE study carried out in Sweden suggests that people who have used phones for half an hour a day for 10 years have a significantly greater risk of developing malignant brain tumors, a finding that spurred the WHO to conclude that MP radiation to be a possible cause of human cancer [3]. It was not until the declaration from the International Agency for Research on Cancer (IARC), that in 2011World Health Organization advised that mobile phone radiations being put under the category of "possible human carcinogen" (category 2B) [4,5]. This makes MPEMFs fall in line with other possible carcinogens like jet fuel, gasoline engine exhaust, burning coal, dry cleaning chemicals, and DDT [6] Recent evidences indicate that the risk of precipitating ipsilateral glioma is increased four folds in individuals from 20 years of age and above who use mobile phones [5].Another review of available epidemiologic studies concluded that the use of mobile phones for over 10 years is associated with increased risk of ipsilateral gliomas and acoustic neuromas [7].

For a long time stem/progenitor cells have been considered an important cellular target for origination of cancer - both tumors and leukemia [8]. Gliomas are believed to originate from stem cells in the brain [9]. DNA double-strand breaks (DSBs) and their misrepairsare a critical molecular event that leads to chromosomal aberrations, which have often been associated with origination of various leukemias and tumors, including gliomas [10]. Inhibition of DSB repair may result in chromosomal aberrations, to repair DSB, so-called DNA repair foci are formed at DSB locations [11]. Inability to form DNA repair foci has been correlated to radiosensitivity, genomic instability and other repair defects [12, 13]. It has recently been demonstrated that, at specific frequencies, GSM/UMTS microwaves from mobile phones inhibit formation of DNA repair foci in human stem cells [14].As there was no rise in temperature, the microwave effects could not be attributed to heating albeit a similar response was observed after heat shock. This similarity indicates that MPEMF exposure at specific frequencies is a stress factor for development of tumors.

Electron photonic imaging (EPI) or Gas discharge visualizer (GDV) is based on the well-known Kirlian effect [15]. EPI Consists of an electrode covered with dielectric, generator of electrical field of a high voltage 12 KV, at a frequency of 1000 Hz, and low current applied for less than 1 millisecond and using a CCD video camera [15]. Investigating these images of finger tips, which change dynamically with emotional and health states, one can identify areas of congestion or energy balance in the whole system. Studies have been performed to understand effects of energy work on human Bio-energy field using GDV and quantifiable results have been obtained [16].

This review tries to understand the effects of MPEMFs on brain physiology and stem cell functioning and its possible link in the development of brain tumors. It also explores early diagnostic value of EPI imaging in detection and quantification of changes induced due to MPEMF on human energy fields.

Effects of MPEMF on Cerebral Blood Flow

A recent study on 29 volunteers tested for acute exposure to MPEMF generated by the MP operating in the Global System for Mobile communication (GSM), 900 MHz, on cerebral blood flow. All participants were exposed to two experimental sessions: a sham exposure session and a real exposure session in a cross-over double-blind study in which a mobile phone was positioned on the left side of the head. In one session, the mobile phone was operated without RF radiation (sham phone) and in the other study it was operated with RF radiation (real phone) for 20 min. Trans-cranial Doppler Sonography was used to measure middle cerebral artery blood flow

velocity. Pulsatility index and resistance index were evaluated. Results showed that there were no significant changes detected in middle cerebral arteries during RF exposure [17]. Another study was conducted on 15 young participants exposed to short term GSM MP radiation to assess cerebral blood flow changes using positron emission tomography. Whole brain images were acquired 12 times, 3 for each condition, in a counter-balanced order. The results provided no evidence for acute effects of short term MP radiation on cerebral blood flow [18]. A previous positron emission tomography (PET) study found increased CBF in the prefrontal cortex after 30 minute exposure to a 900-MHz GSM signal [19]. Another similar PET study showed decreased CBF in the temporal cortex after continuous 51 minutes exposure to a 902-MHz GSM signal [20]. Brain energy metabolism study using PET on 13 young male subjects exposed to a pulse modulated 902.4 MHz GSM for 33 minutes while performing a simple visual vigilance task showed that relative cerebral metabolic rate of glucose was significantly reduced in the temporo-parietal junction and anterior temporal lobe of the right hemisphere ipsilateral to the exposure [21]. In another study, using Functional Near Infrared Spectroscopic (fNIRS), local cerebral blood flow (CBF) on short term exposure to radiofrequency (RF) EMF was measured in 26 boys, age 14-15 years. Temperatures were also measured from both ear canals, and skin temperatures at several sites of the head, trunk and extremities. It was found that local CBF and ear canal temperature did not change and autonomic nervous system was not interfered with [22].

MPEMFs, Human Stem Cells and Cancer Risk

In a study, it was demonstrated that, at specific frequencies, GSM/UMTS microwaves from mobile phones inhibited formation of DNA repair foci in human stem cells. It was also observed that in contrast to well differentiated cells such as fibroblasts, stem cells did not adapt to microwaves from mobile phones during chronic exposure [14]. In other words, the inhibitory effect of MPEMFs on DNA repair in stem cells was irreversible as reported for human lymphocytes also [23]. In addition, specific microwave frequencies are shown to affect stem cells as compared to differentiated cells. Several proteins are involved in DSB (Double-Strand Break) repair, such as phosphorylated histone 2A family member X and tumor suppressor TP53 binding protein 1 (53BP1). They have been shown to produce discrete foci that co-localize to DSBs, referred to as DNA repair [24]. Analysis of DNA repair foci is currently accepted as the most sensitive and specific technique for measuring DSBs in untreated cells, as well as in cells exposed to cytotoxic agents [25]. By analysis of the DNA repair foci in normal human fibroblasts, it was possible to detect DSBs induced by a very low dose of ionizing radiation of 1 cGy, which results, on an average, in 0.4 DSB/cell only [14].

All together, these results show that stem cells are more sensitive to MPEMF exposure than differentiated human primary cells. DNA double-strand breaks (DSBs) and their misrepair are critical molecular events resulting in chromosomal aberrations (CA), which have often been associated with origination of leukemia and tumors including gliomas [23]. Inhibition of DSB repair may lead to chromosomal aberrations by either illegitimate recombination events [12] or reduced functionality of nonhomologous end-joining [26]. Therefore, inhibitory effects of EMF exposure on DSB repair in stem cells may cause origination of cancer. These findings provide a direct mechanistic link to increased cancer risk. Modifications of 53BP1, such as phosphorylation, are needed for repair of DSBs [26]. Thus, the finding on the inhibition of DNA repair foci can be accounted for by inhibition of phosphorylation of 53BP1 protein. Experimental evidence for such a mechanism has been reported [27]. Alternatively, microwave exposure can result in chromatin condensation that prevents DSBs from accessing DNA repair proteins [28]. Regardless of the molecular mechanism, inhibition of DSB repair in stem cells may result in chromosomal aberrations by either illegitimate recombination events or reduced functionality of nonhomologous end-joining [29]. Authors have concluded that stem cells may react more to EMF frequencies as compared to differentiated cells may indicate that stem cells are the most relevant cellular model for validation of safe mobile communication signals. Since stem cells are

more active in children [30], children should represent the most sensitive age group for EMF-increased cancer risk.

Accumulating evidence has shown that the nature of the target cells, that is, tissue stem cells and progenitor cells, needs to be taken into consideration while developing models for carcinogenesis [31]. Stem cell self-renewal and progenitor differentiation is regulated by the specialized microenvironment in which these cells reside and which regulate stem cells they are called as 'niche' [32]. It now appears that most, if not all, human tissues and organs including blood, skin, and brain contain stem/progenitor cells [33]. Therefore, stem cells in different organs are subjected to EMF exposure and attendant increased cancer risks may be anticipated. Therefore, human stem cells may represent a valuable cellular model for evaluation of safe EMF signals. Some part of the human population, such as children and pregnant women could be especially sensitive to MPEMF exposure [30].

To study EMF effects on human lymphocyte activation, Capri et al. analyzed CD25, CD95, CD28 molecules in unstimulated and stimulated CD4+ and CD8+ T cells *invitro* [34]. Peripheral blood mononuclear cells (PBMCs) from young and elderly donors were exposed or sham-exposed to EMFs (1800 MHz, SAR 2 W/kg). No significant changes in the percentage of these cell subsets were found between exposed and sham-exposed lymphocytes in both young and elderly donors. Nevertheless, EMF exposure induced a slight, but significant, down-regulation of CD95 expression in stimulated $CD4^+$ T lymphocytes from elderly, but not from young donors. Stankiewicz et al. investigated whether cultured immune cells induced into the active phases of the cell cycle (G1, S) and then exposed to EMFs (900 MHz simulated GSM signal, 27 V/m, SAR 0.024 W/kg) could also be sensitive to the radiation [35]. The results suggest that the immune activity of responding lymphocytes and monocytes can be changed by exposure to 900 MHz microwaves since the microcultures of PBMC exposed to EMFs demonstrated significantly higher response to mitogens and higher immunogenic activity of monocytes than control cultures.

Stress response has also been suggested as a criterion for adverse effects of electromagnetic fields [36]. Stress may be especially important for stem cells because it is believed to be an important factor in the multistage origination of cancer from human stem cells [37]. Both interpretations of the data either disruption of the balance between cellular repair systems and DNA damage or stress response are not mutually exclusive, and both may provide a mechanistic link to the epidemiologic data showing association of prolonged EMF exposure with brain cancer risk [7]. It should also be mentioned that stress can reduce neurogenesis [38].

Early Diagnostic Value of Gas Discharge Visulaizer in Detection and Quantification of MPEMF-Induced Effects

Electro Photonic Imaging technique/Gas Discharge Visualization (EPI/GDV) is based on the well-known Kirlian effect [39] and utilizes modern optics, electronics, and computer processing for analyzing electro-photonic emission from diverse subjects. These discharge pictures are referred to as EPI-grams. The EPI-grams are obtained by the application of a pulsed electric field, and allows one to identify the functional state of an individual in real time. Through investigating the fluorescent images of finger tips, which change dynamically with emotional and health states, one can identify areas of congestion or energy balance in the whole system. Hence, EPI method can be implemented as a fast screening method for evaluating emotional and physical conditions of people, assessment of treatment procedure's effectiveness and in many related applications [40]. EPI method is easy to apply; it is noninvasive, objective, economic, and time saving equipment [39]. EPI has been used for exploring various areas such as medicine, psychology, consciousness, sport, water and material testing etc [39]. In medicine, EPI has been used to study asthma, cancer, cardiac diseases, autism, surgical implications etc. It has a Russian Certificate of Conformance as a medical device [40]. A systematic reviewed study includes 136 articles addressing four different fields of medical and psychophysiologic applications of EPI. The findings reveal that the software and

equipment EPI complex is a convenient and easy to use device, easy to examine patients with various pathologies and hence, offers a wide range of applications [39].

The EPI device was invented by Korotkov [15, 41] and made by Kirlionics International, St. Petersburg, (Biotech progress LLC, made in Russia). This device consists of an electrode covered with dielectric, a generator of electrical field of a suitable voltage and frequency, and a CCD video camera. It operates in both dynamic and static mode, allowing recording of human energy field in real-time. EPI bioelectrography obtains parameters from 10 fingers of both hands. It uses single pulse of duration 10 ms, repetition frequency of 1000 Hz, induction interval of 1 sec; electrode voltage of 12 kV. Image resolution is 160 x 120 pixels [15]. Reliability and validity of EPI technology has been well established at the St. Petersburg Federal Medical University, establishing baseline with healthy individuals and patients suffering from bronchial asthma. When measuring people in a stable psycho-physiological state, the EPI-gram parameters are reproduced with a 5-10% precision [15, 39, 41]. Another recently published study established the normative data of EPI for the healthy Indian population, to aid in the accuracy of EPI measurements and interpretations [42].

Studies have found correlation between biological markers and EPI imaging parameters [41, 43]. A study found close evidence for the validity of EPI using the mean GDV glow image area as a reliable measure for (at least, certain types of) stress. Comparative analyses of the curve progressions of the parameters tested showed positive correlation between higher GDV glow image area values with increased IgA production in saliva, whilst at the same time, the alpha amylase was negatively correlated [41]. Few studies have assessed effect of MPEMF on human's bio-electromagnetic field (BEM) using EPI [44]. The purpose the present study was to make a comparative analysis of the effects on human BEM caused by mobile telephones. The data about person's BEM was gathered by recording coronas of all ten fingertips using the EPI camera. The discharge pictures for each person were taken three times – first time before wearing the turned-on cellular phone and after wearing the telephone for 60 minutes. Subjects were divided into 2 groups: control group of 17 people - subjects without cellular telephones; 19 people, wearing cellular phones without any protection against possible effects on their BEM. For statistical analysis of the picture data had to be transformed into numerical values. This was done with program EPI-Analysis that is available with the system. EPI-Analysis transforms pictures into numerical parameters that describe the characteristics of fingertip coronas. Parameters of EPI that proved to be important in previous studies were only used [45-48]; namely, area of GDV-gram, number of separated fragments in the image, average area of the fragments, relative area of corona and areas in the sectors of each finger. Since the telephone was worn at the level of the human's heart, it was decided to observe out of 79 in sectors, only 22 parameters that according to finger corona map correspond to those parts of body that might be influenced by cellular phones. Thus, analysis included 4 sectors for heart, 2 sectors for throat with thyroid gland, 2 sectors for brain, dorsal spine, blood circulation, lymph, chest, head, pineal gland and respiratory system. They also defined additional, potentially significant parameters: CW - corona width parameters, describing relative changes of above parameters and CW. The EPI device comes with software that converts the size and intensity of images into a quantifiable data expressed in joules. In the next step the average of above parameters and their counterparts over all ten fingers for every subject was calculated. Results of the study revealed that cellular phones influence the human BEM in a way that coronas become reduced, more fragmented and incomplete after 60 minutes of exposure. Though the results from statistical analysis confirmed these conclusions, the majority of results were not significant. Authors proposed that a probable reason for this could be insufficient quantity of data. Since there were large deviations, presumably caused by insufficient number of people in groups, there was a need to repeat this study on a larger population. We performed a randomized controlled pilot study [49] on 60 healthy teenagers who were randomly divided into two groups: 1) MPON and 2) MPOF. MPON group was exposed to 900 Hz GSM mobile phone radiations for 30 minutes on the right side of the ear ~ 1.5 centimetres distance from the tragus. MPOF group was exposed to the same mobile on the same side for the same duration to mobile phone in off mode with

the batteries removed. The assessments were done for obtaining human BEM using GDV Pro device before and immediately after the exposure. We found that the EPI images were significantly different between the groups. The subtle energy levels were significantly reduced after the exposure to MPEMFs for the following area zones of human BEM in the MPON group as compared to MPOF group: a) Pancreas ($p = 0.001$); b) Thyroid gland ($p = 0.002$); c) Cerebral Zone Cortex ($P < 0.01$); and d) Hypophysis ($p = 0.013$). This suggests that there are definite effects of MPEMFs on human BEM and they are quantifiable [49]. Future studies with larger sample size should confirm these findings. Studies in future should explore the diagnostic potential of emerging EPI technique through large sample studies with randomized controlled designs. Studies should also be planned to detect a subtle energy bio-marker of MPEMF effects on human BEM that can be used to identify and quantify cancer risk earlier to its physical manifestation [44].

Conclusion

MPEMFs are potentially hazardous to human health especially if the exposure period spans over 10 years. MPEMFs can alter brain physiology and hemodynamics. EMFs from mobile phones may inhibit formation of endogenous 53BP1 foci in stem cells. Stem cells are more sensitive to MPEMF exposure than are differentiated human primary cells. Inhibitory effects of MPEMF exposure on DSB repair in stem cells may result in formation of chromosomal aberrations and therefore origination of cancer. Alternatively, MPEMF exposures may induce a stress response. Both possible interpretations provide a mechanistic link to increased cancer risk. Electro photonic imaging (EPI) is subtle energy diagnostic tool which is valid and reliable tool to assess early effects of MPEMF radiations.

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