Effects of Electromagnetic Radiation Produced by Mobile Phone on Some Visceral Organs of Rat

Abu Bakr El-Bediwi, Attal F. El-kott, Mohamed Saad and Eman Eid

The present study investigated the effect of electromagnetic field (EMF) radiated from mobile telephones with frequency equals 900 MHz on some liver enzymes, testosterone hormone and histological structure of liver and testis organs in albino rats after exposing them to the electromagnetic field for 3 and 6 months. Wistar rats were divided into three groups: I- control animals (10 animals) without near source of EMR, II- rats constantly exposed to EMR (20 animals) for 3 months and III- rats exposed to EMR (20 animals) for 6 months. Rats were exposed to 900 MHz continuous RF/MW fields for 1 h daily, 7 days/week. Results showed that electromagnetic field exposure caused a significant decrease in Albunin and testosterone hormone but the significant increases in Serum aminotransferase ALT, aminotransferase AST and total bilirubin were recorded. After three and six months of phone radiation exposure, there were the more severe fatty vacuolation, dilated portal vein and infiltration of a large amount of inflammatory cells with the sinusoids were moderately obliterated in liver, also, there were severing spermatogenic cells in some of the seminiferous tubules and major edema in the interstitial tissues and histopathological change's severity are increasing with the increase the time. Based on this animal model study, such effects are also expected in humans; therefore, it is suggested that long term and/or excessive use of mobile phones should be avoided. This can be achieved by health promotion activities such as group discussions, public presentations and through electronic and print media sources.

Key words: EMR, phone radiation, liver enzymes, testis, testosterone

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INTRODUCTION

The mobile phone (MP), one of the fastest growing technological developments, has become popular and necessary in modern life. The widespread use of mobile phone in recent years has raised the research activities in many countries to determine the effect of the emitted electromagnetic radiation from it. The mobile phone emitting 900 MHZ electromagnetic radiation, this emitting radiation may be absorbed by various body organs according to the places where they are carried (Oztun et al., 2005a; Oktem et al., 2005). There is accumulating evidence that exposure to the radio frequency radiation from mobile telephones or their base station could affect people’s health (Repacholi, 2001). Herein if there is any impact on health from mobile telephones, it will affect almost everyone in the world (Cox, 2003). The use of cellular phones in recent years has raised many questions about their safety, because the operator is exposed to electromagnetic (radio frequency) radiation (EMR) in the ultra-high frequency range (i.e., 300-3000 MHz), the effect of which on the body depends on its frequency and power. There has been increasing interest in the biological effects and possible health outcomes of weak, high-frequency electric and magnetic fields (Knave, 2001).

Mobile phone-induced free radical formation in other tissues has been reported. Reactive Oxygen Species (ROS) have been implicated in tissue injury. The main ROS that have to be considered are superoxide anion (O₂⁻) which is predominantly generated by the mitochondria; hydrogen peroxide (H₂O₂) produced from O₂ by the action of superoxide dismutase (SOD) and peroxynitrite (ONOO⁻), generated by the reaction of O₂ with nitric oxide (NO). ROS are scavenged by SOD, glutathione peroxidase (GSH-Px) and catalase (Oktem et al., 2005). Two hours of exposure by a cellular mobile phone, changed the structural and biochemical characteristics of acetylcholinesterase, an important central nervous system enzyme, resulting to a significant alteration of its activity. The enzyme was exposed within an aqueous solution at 5 cm distance from the mobile phone (Barteri et al., 2005).

Some studies on magnetic fields, cancer and reproduction and neurobehavioral reactions have presented that different system diseases related to such as mobile phones (Oztun et al., 2005b).

Due to the worldwide concern on the possible health hazards induced by EMF’s (electromagnetic fields), current research is extended using a variety of approaches: histological, biochemical, experimental exposure on laboratory animals.

MATERIALS AND METHODS

Experiments were performed on adult Wistar Albino rats bred at the animal house of Biophysics Department, Faculty of Science, Mansoura University, Egypt, under conventional laboratory conditions. Wistar rats were divided into three groups: I- control animals (10 animals) without near source of EMR, II- rats constantly exposed to EMR (20 animals) for 3 months and III-rats exposed to EMR (20 animals) for 6 months. Rats were exposed to 900 MHz continuous RF/MW fields for 1 h daily, 7 days/week. All animals in control and experimental group were housed collectively in polycarbonate cages 50×40×40 cm (W×L×H) and given ad libitum access to standard laboratory food and water. The housing room was maintained at 24°C with 42±5% relative humidity and had a 12/12 h light-dark cycle (light on 06:00-18:00 h). Experimental groups were continually exposed to EMR from mobile phone. The microwave radiation was produced by a mobile test phone (model NOKIA 3110; Nokia Mobile Phones Ltd.). A 900 MHz electromagnetic near-field signal for GSM (Global System for Mobile communication at 900 MHz, continuous wave, analog phone) system was used. The mobile phone was situated in the center of the cage, while the distance of EMR generator from the floor was 3 cm and maximal distance from the floor corners was 28.2 cm. In this experiment, handsets of Global System for Communication (GSM) mobile phone of the same brand and model were used. A call was given with another mobile phone and it was also ensured that the mobile phone inside the cage was powered-on and with call accepting [answering] mode and the rats were in close proximity to the mobile phone (Sokolovic et al., 2008).

In the end of 3 and 6 months from the start experiment, the rats were anesthetized with ketamine HCl (50 mg kg⁻¹), administered intraperitoneally (i.p.), before sacrificing, the blood from aorta was collected in plastic heparinised tubes for biochemical assays.

For the biochemical tests, about 2-3 mL of blood sample depending on the rat weight was collected into a centrifuge tube without any anticoagulant. The centrifuge tube was left for about 15 min to allow blood coagulation. Clear serum samples were then separated by centrifugation at 1000 g for 20 min. Clear serum samples were separated in glass tubes, labeled and stored in deep freezer for different biochemical analysis for different biochemical assays. However, determination of enzyme activities was carried out on fresh serum samples. Serum aspartate aminotransferase (AST) is an enzyme belonging to the class of transferases. It is commonly referred to as a transaminase and is involved in the transfer of an amino group between aspartate and aketo acids. AST activity is
measured by using optimized ultraviolet-test according to International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) (Thomas, 1998). Serum alanine aminotransferase (ALT) is a transferase with enzymatic activity similar to AST. Specifically, it catalyzes the transfer of an amino group from alanine to a ketoglutarate with the formation of glutamate and pyruvate. ALT activity is measured by using optimized ultraviolet-test according to IFCC (Thomas, 1998). Albumin, total bilirubin and testosterone were measured using Coulter STKS Counter Model S Plus.

For light microscopy liver and testis were fixed in 10% formalin and boun fixatives respectively, dehydration with ascending alcohol, clearing with xylol and embedded in paraffin, cut in 3 μm thick sections and stained with Hematoxylin and Eosin (H and E) for histopathology, the Results of biochemical assays were presented as Means±SD. Statistical significance was determined at level of p<0.05 using the Student’s t-test.

RESULTS

Bio-assays of liver and testes: In Table 1 Electromagnetic field exposure caused a significant increase in AST, ALT and Bilirubin after three and six months (p<0.05) but caused a significant decrease in Albumin and Testosterone hormone (p<0.02).

Histopathological examinations of liver and testis: In rats of the normal group (1a), the structure of liver lobule and portal areas was normal. There was no obvious degeneration or necrosis, no congestion, no proliferation of sinusoids, no pathological changes and no formation of fibrous intervals. While in rats of three months-exposed phone radiation group (1c), there was severe steatosis, diffuse degeneration and necrosis, streak proliferation of fibrous tissue and infiltration of a small amount of inflammatory cells in portal areas. These symptoms are very similar to the clinical pathological changes of viral hepatitis. In rats of six months-exposed phone radiation group (1e), there were the more severe fatty vacuolation, dilated portal vein and infiltration of a large amount of inflammatory cells with the sinusoids were moderately obliterated (Fig. 1).

The spermatogenic cells and sertoli cells in the seminiferous tubules of the control rats were structurally normal (1b). Leydig cells were found in the interstitial connective tissue between the seminiferous tubules and the tubules appeared to be uniform in size and shape. They were lined by regularly arranged rows of spermatogenic cells at different stages of maturation. In contrast, after three months of phone radiation exposure, there were fewer spermatogenic cells in some of the seminiferous tubules and necrosis in some seminiferous tubules and edema in interstitial tissue were observed (1d). Moreover, after six months of phone radiation exposure, there were severing spermatogenic cells in some of the seminiferous tubules and major edema in the interstitial tissues (1f).

![Fig. 1(a-f): Effects of electromagnetic field radiation generated by mobile phone on histological structural of live and testis in different experimental groups. Original magnification X 250, hematoxylin and Eosin](image)
**DISCUSSION**

The use of mobile phones is currently one of the fastest growing technological developments. The close proximity of the antenna of such a device to the abdominal organs has raised concerns about the biological interactions between EMR and the liver and testes (Kesari and Behari, 2010). Mobile Phones (MP) and their base stations produce electromagnetic radiation (EMR). EMR is absorbed in the body and produces heat but the body’s normal thermoregulatory processes carry this heat away. All established health effects of EMR exposure are related to thermal effect. Since EMR from mobile phones can interact with body tissues at levels too low to cause any significant heating, no study has shown adverse thermal effects at exposure levels below international guideline limits (Illian et al., 2004). The direct biological effects of exposure to 900 MHz EMR had not been studied extensively. The 900 MHz mobile phones are mainly used in Egypt and in many other countries. Our findings demonstrate that the exposure of 900 MHz microwave radiations emitted by mobile phone to male rats alters enzymatic activity in the liver and hormones in the testes. Liver is an important metabolic tissue and the main organ of detoxification. Another reason for selection of liver was its sensitivity to waste products. Furthermore, markers of liver function could be measured more easily than the other organs. One of the most important features of pathologic changes of liver cells is the change of the level of liver albumin, total bilirubin, ALT and AST enzymes in serum. During cell injury, because of higher permeability of hepatocyte membrane, these enzymes penetrate to simuscoid and then enter into the peripheral blood and an increase in the level of such enzymes (ALT, AST, bilirubin) is observed (Friedel et al., 1979) but decrease in albumin and sexual hormone (testosterone).

Testosterone is a primary male gender hormone and plays a significant role in the spermatogenesis and is vital to general metabolism of human body as well. The causative agents may be including EMF radiation (Wdowiak et al., 2007). The effect of EMF radiation on living organisms depends on the frequency and intensity (Andersen et al., 2000). These radiations may exert an effect on the state of polarization of the cellular membranes. An inadequate polarization of cellular membrane is responsible for the process of various abnormalities of testosterone synthesis, secretion which may impair spermatogenesis and ultimately become a cause of infertility. There are few animal studies that show that EMF radiation generated by mobile phones have a wide range of damaging effects on the male reproductive system and sperm parameters (Derias et al., 2006). In the present study, we found that long term exposure to mobile phone can cause decrease serum testosterone level in rats compared to their matched control.

The extent of liver changes has been shown to depend on the duration of the exposure to phone radiation. Vacuolation of the cytoplasm, multi nucleation and nuclear pleomorphism were reported in this work. We suggest that these changes could be considered as sign of metabolic alterations under the influence of the exposure to the EMF. Repeated exposure to the electromagnetic radiation (EMR) emitted from mobile phones is able to induce hepatic tissue damage. The degree of damage increased with time of exposure to EMR. Previously similar tissue changes have been described using lower frequency EMR (Forgacs et al., 2006).

MW can affect reproductive function by (1) a unique MW-specific non-thermal action, (2) thermal action, or (3) a combination of these mechanisms. It is commonly accepted that MW emitted by Cellular Phones are at non-thermal power density level. But there is no consensus on non-thermal exposure levels of MW in the literature (Dascal et al., 2003). In our study, chronic MW exposure of rats resulted in alteration of testicular histology. The animal studies show that EMF radiation generated by mobile phones has a wide range of damaging effects on the male reproductive system and sperm parameters (Derias et al., 2006).

In conclusion, long term exposure to mobile phone radiation can cause increase serum AST, ALT, total bilirubin and decrease serum albumin and testosterone in rats. Also, the alteration of histopathological of hepatic and testicular tissues can be caused by mobile phone radiation. Based on this animal model study, such effects are also expected in humans; therefore, it is suggested that long term and/or excessive use of mobile phones should be avoided. This can be achieved by health promotion activities such as group discussions, public presentations and through electronic and print media sources.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>3 months</th>
<th>6 months</th>
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<tbody>
<tr>
<td>AST (U/L)</td>
<td>60±3.8</td>
<td>110±5.2*</td>
<td>140±6.0**</td>
</tr>
<tr>
<td>ALT (U/L)</td>
<td>38±2.1</td>
<td>95±2.4*</td>
<td>120±5.1**</td>
</tr>
<tr>
<td>Bilirubin (mg dL-1)</td>
<td>0.1±0.01</td>
<td>1.2±0.9*</td>
<td>1.5±0.02**</td>
</tr>
<tr>
<td>Albumin (g dL-1)</td>
<td>4.1±0.9</td>
<td>2.9±0.71*</td>
<td>2.5±0.88**</td>
</tr>
<tr>
<td>Testosterone (ng dL-1)</td>
<td>4.2±0.84</td>
<td>2.7±0.48**</td>
<td>2.8±0.40**</td>
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</tbody>
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Mean±SE of rats bio-assays in each group. *p<0.05, **p<0.01
REFERENCES


