



Effects of Electromagnetic Radiation Emitted from Mobile Phones on Different Physiological Systems and Possible Remedies

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ABSTRACT

Aim: In this paper, we aim to provide a review of some of the studies which investigated the possible negative biological effects of mobile phone radiation on different mammalian systems. This review will provide answers to public concerns about the risks of using mobile phone.

Background: Mobile phone has become an indispensable gadget for all. The growth in the use of mobile phones has raised concerns about the possible interaction between the electromagnetic field (EMF) radiation and the biological effects on mammalian systems, particularly the nervous, haematological, endocrine and reproductive systems.

Conclusion: Our conclusion shows that long term exposure to EMF radiation may cause permanent damage to different mammalian systems. Finally, some studies have also showed no effects due to exposure to EMF. More long term studies and analysis are needed.

Key Words: SAR (Specific absorption rate), Radio frequency, Electromagnetic radiation, GSM (Global System for mobile communications), CDMA (Code Division Multiple Access), Nutritional supplement

INTRODUCTION

It is nowadays impossible to imagine a modern, socially active person who does not use mobile devices. During the last two decades there has been a significant increase in the use of mobile phones throughout the world.⁽¹⁾ These mobile phones radiate harmful radiation which may cause harmful effects on the different physiological systems.

The transfer of energy to electrons when they fall back to ground state is unique to each element, as it depends upon the electronic configuration of the orbital. The energy transfer is inversely proportional to the wavelength of electromagnetic radiation.

$$E = hc/E\lambda$$

[Where, h = Planck's constant

c = velocity of light

λ = wavelength]⁽²⁾

The initial safety guidelines for radio frequency and microwave radiation (RFR and MWR) were set by American National Standards Institute (ANSI) in 1982 and the US Federal Communications Commission (FCC) on Feb 26, 1985 based on "thermal effects."⁽³⁾

ANSI (1982) published the first exposure standard, incorporating a 10 fold safety factor for humans exposed to electromagnetic fields between 300 KHz and 100 GHz frequencies.

As per estimated figures released by Telecom Regulatory Authority of India (TRAI), there were 936 million active

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mobile connections in India as on March 2016. There are almost 5 billion mobile phone users all over the world. Out of them, more than 900 million are Indians, which accounts for more than 80% of the total Indian population.

Electromagnetic emissions from mobile towers (Base transceiver stations, BTS) emanate at 900 MHz, 1800 MHz, 2100 MHz and 2300 MHz frequencies and from mobile handsets at 900 MHz and 1800 MHz for GSM (Global System for mobile communications) and at 1800 MHz for CDMA (Code Division Multiple Access).⁽⁴⁾

Good nutrition may ameliorate the harmful effects of mobile phone radiation. Especially, high quality protein having good biological value can protect the mammalian systems from the harmful effects of radiation.

The Specific Absorption Rate (SAR) value and various regulatory agencies

The SAR value defines the amount of energy deposited per kilogram of body weight and is a measure for assessing the thermal effects. International Commission for Non-ionising Radiation Protection (ICNIRP) and the FDA (Food and Drug Administration) safety standards of USA limit the spatial peak microwave exposure to 2W/Kg and 1.6W/Kg SAR values respectively, averaging over 10g tissue for 6 minutes.⁽⁵⁾

Legislations implemented by various Indian regulatory agencies regarding microwave radiation exposure

In India also, there are several laws and regulations regarding the radiation emitted from different mobile base stations as well as mobile handsets.

Department of Telecommunications (DoT) monitors radiation emitted from 10% of the randomly selected base stations, as or and when, on a complaint basis. In this regard, an international committee was set up with members from Indian Council of Medical research (ICMR), DoT, Department of Biotechnology (DBT) and Ministry of Environment and Forest and in its meeting on 24/08/2010, the members expressed their concern that “Indians are at higher risk due to tropical climate, low body mass index, low fat content and high environmental EMR”. Based on their recommendations, DoT further lowered the safety standards with effect from 01/09/2012, i.e. frequency/2000W/Sq.m at the above mentioned frequencies. For the mobile handsets, the new standard is 1.6W/Kg averaged over 1 g of tissue, 6 minutes. These safety standards are stringent as compared to many western countries. Since 01/09/2013, it has become mandatory to display the SAR values on handsets and EMR (Electromagnetic radiation) should be monitored like noise and air-pollution through monitoring devices.⁽⁵⁾

DISCUSSIONS

The effects of mobile phone radiation on different physiological systems and their possible remedies are discussed in this review article.

Carcinogenic effects of mobile phone radiation

The International Agency for Research on Cancer (IARC) of the World Health Organisation (WHO) issued a press release on May 31, 2011, labelling cell phone radiation as “possibly carcinogenic to humans” and added it to the list of other group 2B agents.⁽⁶⁾

According to the data base of the National Cancer Institute, December 2014, it was suggested that the increasing cell phone usage in humans enhanced the risk of tumour formation. They also tried to establish whether there is any direct relation between cell phone radiation and formation of malignant tumours. In this context, a study was conducted in May, 2016, called the case control study. In this study, data regarding the incidence of cancer occurring in a large group of population using cell phones was analysed over time. The results of the study showed that the probability of formation of malignant tumours is increased among the people who used cell phones.⁽⁷⁾

In America the use of cell phone started since 1991. A large study was done by the US National Toxicology Program (NTP) where a large group of laboratory rats and mice were exposed to RF (radio frequency) energy over their entire bodies for about 9 hours a day, starting before birth and continuing for up to 2 years. They found a probability to get damaged the of gliomas and schwannomas of the hearts in the rats exposed to RF radiation.⁽⁸⁾

According to the American Cancer Society, as cell phones are held near the head when being used, they might cause tumours in the following are as:

- a) Malignant brain tumours such as gliomas.
- b) Non-cancerous tumours of the brain such as meningiomas.
- c) Non-cancerous tumours in the nerves connecting the brain to the ear (vestibular schwannomas, also known as acoustic neuromas).
- d) Non-cancerous tumours of the salivary glands.

Brain cancer rates in USA have increased by 25% since 1975. In 2001, 185,000 Americans were diagnosed with some form of brain cancer. A grade forebrain tumour can grow from the size of a grape to tennis ball size in just 4 months. Although no specific cause has been reported, but interestingly, a dramatic increase in the rate of RF exposure had been reported in these patients. This radiation exposure may thus be considered to be the causative factor for tumour formation in those brain tumour patients.⁽⁹⁾

An epidemiological study conducted by Dr. Lennart Hardell found a higher incidence of brain tumours on the sides of heads used by mobile phone subscribers to make and receive calls.⁽¹⁰⁾

In 2009, the Jennie Zoline foundation of the University of Pittsburgh Medical Centre and the Osaka Medical Research Foundation published an article which concluded that the correlation between cell phones and cancer is inconclusive. However, the article did lead to the circulation of a hospital-wide memo warning about the “growing body of literature linking long term cell phone use to possible adverse health effects including cancer” (UPCI Memo, 2009).⁽¹¹⁾

Effect of mobile phone radiation on the nervous system

Human beings have dual sensitivity i.e. to microwave carrier frequency and the low frequency pulsing at 8.34 Hz of TDMA technology (Time Division Multiple Access, where multiple users can communicate simultaneously with the base station) and 2 Hz of DTX mode (Discontinuous Transmission mode, when the user is only listening) that are similar to alpha and delta rhythms of human brain. These emissions can interfere with brain's signal processing activity due to their oscillatory similitude to the above inherent rhythms of the brain. This phenomenon is akin to “Electromagnetic interference” (EMI) that occurs while using mobile phones in aeroplanes.⁽¹²⁾

A study was done in Zhejiang University School of Medicine, China by Y. Zhu et al. in 2008, where *in vitro* cultured cortical neuronal cells and *in vivo* rat's brain were exposed to the electromagnetic waves emitted by mobile phone. The result showed that microwave radiation emitted from mobile phones is harmful for both the *in vitro* cultured cortical neuronal cells and *in vivo* brain neuronal cells from rat with cranial defect.⁽¹³⁾

Another study was done by Y.A Khadrawy et al. in National Research Centre, Giza, Egypt, 2009, where adult young rats were exposed to EMR for 1 hour/day. Amino acid neurotransmitters - glutamate, aspartate, GABA (Gama Amino Butyric Acid), glycine and taurine in the cortex were measured. The data showed that, in the adult rats EMR induced significant changes in the cortical levels of some of the studied amino acids throughout the exposure period. However in the young rats, EMR induced significant changes were seen even after stopping of the exposure.⁽¹⁴⁾

A study was done by M. Jadidi et al., where animals were exposed to mobile phone radiation and their anxiety levels were observed. No behavioural changes were observed in animals exposed to different levels of electromagnetic radiation emitted from mobile phones.⁽¹⁵⁾

An update of reports on the neurological effects of non-ion-

ising electromagnetic fields published, between 2007-2014 by Henry Lai, suggests the presence of neurological effects in 68% of the publications and absence of effects in 32% publications.⁽¹⁶⁾

The neurological effects described in the review are changes in brain electrical activities after acute exposure to mobile phone radiation like- event related potentials, changes of the alpha-wave power of EEG after exposure to 2G, but not 3G mobile phone radiation. However, some authors reported no significant effects on EEG and event related potentials recorded in awake and conscious human beings after exposure to mobile phone EMR. Electromagnetic hypersensitivity is reported in many individuals who are sensitive to mobile phone radiation. Headaches, dizziness, memory and sleep problems are experienced.

Effect of EMR on the cardio vascular systems

A study was done in Electrical Engineering Department, National Institute of Technology, Calicut, Kerala, India by V.T. Ahamed et al. The study dealt with the effect of electromagnetic fields radiated from mobile phones on heart rate variability (HRV) of 14 male volunteers. The result indicated that HRV was increased when the mobile phone was kept near the chest and decreased when it is kept close to the head. Mobile phone radiation is thus not only responsible for causing variations in heart rates, but such variability is also dependent on the position in which the mobile phone is held.⁽¹⁷⁾

Saini and Pandey investigated the effects of wireless Network Radiations (WNR) on Heart Rate Variability (HRV). They chose two non-linear indices namely i) Approximate Entropy (ApEn), ii) Detrended Fluctual Analysis (DFA) for deciphering the hidden dynamics of HRV. The study comprised of 19 healthy male subjects in the age group (23 ± 4.3) years. The ECG of each subject obtained under three different exposure modes. The result showed that there were a significant increase of DFA scaling exponent when WNR level changed from minimum to maximum value.⁽¹⁸⁾

Role of mobile phone radiation on oxidative stress and liver damage

Free radicals are atoms or molecules that have unpaired electrons; these are unstable and highly reactive. According to their source, free radicals are divided into two categories:

- a) Reactive Oxygen Species (ROS), such as superoxide, hydroxyl radicals.
- b) Reactive Nitrogen Species (RNS), such as nitrogen dioxide, nitric oxide radicals and peroxyxynitrite.⁽¹⁹⁾

The liver is the main biochemical organ in the body. It represents the body's major detoxification system. Liver detoxifies the different toxic materials which have entered into the body or are produced by the various spontaneous biochemical reactions in the body. Such detoxified materi-

als are excreted by the kidney and the intestine. Thus the liver and the kidney continuously detoxify and excrete many toxic materials including metabolic wastes.⁽²⁰⁾ Parenchymal cells are primary cells subjected to oxidative stress injury in the liver. The mitochondria, microsomes and peroxisomes in liver parenchymal cells can produce ROS, regulating on PPAR α (Peroxisome-proliferator activated receptor), it is mainly related to the liver fatty acid oxidation and gene expression. Moreover, Kupffer cells, hepatic stellate cells and endothelial cells are potentially more exposed or sensitive to oxidative stress related molecules. A variety of cytokines like TNF α can be produced in Kupffer cells induced by oxidative stress which might increase inflammation and apoptosis.⁽²¹⁾ The general mechanism of production of oxidative stress induced by various factors on liver disease may also be explained by Fig 1.

Various research studies indicate that microwave radiation emitted from mobile phones may cause oxidative stress through its thermal effect on liver damage. In 1996, Cleary et al. suggested that mobile phone exposure to 900 MHz RF-EMW (Electromagnetic wave) was associated with a significant increase in the mitochondrial membrane potential. Very recently, Friedman et al. reported that RF-EMW stimulates plasma membrane NADH oxidase can lead to oxidative stress and subsequent carcinogens.⁽²²⁾

A research was done by M. Asgari et al. in Islamic Azad University, Department of Hematology, Tehran, Iran. Male Wistar rats were exposed to mobile phone radiation for 1, 3 and 6 hour/day. After 8 weeks their blood were drawn for assay. The result showed that there was a significant increase in serum creatinine level in the group of rats exposed to mobile phone radiation.⁽²³⁾

A study was done by M. Baleci et al. in Ankara Oncology hospital, Turkey. Forty Wistar Albino rats were exposed to mobile phone radiation (GSM frequency 900MHz with SAR value 1.2 W/Kg). After 4 weeks animals were sacrificed and their cornea and lens tissues were dissected. Tissues were homogenised and MDA (Malondialdehyde), SOD (Superoxide dismutase), GSH-Px (Glutathione peroxidase) and CAT (Catalase) enzyme activities in the supernatants were measured. Results indicated that the MDA and CAT enzyme activity were increased significantly in the animals exposed to mobile phone radiation while the SOD activity was decreased significantly in the same group.⁽²⁴⁾

Mobile phone radiation on reproductive and foetal health

Male reproduction

A number of recent reports suggested a possible link between mobile phone use and male infertility.

An initial study was done by Desai et al. involving 361 men who had attended an infertility clinic suggested that the use of cell phones adversely affects semen quality by decreasing sperm count, motility, viability and morphology, which might be responsible for male infertility.⁽²⁵⁾ Why should electromagnetic radiation affects the movement of sperm? One study points to a possible explanation. Lishko (2010) showed the human sperm move to the egg in an electrically created pathway, which might be affected by the electromagnetic field created by mobile phone radiation.⁽²⁶⁾

Similarly, Fejes et al. studied 371 men undergoing infertility evaluations and reported that the duration of possession and transmission time of cell phones correlated negatively with the proportion of rapidly progressive motile spermatozoa, suggesting that prolonged use of cell phones might have negative effects on sperm motility.⁽²⁷⁾

Davoudi et al., in a small prospective study involving 13 men with normal semen analysis, also found that using mobile phones for 6 hour/day for 5 days decreased the rapid progressive motility of spermatozoa.⁽²⁸⁾

Thus recent epidemiological studies have highlighted the role of mobile phone exposure on sperm motility, morphology and viability, thus proposing a reduction in the fertilizing potential of males.

In addition to the epidemiological studies, the effect of mobile phone radiation is well studied in animal models and *in vitro* studies on human semen. Many studies have indicated that EMW decreases the size of the testicular organs. A decrease in the diameter of the seminiferous tubules had been reported after exposure to mobile phone radiation. Ozyguner et al. demonstrated a decrease in seminiferous tubular diameter and epithelium thickness after applying RF-EMW of 869 to 894 MHz.⁽²⁹⁾

These results support the study done by Saunders and Kowalczyk that microwave radiation of 50 mW / cm² at a frequency of 2.45 GHz for 30–40 minutes resulted in a significant degeneration of the seminiferous epithelium in mice. Wang et al. suggested that mobile phone radiation might change the permeability of blood testis barrier.⁽³⁰⁾ The radiofrequency emitted from mobile phone mediated ROS formation can lead to phosphorylation of heat shock protein (hsp), which can alter the secretion of growth factors. This in turn can increase the permeability of blood brain barrier as suggested in figure 2.⁽²⁵⁾

Female reproduction

The female genital system is composed of the uterus, ovaries, fallopian tubules, the released oocytes and germ somatic cells in their tissues. According to many researchers, neuro-endocrine changes caused by mobile phone radiation is a key factor in changing hormone function and causing in-

fertility symptoms in females.⁽³¹⁾ A number of other researchers have focused on the estrous cycle. One of the differences between women's and female rodents' sexual cycle is that the women's cycles are completed, and the peak of estrogen-progesterone level in the blood can be separated. In case of female rodents, the peak of these two hormones is concurrent.⁽³²⁾

Besides, a lot of research has focused on the harmful effects of radiation on the granulosa cells of the oocytes. Apoptosis of these cells is another issue in many articles.⁽³³⁾

In this paragraph, several reports regarding this fact are discussed. Spontaneous abortion and fetal abnormalities are two interrelated issues that have attracted the attention of many researchers.⁽³⁴⁾ Although the negative effects on fetal development are controversial, Williams and Fletcher (2010) concluded that "The fetus is most susceptible to radiation during organogenesis (2-7 week after conception) and in the early fetal period (8-15 weeks after conception)".⁽³⁵⁾ The male offsprings of female rats after their exposure to 60 Hz frequency showed reduction in number, height and volume of seminiferous tubules and in the number and diameter of Leydig cells. However, serum levels of testosterone, gonadosomatic index, and number of Sertoli cells remained unchanged.⁽³⁶⁾

Another study done to determine the relationship between electromagnetic radiation and ovulation in rats showed that the waves inhibited ovulation and reduced the number of corpora leutea.⁽³⁷⁾ Radiation exposures caused reproductive and developmental toxicity effect that degenerates oocytes in mice.⁽³⁸⁾ Another research showed that exposure to 33-50 Hz frequency for 3 days prevented the formation of antral follicles *in vitro*.⁽³⁹⁾ When female rats were exposed to 900 MHz frequency for 30 days, endometrial apoptosis and oxidative stress increased.

During mating, mice exposed to 50 Hz frequency for 4 h/day for 2 weeks had significant reduction in the number of blastocytes and increased DNA fragmentation.⁽⁴⁰⁾ This study suggested that exposure to electromagnetic radiations in the implantation period, may have deleterious effects on the development of embryos. Radiation for 4 h before ovulation showed negative effects on the early development of the embryo.⁽⁴¹⁾

A study done by Rozavinia A. et al. in Chennai where female rats were exposed to mobile phone radiation for 1, 3, 6 h/day. After 8 weeks serum level of progesterone was assayed. Results indicated that long term exposure increased serum progesterone level in female rats, which might seriously influence the endocrine system.⁽⁴²⁾

Effects on haematological parameters

Most significant studies were done by using GSM frequencies or the microwave frequencies and their effect on haematological parameters in animals.

Experiments were done by K. Nageswari et al. where rabbits were exposed to microwave radiation at 5mW/cm², 2.1 GHz, 3h daily, 6 days / week for 3 months. The result speculated that the T-lymphocytes were sequestered to various lymphoid agents under the influence of microwaves. It is clear from the experiment that chronic microwave exposure leads to suppression of T-lymphocyte numbers.⁽⁴³⁾

Liburdi R.P. et al. stated in their study that RF EMF was capable due to their thermal effects to increase the number of neutrophils and decreased the level of lymphocytes.⁽⁴⁴⁾

An experiment was done by P. Kumari et al. in Manipal. They collected the blood from 37 volunteers, from the department of Physiology, Kasturba Medical College, Manipal. The blood samples were exposed to the mobile phone radiation. The total R.B.C. and W.B.C. count changed significantly. But there was no significant change in osmotic fragility of R.B.C. in mobile phone radiation exposed group.⁽⁴⁵⁾

Md. F. Assasa from Al-Azhar University studied adult male Albino rats exposed to 900 MHz electromagnetic radiation emitted from mobile phones. Their total R.B.C. and W.B.C. count, packed cell volume and haemoglobin content were measured. From the result it was noted that there were significantly increase the total count of W.B.C., MCHC (Mean corpuscular haemoglobin content) and platelet count in the rats exposed to mobile phone radiation than the control group and R.B.C. total count, haemoglobin content, PCV (Packed cell volume) were decreased significantly in the same group than the control group.⁽⁴⁶⁾

Another study was done by M. Sikdar et al. in Presidency University, Department of Biological Sciences, Kolkata. Male Swiss Albino Mice were exposed to electromagnetic radiation emitted from mobile phone and supplemented with High Protein diet (Fortified with 20% Casein) and the haematological parameters were studied. The total count of R.B.C., W.B.C., differential count of W.B.C. and total haemoglobin content were measured in the blood. The surface structures of R.B.C. were also studied under scanning electron microscope. It was observed that the animals exposed to mobile phone radiation, the total number of R.B.C. was decreased and the total number of W.B.C. was increased in comparison to control group. The haemoglobin concentration in the blood in animals exposed to mobile phone radiation was also decreased. The distorted R.B.C. structures were also seen under the electron microscope. Sign of recovery were seen in the group of animals supplemented with high protein diet.⁽⁴⁷⁾

Usman et al. in 2012 investigated the effect of long term RF EMF (Electromagnetic field) exposures due to GSM frequencies. Blood samples and tissues were taken for hematology and histopathology tests. The complete blood count result showed that the hematological parameters both of sham exposed and exposed mice were within the normal

range. A statistical analysis was also conducted to determine whether differences observed between the experimental groups were significant or not. The histopathology examination on some internal organs showed that spleen and bone marrow of the mice were normal for all three experimental groups, while a sign of tissue degeneration and inflammations were observed after 8 weeks of exposure on the brain, liver and lungs of the mice in the exposed groups. These signs increased in severity with prolonged exposure.⁽⁴⁸⁾

Otitolaju A et al. had studied the levels of radiofrequency radiations around two GSM base stations located in the vicinity of residential quarter and workplace complex. The haematological studies revealed an elevation of W.B.C. counts in mice exposed to RF (Radio frequency) radiations compared to control group in both workplaces and residential complex area. The R.B.C count was not changed significantly in mice exposed to mobile phone radiation in residential areas compared to control group, but the animals exposed to RF radiation in work place area showed significantly a marked increase value.⁽⁴⁹⁾

According to the study done by Sikdar et al. and Otitolaju et al. it is seen that the W.B.C. count increased significantly in the mice exposed to mobile phone radiation in both cases. From these studies it may be said that it is related to the induction of protective mechanism in the exposed mice to the effect of the RF radiation and other activities around the GSM base stations. Therefore, it could be deduced that exposure to radiofrequency radiations induces stress in exposed animals which led to the synthesis of abnormally high levels of white blood cells.

Role of various nutritional supplements preventing the damage caused by electromagnetic radiation

Good nutrition, specially fortified with first class proteins have good biological values and rich in antioxidants can ameliorate these harmful effects of electromagnetic radiation in the body. Various studies are being conducted to search remedies to people make safe from the bad effects of radiations.

Mice were exposed to 10 GHz microwaves with the power density of 0.25 m W/ cm². One group of mice supplemented with alcoholic extract of *Prunus domestica*. The blood samples were collected for the assay. This study was done by R. Sisodia et al. at Department of Zoology, University of Rajasthan. Microwave exposure resulted in significant decrease in haemoglobin, monocytes, packed cell volume, red blood cells, mean corpuscular haemoglobin concentration whereas, the number of white blood cells, lymphocytes, erythrocyte sedimentation rate and mean corpuscular volume increased significantly compared to the sham exposed animals. Signs

of improvements in the haemoglobin and other haematological parameters were observed where the mice were supplemented with *P. domestica* extract.⁽⁵⁰⁾

Casein is a first class milk protein, fortified with almost all essential amino acids. It is also fortified with various antioxidant agents. It has antioxidant properties studied *in vitro*. Experiments were done by M. Sikdar et al. where male Swiss Albino mice were exposed to 0.9 GHz electromagnetic radiation emitted from GSM mobile phone for 3 hour / day. One group of mice were supplemented with 20% casein diet. Various blood parameters were altered due to the exposure of electromagnetic radiation. Signs of recovery were noticed in the group supplemented with casein diet.⁽⁴⁷⁾

B. Hajiun from Islamic Azad University, Iran did an experiment with female rats, they were exposed to 900 MHz electromagnetic radiation emitted from mobile phone. The animals were treated with 400 mg and 200 mg/kg body weight garlic extract. The serum estrogen and progesterone level were assayed. The hormone level was altered due to mobile phone radiation. The changes were restored by the application of garlic extract.⁽⁵¹⁾

Protective action of vitamin E against the harmful effects of mobile phone radiation were studied by A. Ghanbari et al. Rats were exposed to electromagnetic radiation along with and treated with 200 mg / kg body weight vitamin E. After exposed to the radiation antioxidant stress enzymes like MDA, Glutathione peroxidase (GSH-Px) in the cells of substantianigra were increased significantly. But SOD activity was decreased significantly. Vitamin E treatment significantly prevented the level of increased MDA levels and GSHPx activity and also prevented the decreased SOD activity.⁽⁵²⁾

From the studies on the effect of nutritional supplements on animals exposed to electromagnetic radiation, it could be attributed that electromagnetic radiation is considered as a stress factor acts on the different physiological systems of mammals. Supplements have good antioxidant properties can ameliorate these harmful effects of radiation.

CONCLUSION

Many studies are being done to assess the effect of electromagnetic radiation on different physiological systems. It has been proved that EMF has a negative role in the body. Different mobile phone companies always do not obey the rules and regulations regarding SAR values of the mobile phones for giving better service to their customers. It is also an unavoidable fact that the use of mobile phones cannot be stopped or lessens in this 21st century. So, it is needed to search a strong remedy which can ameliorate the harmful effects of mobile phone radiation in the body. Various researches are being carried out in search of the remedy. But further studies are needed to be carried out.

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ABBREVIATION

1. SAR : Specific Absorption Rate
2. GSM: Global System for mobile communications
3. CDMA: Code Division Multiple Access

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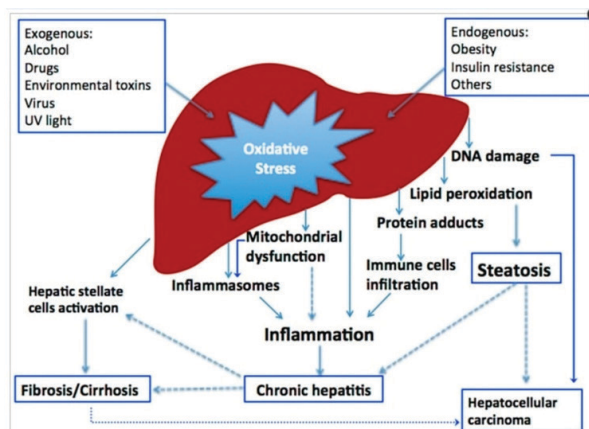


Figure 1: The general mechanism scheme of oxidative stress induced by various factors on liver disease.

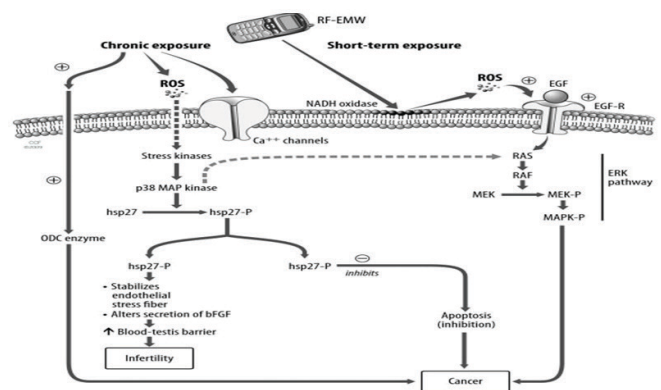


Figure 2: Mechanism of lipid peroxidation caused by mobile phone radiation.