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Review Article

THE EFFECT OF MOBILE PHONE RADIATION ON THE BLOOD-BRAIN BARRIER (BBB): A REVIEW

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ABSTRACT

Health effects of Radio frequency waves have been raised because of the gradual increase in usage of cell phones, and this Usage of cellular phones is associated with alterations in various body systems including the central nervous system. The impact of radiation emitted from mobile phone on experimental animals still unclear and contradictory and there is limited reviewed work of Mobile phones radiation effect on blood-brain barrier and therefore; the purpose of this work was to review the possible effects of mobile phone radiation on blood-brain barrier from findings in the literature on tissues in human and experimental animals.

This review is grounded on the various scientific published articles, journals and textbooks accessed on line from January 2010- November, 2011 and summarize the main results of studies of mobile phone radiation impact on blood-brain barrier permeability published until 2009. Accordingly, number of studies relating to electromagnetic field emitted by cell phones over a wide range of frequency is used, depending on a number of electromagnetic field parameters, duration of exposure and Specific absorption rate values.

Several authors have reported that electromagnetic exposure alters blood-brain barrier permeability. On the contrarily; other authors have reported differently in confirming these findings and more over it is also reported that mobile phone radiation-induced activation of cellular stress response might affect blood-brain barrier permeability . Generally, the results of different studies conducted in experimental animals have revealed that long term exposure to cell phone radiation and at high or low Specific absorption rate value enhances increased permeability of the blood-brain barrier.

KEY WORDS: Blood-Brain Barrier, Radiation, Radio frequency waves, Mobile phone radiation.

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INTRODUCTION

Our environment is subjected to exposure to microwaves and electromagnetic irradiations as a result of widespread use of wireless telecommunication [1]. It is reported that Cell phone usage is a public health concern because of the potential risk of chronic exposure to the low levels of radiofrequency and microwave radiation that pulse off the phone antenna, in close proximity to the user's head [2]. The cell phone is an integral part of our everyday life that is used for multipurpose like a voice call, video call, browsing, chatting, listening music, meeting games, reading books etc. [3].

About 3.5 billion mobile phone connections use Global system for mobile communications (GSM) across 222 countries, which is over 80% of all the connections in the world and the GSM network operates in the 900 and 1800 MHz bands in most countries [4,5]. Moreover; others

have been also reported that Mobile phones operate on wireless technology using a variable frequencies as described by different authors [6,7,1,8,2,9,10,5,11], at variable range of power [8,9]. Different mobile phone systems use [1] different signals (different frequency bands and information coding methods) [4].

Mobile phones emits radiofrequency- electromagnetic waves (RF-EMW) to nearby relay base stations or antennas, and our bodies act as antennas that absorb the radiation and convert it into alternating eddy currents [9]. Because of the mobile phones are held close the body and are used frequently, these devices are potentially the most dangerous sources of electromagnetic radiation that the average person possesses, and because of its penetration, exposure of an electromagnetic field could cause significant alternation in the blood brain barrier behavior [5].

The impact of electromagnetic radiation (EMR) emitted from mobile phone on experimental animals still unclear and contradictory and there is almost no published review of Mobile phones radiation effect on blood-brain barrier (BBB) and therefore the purpose of this work is to build up the knowledge on the possible effects of mobile phone radiation on blood-brain barrier from findings in the literature on tissues of human and experimental animals.

This review uses different Literatures about the effects of electromagnetic field emitted by cell phones over a wide range of frequency depending on a number of electromagnetic field parameters and duration of exposure.

METHODOLOGY

This work is grounded on the various scientific published articles, journals, reviewed articles and textbooks accessed on line from January 2010-2011november and this paper summarizes the main results of studies, on impact of mobile phone radiation published until 2009.

Literature Review:

Effect of digital mobile telephony radiations on health: Mobile phone use in close proximity to the head has increased public concern about adverse effects of mobile phone radiation on the nervous system [4]. Cell phones transmit electromagnetic waves in all directions, increasing the region of cells within the brain that are at risk for damage by radiofrequency and microwave radiation penetrating the skull [2]. It emits radiofrequency energy, which can be absorbed by tissues closest to where the phone is held [11].

The emitted radiofrequency (RF) consists of magnetic fields and oscillating electric which interact negatively with the cells of plants and human beings and this radiation is dangerous to different human body functions like the head and organs damage [3]. Mobile phones are used frequently, and therefore appear to be one of the major biological exposures [12]. This feature has led to public concern about possible adverse health effects (8). Other researchers have also supported the idea that the possible risks by radiofrequency electromagnetic fields exposure of the human body, is a major concern for the society [7,13,14]. Similarly, this idea is also supported by [8].

The exact underlying pathophysiologic mechanism of cell phone related health impacts is not entirely known [9,8], However, there are two proposed cell phone related biological effects on the human body i.e the thermal effect which occurs particularly high frequencies where the radio-frequency radiation has heating properties which may lead to an increase in tissue temperature and may cause disruption of cell function and development [11,9] and the other 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 electromagnetic wave (EMW), endothelial dysfunction & alterations in the blood-brain barrier [9,12].

According to [4] Specific absorption rate (SAR) is a measure of the rate at which RF energy is absorbed by a unit mass of tissue (W/kg, and exposure limits relevant to mobile phones are expressed in terms of the SAR averaged over a small sample volume (typically 1 or 10 g) of tissue for instance, SAR1g < 1.6 W/kg and SAR10g < 2.0 W/kg. The limit of mobile phone radiation exposure level set in united states and Europe is ~ 1.6 w/kg and 2.0w/kg respectively, and people get exposed under these limit [5]. It has been shown that the health effects of

digital mobile telephony radiations are non-thermal and a lot of biological effects were recorded at radiation intensities much lower than the values of exposure criteria set by the International Radiation Protection Association and the International Commission and this is the reason why several countries in Europe have established much more stringent national exposure criteria [10]. On the other hand; it is reported that no consistent indication from in vitro research that RF fields affect cells at the nonthermal exposure level [15].

The mobile phone user places their mobile near the brain which produces more critical condition due to the exposure of electromagnetic radiation and the heat produced due to the electromagnetic wave that damages the tissues and So that, these radiations connected with the brain cancer and Alzheimer's disease [3]., and it might also alter the cell structure beginning with the plasma membrane and its receptors to the different biomolecules present within the cell which might cause genotoxicity [11]. Moreover; Usage of cellular phones is associated with alterations in various body systems including the central nervous system, cardiovascular system, male reproductive system and some evidence of potential adverse effects including headaches, increased resting blood pressure has been also reported by [9].

Studies conducted on experimental animals have shown that mobile phone radiation-induced changes in hsp27 expression/activity of cell might eventually lead to increase in the permeability of blood-brain barrier (BBB) [14]. Similarly, Same other investigates have supported this finding that, from real GSM mobile phones have the potency to significantly open the BBB for the animals' own albumin to pass out into the brain and to accumulate in the neurons and glial cells and albumin extravasations are most prominent at the lower Specific absorption rate (SAR) values [7,12,5]. Other literature conducted on experimental animal reported that radiofrequency - magnetic field exposed rat usually showed several albumin-positive foci around the finer blood vessels in white and gray matter and the albumin had spread in the tissue between the cell bodies and surrounded neurons. Likewise, weak pulsed microwaves give rise to a significant leakage of albumin through the blood-brain barrier[13].

Four hours of GSM-900MHZ exposure at brain power densities ranging from 0.3 to 7.5W/KG resulted in significantly increased albumin extravasation both at SAR-value of 7.5W/KG .,1.3W/KG [12]. Another study reported by [10], discussed also that 915 MHz microwaves at non-thermal intensities causes leakage of albumin into the brain through the BBB in rats, accumulating in the neurons and glial cells.

Effect of electro-magnetic radiation OnAstrocytes: Astrocytes are the most numerous glial cells of the central nervous system, characterized by numerous cytoplasmic processes radiating from the glial cell body and are an important part of the blood-brain barrier regulating entry of molecules and ions from blood into central nervous system tissue [16,17]. Likewise, it is also reported that the blood-brain barrier is formed by vascular endothelial cells of capillaries of the brain and the glial cells [12]. The blood-brain barrier (BBB) has the function to regulate transport of substances between the blood and the brain in mammals and is of utmost importance for the protection of the brain from harmful compounds [7]. It is a selectively permeable, hydrophobic barrier that is readily crossed by small, lipidsoluble molecules and Certain lipid-insoluble molecules such as glucose also readily crosses the cell layers constituting the barrier through carrier proteins that have a high affinity with specific molecules [6].

The fact that RF exposure causes neurological damage has been documented repeatedly and it is reported that Increased BBB permeability and oxidative damage, which are associated with brain cancer and neurodegenerative diseases [11]. Investigation conducted by [18] provides that a one hour exposure of normal human astrocytes to mobile phone radiation in conjunction with a twenty four post exposure incubation decreases the number of astrocytes**.** DNA damage as a result of EMF can cause diseases that affect the nervous system especially DNA damage in an area of glial cells which undergo cell division can cause cancer [19]. Electromagnetic field predominantly affects neurological tissue and the largest collection of this tissue is the brain [18]**.**

Adverse effects of radiofrequency-magnetic wave radiation on human health is still limited [20], nevertheless published research reported by [14] have concluded that the induction of cellular stress response by the non-thermal levels of mobile phone radiation has been shown that overnight irradiation of nematode worms with RF-EMF (750MHz) at SAR of 0.001W/kg causes increase in expression of heat shock protein.

In another study exposure of human endothelial cells in vitro, to GSM 900 MHz mobile phone radiation for 1hour at non-thermal levels, average SAR 2 W/kg, caused transient increase in heat shock protein hsp27 phosphorylation and transient changes in protein expression levels [10]. Thus, because of the known broad spectrum of physiological processes that are regulated by stress proteins, it is possible to suggest that mobile phone radiation-induced activation of cellular stress response might affect variety blood-brain barrier permeability [14].

The effects from exposure to electromagnetic fields used in GSM mobile communications on the rat brain found increased permeability of the BBB to endogenous albumin and Pronounced leakage was seen at the lowest power depositions (SAR<2mW/kg (7). According to the finding of [13] rats Exposed to RF- EMF showed that several albumin around the blood vessels in white and gray matter of rat brain and rats exposed to 915 MHz microwaves with different modulation frequencies at SAR values 0.11—8.3 W/kg revealed that minute amounts of albumin leaking through the BBB and may be harmless to the brain [6].

Overall, from these different literatures it was concluded that exposure to mobile phone radiation especially lower SAR value influence brain function particularly non-thermal intensities causes leakage of albumin into the brain through the BBB in experimental animals. However, further detail research is needed.

CONCLUSION

A large number of studies have investigated the possible effects of mobile phone exposure on health and it is certain from literature that; Cell phone usage is a public health concern because of the potential risk of chronic exposure to the low or high levels of radiofrequency and microwave radiation. The impact of mobile phone radiation on blood brain barrier from findings in the literature on tissues of human and experimental animals revealed that exposure to mobile phone radiation on experimental animals is still unclear and contradictory in most cases; on the contrary, same results showed that lower Specific absorption rate value particularly non-thermal intensities causes leakage of albumin into the brain through the blood brain barrier in experimental animals.

Eventually, from a health perspective, manufacturers who sell these products have a lot of responsibilities, the people should give attention to cell phone's radiation levels, and use other options which minimize radiation exposure at individual level by using like ear phone and Bluetooth and the stalk holders of the government at large should be responsible to control and set limit on Specific absorption rate value of mobile phones entering to once own territory specially in developing countries.

Conflicts of Interests: **None**

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