

A Review on the Effect of Antioxidants in Prenatal Brain Development on Exposure to Low-Frequency Electromagnetic Fields

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Abstract

Electromagnetic pollution has tremendously increased in this current century. Increased human exposure to extremely low frequency electro-magnetic fields (ELF-EMFs) caused due to increasing use of electric and electronic devices. Exposure to electric fields disturbs brain functions, hormones and enzyme activity, depending on the frequency and duration of that exposure. The World Health Organization (WHO) and Environmental Health Trust, started a new project called “BABY SAFE WIRELESS PROJECT” to voice their concern and limit their exposure on pregnant women. Studies also showed the effect on the behavior, cognitive functions, learning and memory disabilities of rodents of EMF caused by mobile phones have particularly on prenatal exposure. Exposure to EMF has been observed to cause increased free radical production in the cellular environment and alters its functions. Overproduction of reactive oxygen species (ROS) can cause oxidative stress in the body and leads to changes in antioxidant defense systems. It would be more beneficial when the pregnant women are treated with antioxidants as EMF concentrating on alterations in several antioxidant enzyme activities and different parameters of oxidation.

Key words: Electromagnetic Radiation, Prenatal Brain Development, Anti oxidant, Reactive Oxygen Species (ROS), Free Radicals, Oxidative Stress

1. Introduction

People in this century are surrounded by extreme Electromagnetic waves (EMW). These waves are emitted by electric and electronic devices like mobile phone, television, personal computers, radios, microwave ovens, etc.,. In this current century exposure to these waves are tremendously increased. EMF gives an alert on biological effects like altering physical measurable changes within an organism in biology by the production of heat and auditory clicks. Though the ill effects of low-frequency electromagnetic fields (EMW-LF) on health are studied extremely it has become unavoidable. Depends on the level of duration and frequency of exposure to electromagnetic fields disturbs brain functions, hormones, and enzyme activity. Biological risk caused by electromagnetic field (EMF) exposure threatens human protection at home and work has become a chief issue in this century. Prolonged exposure to EMW-LF not only results in altered brain tissue function and also affects the developing brain of newborns when it is exposed during the prenatal period (1-2). Several studies have reported findings such as stress, headache, tiredness, anxiety, decreased learning potential, impairment in cognitive functions and poor concentration in case of exposure to microwave radiation emitted from mobile phones (3-4). World Health Organization (WHO) and Environmental Health Trust started a new project called

“BABY SAFE WIRELESS PROJECT ” to voice their concern regarding the risk exposure to wireless radiation during pregnancy and to urge pregnant women to limit their exposure (5).

2. Rudiments of electromagnetic field

Electromagnetic field is a physical field produced by motion of electrically charged objects which affects the behavior of charged objects in the vicinity of the field. Electromagnetic waves at low frequencies are referred to as electromagnetic fields and those at very high frequencies are called electromagnetic radiations (6).

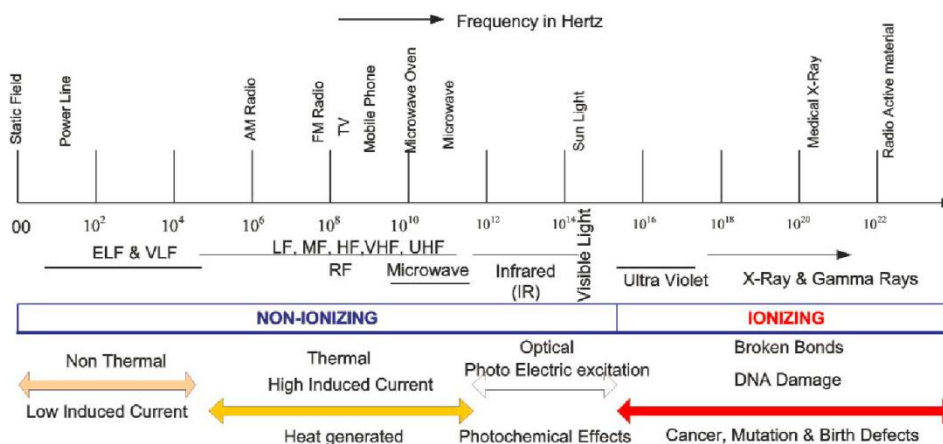


Figure: 1 Electromagnetic Spectrum (7).

2.1 Classification of Electromagnetic radiations

There are two types' electromagnetic radiations, Ionizing radiation and Non-ionizing radiation. Figure 1 shows the different graphical representation of the electromagnetic spectrum of energy or radiation in ascending frequency including the natural sources.

2.1.1 Ionizing Radiation

Ionizing radiation contains enough electromagnetic energy to strip atoms and molecules from the tissue by altering chemical reactions in the body (causing the atom to become charged or ionized). Ionizing radiation are X-Rays and Gamma. These rays are known to cause damage, which is why a lead vest must be worn when X-rays are taken of our bodies, and heavy shielding surrounds nuclear power plants. Human beings are also persistently exposing themselves to the low levels of ionizing radiations from natural sources. Examples of natural ionizing radiations are visible light, ultraviolet light and infrared light (sunlight) radioactive gases and materials on the earth's surface etc.

2.1.2 Non-Ionizing Radiation

The lower part of the frequency spectrum is considered non-ionizing Electromagnetic Radiation (EMR), with energy levels below that required for effects at the atomic level. Examples of non-ionizing radiations are:

- Static electromagnetic fields from direct current (0 Hz)
- Low-frequency waves from electric power (50-60 Hz)
- Extremely Low Frequency (ELF) and Very Low Frequency (VLF) fields (up to 30 kHz)
- Radio Frequencies (RF), including Low Frequency (LF), Medium Frequency (MF) High frequency (HF), Very High Frequency (VHF), Ultra High Frequency (UHF) Microwave (MW) and Millimeter wave (30 kHz to 300 GHz) (7).

3. Mechanism of EMF on cellular levels

The unpaired electron in an atomic orbit able to exist independently in a molecular species is called free radicals (8). In many diseases oxygen-containing free radicals are hydroxyl radical, superoxide anion radical, hydrogen peroxide, oxygen singlet, hypochlorite, nitric oxide radical, and peroxynitrite radical. These are most important highly reactive species, damaging biologically relevant molecules such as DNA, proteins, carbohydrates, and lipids, capable in the nucleus, and in the membranes of cells (9). Oxidative stress, defined as imbalance between free radical production and antioxidant defenses, is related with damage to a wide range of molecular species including nucleic acids, proteins and lipids (10, 14). Reactive Oxygen Species (ROS) is a number of reactive molecules and free radicals derived from molecular oxygen. The production of oxygen based radicals is the nemesis to all aerobic species (11). Overproduction of ROS can cause oxidative stress in the body and leads to changes in antioxidant defense systems. Despite, the ionizing and non-ionizing radiation increases the production of ROS in the tissues by altering the transcription and translation of genes such as JUN, HSP 70 and MYC, via the epidermal growth factor receptor EGFR-ras, shown in figure 2 (12). Furthermore, an uncontrolled increase in ROS degradation due to pro-oxidant-antioxidant balance ends in lipid peroxidation. The cell membranes are rapidly destroyed due to the oxidation of components of phospholipids containing unsaturated fatty acids called lipid peroxidation (13). Some studies reported that the ordination of oxidative stress and the level of intracellular ROS in human mononuclear cells in EMF exposure to 900-MHz (14).

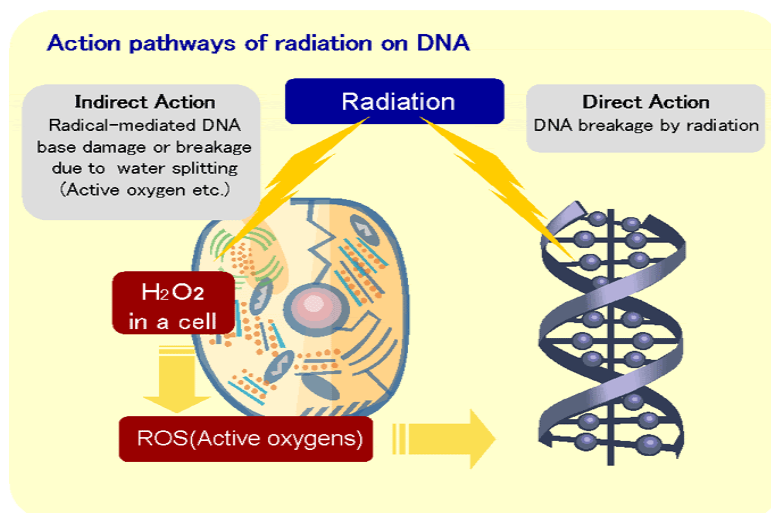


Figure2. Harm of EMF on cellular levels. Source: Osato Research Institute.

4. EMF and Prenatal brain development

Several studies have showed that EMF is led to the accumulation of reactive oxygen species in the brain cells and leads to neurodegenerative disease (15). During the prenatal period harmful environmental conditions may have increased neuro-biological or concurrent behavioral defects in 900MHz EMF frequencies and may deeply affect neurogenesis in the brain (16). Some studies showed that during the prenatal period decrease in the number of granule neurons in the dentate gyrus (DG) and pyramidal neurons in the hippocampus of rats exposed to 900 MHz EMF when compared with the control group. Moreover, a large number of morphological deteriorations have been documented to occur in addition to a decrease in cell number (17, 18). Studies investigated that 900 MHz EMF's and 1.8 GHz EMF increased permeability of the blood brain barrier to sucrose. There was a lot of albumin leakage from the various vessels after the EMF exposure (19). Continuous exposure to EMF can cause developmental and histopathological changes in the human fetus spinal cord such as vacuolization, atrophy, and thickening in the gestational period. They also superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) levels of exposed spinal cord tissues have significant changes (20). The whole-body exposure to cell phone radiation of the pregnant mother can result in hyperactivity, impaired memory and behavioral changes in the offspring (21). In embryonic period EMF can induce cell death, and that can inhibit differentiation of neuronal stem cells into neurons (22). Deniz et al (2016) investigated the effects of mobile phones, not only on the morphology of the human brain but also on cognitive performance, memory, learning etc.,

The embryos exposed to EMR for 16 hours daily for 15 days could not determine any significant difference in DNA mutation between the non-exposed groups and explained that EMR produced from mobile phones appears to have harmful effects on the human body in two different ways. First, a thermal effect increases due to absorption of EMR by the body. Second, non-thermal

effects such as headache, lack of attention and changes in sleep and brain function are observed (23). EMF affects the fetus brain development when hundreds of billions of nerve cells in the body get synapses even in the first few months of pregnancy (24). First two weeks of embryonic life is the cell in the form of most stem cells, and these cells are very sensitive to toxic effects of EMF especially embryonic neural stem cells (eNSCs) have a critical role in fetal brain development (25). EMF could result in reduction of birth weight, circumference of head, upper arm, and abdomen and skin fold thickness of back, triceps and abdomen in girls, but not in boys (26).

5. Antioxidants attenuate the potential risks of EMF exposure

EMF exposure causes decrease in antioxidant system because of raised lipid peroxidation and generation of reactive oxygen species that causes loss of cells and blocks their production. Furthermore, EMF is decreasing the antioxidant enzymes capacities it was detected. In organisms the antioxidant defense system controls the free radicals and prevents the damage of the cells (27). These antioxidants act as scavengers and reduce or impair the damage mechanism of ROS via their free radical (28). Main two major mechanisms of antioxidants, the first is a mechanism of chain disruption in which the primary antioxidant releases an electron to the free radical found in the system. The second mechanism includes elimination of the initiators of species of ROS/reactive nitrogen (secondary antioxidants) by suppressing chain-initiating catalysts. Antioxidants may also impact on biological systems by various mechanisms involving electron releasing, metal ion chelating, co-antioxidants, or by maintaining the expression of genes (29). Prevention of excessive ROS and repair of cellular damage is essential for a cell's life. Antioxidant supplemented with EMF exposure, improved the hydrophilic, lipophilic and enzymatic antioxidant blood capacity. Exogenous antioxidants -Vitamin E (tocopherol), vitamin A carotene, vitamin B9 (folic acid and folvate) and vitamin C attenuate the effects of EMF exposure. Its main antioxidant function is to prevent lipid peroxidation and prevent ultrastructural damages in tissue (30). Melatonin (MEL) secreted by the pineal gland prevents EMF-induced DNA damage resulting from free radical generation in rat brain cells (31).

6. Conclusion

Mobile phones and radiating equipment are used by all humans' day to day life especially the pregnant women should take care more about that. Using mobile phones is inevitable; awareness helps the society to know more about its usage and its ill effects. Many studies have shown that electromagnetic fields can have destructive effects on sex hormones, gonadal function, fetal development, and pregnancy. So people must be aware of the negative effects of EMFs. Although the impact of the waves varied at different frequencies, it is better to stay as far away as possible from their origin because of the risks associated with exposures to these waves. Recent studies have not only clearly illustrated the oxidative stress in tissues triggered by EMF exposure but significant reduction in antioxidant levels in the blood. Antioxidant is endogenous

and exogenous, though EMF decreases the endogenous antioxidant defense system, the exogenous natural antioxidant helps reduce the possible adverse effects of these waves.

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