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Electromagnetic Radiation from Mobile Phone and its effects on Human Brain

Naba Kumar Mondal, Tapan Dhibar, Kausik Das, Uttiya Dey, Sanhita Roy, Jayanta Kumar Datta, Niranjan Gupta and Nikhiles Biswas

Abstract

Today, cell phone technology is an integral part of everyday life and its use is not only restricted to mobile telephony but also extends to internet surfing, data and image sharing, music and video downloading etc. With increased usage and growing numbers of subscribers, concern for radiation hazards from cell phone towers have also increased. The present article deals with cell phone radiation, its interaction with cellular and sub cellular structures of the human body and resulting ill effects on human brains. Finally, a few suggestions are made to overcome the challenge.

Introduction

Discovery of telephone in March 1876 by Alexander Graham Bell was a standout event in world history for which he was subsequently awarded the first patent for electronic telephone[1]. Eversince this discovery, telephone has seen many technological changes. Worldwide, a dramatic increase of cellular phones has prompted concerns regarding potential harmful effect from electromagnetic radiation (EMR). It is well documented[2-4] that there is a close association between cell phone use and prevalence of brain tumors.

The radiation emitted by cell phones is absorbed by the brain tissue within a range that could influence neuronal activity[5-6].

In view of the proximity between radio-frequency source (i.e. mobile phones) and the human brain, several studies have investigated the effects of EMR on resting cerebral activity, but results have often been contradictory[7-8]. The EMR is characterized by its frequency, intensity of electric and magnetic fields, their direction and polarization characteristics in free space. When an electromagnetic field falls upon the human body, it partially penetrates the body and is absorbed by body tissues[9]. The adsorption of EMR is expected to raise the body temperature.

The present article discusses about the nature of electromagnetic radiation, which originate from use of mobile phones and their effects on brain tissue.

EMR from Mobile Phones Base Station

The radiation emitted by mobile phone transmission towers are electromagnetic fields in the microwave frequency range. The intensity of this field is maximum near the tower and reduces with increasing distance from the tower according to inverse law : $I \propto \frac{1}{r^2}$.

The value of electric field E_0 at a distance r, from a vertical transmitting antenna of power P, is given by Polk[10].

$$P/_{4\pi r^2} = E_0^2 \frac{\varepsilon_0 C}{2}$$

$$E_0 = \left(\frac{P}{2\pi r^2 \varepsilon_0 C}\right)^{\frac{1}{2}} = 7.746\sqrt{P/_r}$$

where 'ε_0' is permittivity of free space; and 'c' speed of light.

The electric field E_0 at a distance r, from vertical transmitting antenna of effective radiation power (ERP) of 50 w is

$$E_0 = \frac{54.76}{r}\ \frac{V}{m}$$

Thus it is clear from the above equation that electric field varies inversely proportional to the distance from the transmission tower.

Mobile phone technology and radio field

The maximum powers that GSM mobile phones are permitted to transmit by the present ICNIRP standard are 2W and 1W at 900 Hz and 1800 Hz, respectively. Generally, a part of the radiated energy will be absorbed in tissues. The power absorbed per unit mass is given by the following expression[11].

Specific Absorption $(SAR) = {(SE^2)}/_r$

where S is the electrical conductivity of tissue and r is the mass density. The SAR is measured in watts per kilogram. It varies from point to point in the body, because the electric field changes with position and the conductivity is different for different types of tissues. However, in most of the situations, SAR is directly

proportional to $1/d^r$ where d is the distance between the antenna and the head 'P' varies from 1.5 - 2.

The calculated values[3] of SAR in fat and skeletal muscle of human body from mobile phone base station are presented in Table 1 and Table 2. These tables (Table 1 and 2) clearly reveals that the harmful values of SAR for fat are up to a distance 10 cm from the base station and for skeletal muscles, these values are up to 400 cm from the base station.

Sl. No.	Distance from tower, in cm	Incident electric field (E_0) Vm^{-1}	SAR Wkg^{-1}		
			1 cm	2 cm	3 cm
1	10	547.6	10.10	3.9	2.41
2	30	163.5	0.99	0.384	0.238
3	60	91.3	0.28	0.180	0.670
4	100	54.8	0.101	0.038	0.024

Table 1. Variation of SAR inside FAT at different depths

(adopted from : Kumar and Pathak, 2011)[3]

Sl. No.	Distance from tower, in cm	Incident electric field (E_0) Vm^{-1}	SAR Wkg^{-1}		
			1 cm	2 cm	3 cm
1	10	547.6	3848.2	3674.5	3505.4
2	30	163.5	342.7	327.4	312.4
3	60	91.3	106.8	102.04	97.34
4	100	54.8	38.46	36.74	35.04
5	200	27.4	9.61	9.18	8.76
6	400	13.7	2.41	2.29	2.18
7	800	6.8	0.599	0.573	0.546
8	1000	5.47	0.383	0.365	0.348

Table 2. Variation of SAR inside skeletal muscle at different depths

(Adopted from : Kumar and Pathak, 2011)[3]

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The guidelines and regulations governing the safe use of RF/microwave radiations are given by the International Commission on Non-ionizing Radiation Protection (ICNIRP,1998)[12], the Institute of Electrical and Electronic Engineers (IEEE,2001)[13], National Council on Radiation Protection and Measurement (NCRP, 1986)[14], The Australian Radiation Protection and Nuclear Safety Agency Standard (ARPANSA, 2002)[15] etc. All these agencies have set the safe limits of whole body SAR as 1.6 Wkg^{-1}.

Interaction of cell phone radiation with biological tissues

The human body (contains 70% of liquid) acts as parasitic antenna that receives the electromagnetic radiations or waves from external sources[16]. It is very similar to that of cooking in the microwave oven. The human height is much greater than the wavelength of the cell tower's transmitting signals, so there will be multiple resonances in the body, which creates localized heating inside the body. This results in the drying up of the eyes, brain, joints, heart, abdomen[17] etc . Radiation from cell phone towers has been associated with greater increase in brain tumor[18]. One of the very recent study[2] demonstrated that continuous 50 minutes cell phone exposure increase brain glucose metabolism in the region closest to the antenna. Because of electric field, E(r), produced by the cell phone, which decreases rapidly with distance from the antenna, the scientist hypothesized that the effect of cell phones on glucose metabolism would occur in regions close to the antenna and that the regions far from the antenna would show no effects. Therefore, the corrections for multiple comparisons were restricted to brain regions in which E(r) was higher than 50 % of the maximum field value E_0, in the brain ($E_0/2 < E(r) < E_0$) (Fig. 1). However, whole-brain glucose metabolism did not differ between conditions, which for the off condition corresponded to 41.2 µmol/100 g per minute and for the on condition to 41.7 µmol/100 g per minute (Figure 2).

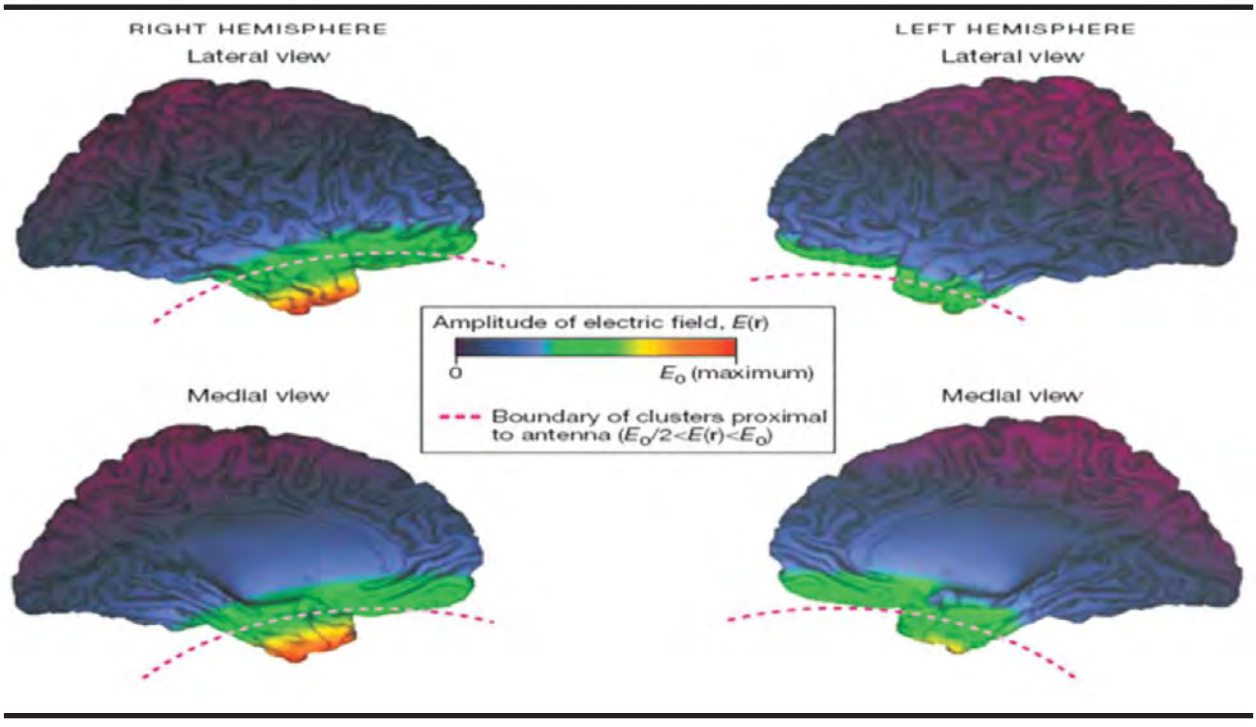
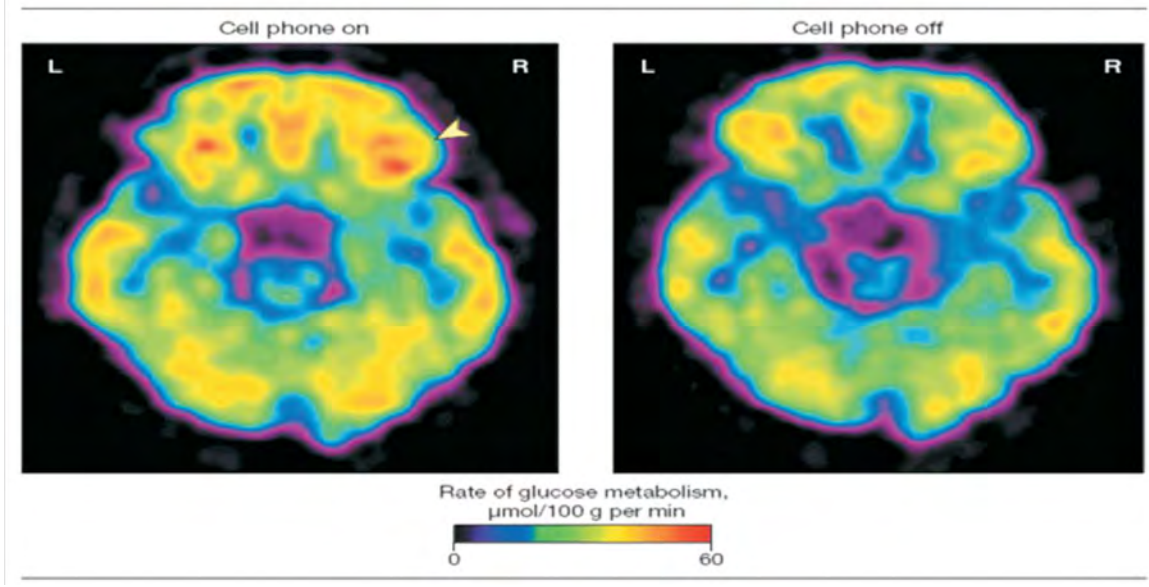


Figure 1. Amplitude of the Electric Field emitted by the right cellular telephone antenna rendered on the surface of the human brain

(Figure adapted from Volkow et al., 2011)[2]



Images are from a single participant representative of the study population. Glucose metabolism in right orbitofrontal cortex (arrowhead) was higher for the 'on' than the 'off' condition (see 'Methods' for description of condition).

Figure 2. Brain Glucose Metabolic Images showing Axial Planes at the level of the Orbitofrontal Cortex

(Figure adapted from Volkow et al., 2011)[2]

Other effects of cell phone radiation

On the other hand, Carl Blackman[19] have shown that weak electromagnetic field release calcium ions from the membranes. Moreover, leakage of calcium ions in to the cytosol acts as a metabolic stimulant, which accelerates the growth of tumors. Loss of calcium ions causes leaks in the membranes of lysosomes that causes DNA damage (Figure 3). From Fig. 3, it is also clear how cell phone radiation causes effective interaction with cellular and sub-cellular structure.

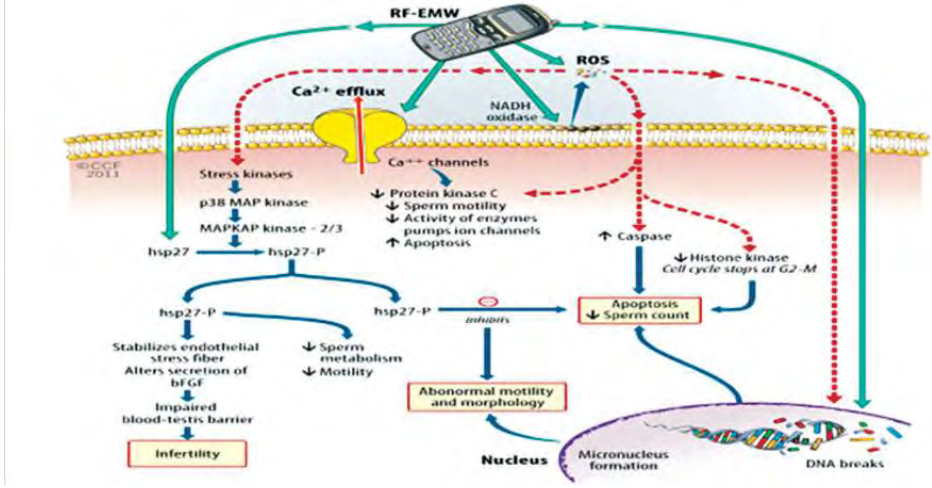


Fig. 3. Effects of RF-EMW on cellular and sub-cellular structure.

(Figure adapted from Hamada et al., 2011)[20]

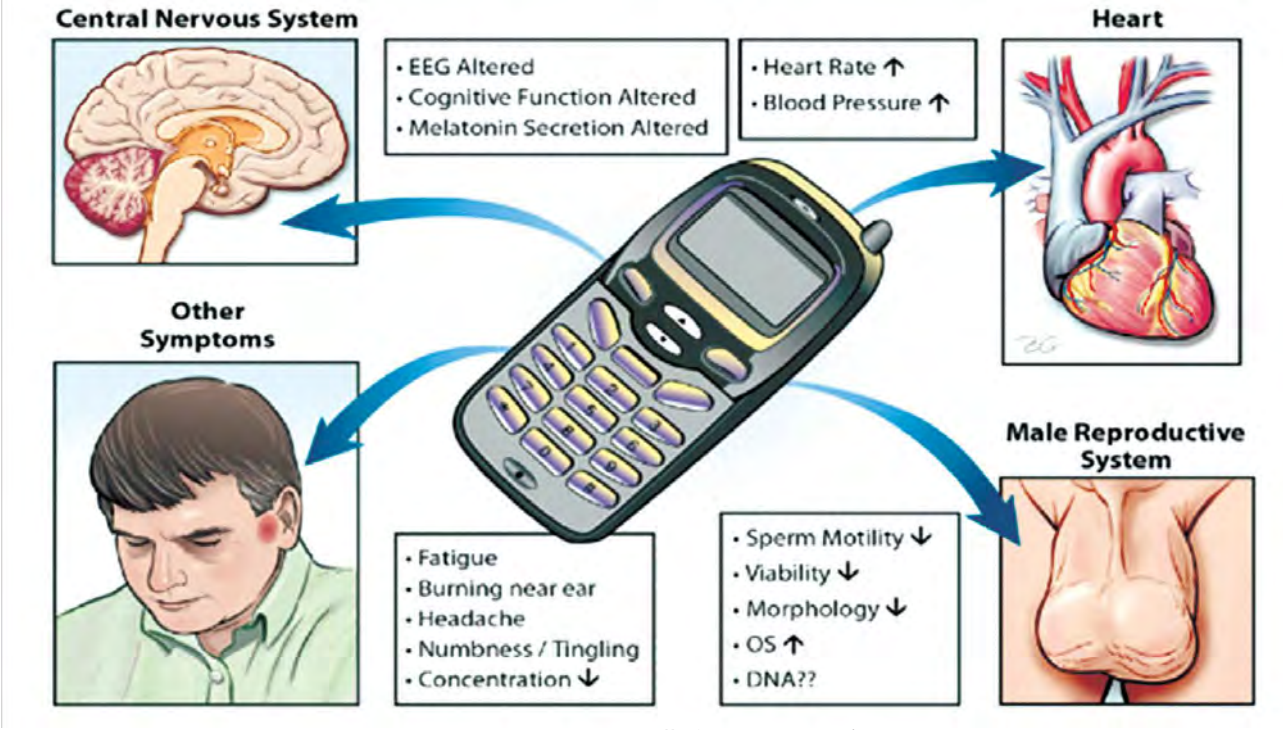


Figure 4. Gross effects of cell phone EMW radiation.

(Figure adapted from Makker, 2009)[21]

Microwave radiation damages the placental barrier, this clearly suggest that pregnant women should avoid use of cell phone[22]. A pregnant woman and the fetus both are vulnerable because of the fact that these RF radiations continuously react with the developing embryo and increasing cells. Children are more vulnerable to radio frequency (RF) radiation emissions as their skulls are thinner, their nervous system still developing and myelin sheath is yet not developed.

Moreover, RF exposure can adversely affect the heart pace maker, implantable cardiovascular defibrillators and impulse generators[23]. This RF radiation may stop peace maker from delivering pulses in regular way or may generate some kind of external controlling pulse resulting in conditions that may lead to death. Another important report from WHO[24], states that diseases like Alzheimer and Parkinson are highly connected with electromagnetic radiation. Finally at the end of May' 2011, after reviewing dozens of studies, WHO announced that cell phone may cause brain cancer and they classified cell phones as "possible carcinogenic to humans" and placed them in the same category as the pesticide DDT and gasoline engine exhaust.

Conclusions

It is clear from the study that the electromagnetic radiation discharge from different sources such as mobile phone, computer, laptop, TV towers, FM towers, microwave oven etc can be dangerous for human beings. Scientists are unanimous in concluding that excessive exposure to such radiations may lead to brain tumors. Continuous fifty minute cell phone exposure is found to be associated with increased brain glucose metabolism in the region closest to the antenna. Study also reveals that children are more vulnerable due to the electromagnetic radiation from cell phones.

Therefore, the message we want to covey towards our society is that we must be careful in our use of technology so as not to damage our own health. It is also suggested that no transmission tower should be located near populated areas and there should be strict enforcement of radiation norms from mobile phone towers. People should keep themselves at least 4 m away from mobile phone base stations and the government should take initiative to reduce the mobile phone tower radiation from 4 watt/m^2 to 0.4 watt/m^2. Moreover,

people may use headphones instead of putting the mobile phone directly on their ears.

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Dr. Naba Kumar Mondal, Assistant Professor
Department of Environmental Science, The University of Burdwan, West Bengal, India
Email : nkmenvbu@gmail.com, Mobile - 09434545694