

Effects of Acute and Chronic Exposure to 900 Mhz Electromagnetic Field on the Rat Liver Microarchitecture [†]

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Abstract: Technological devices such as mobile phones, wi-fi and bluetooth applications used widely in daily life emit low-dose electromagnetic fields (EMFs). EMFs influence metabolic processes in the body and exert various harmful biological effects on cells. This study aims to evaluate acute and chronic effects of 900 MHz EMF exposure on the microscopic structure of rat liver. Twenty-four adult Wistar albino rats were randomly divided into sham-control (Group I), acutely EMF-exposed (Group II) and chronically EMF-exposed (Group III) groups ($n = 8$ in each). The Rats of Group II were exposed to 900 MHz EMF using a microwave test transmitter during 24 h continuously just for one day. Group III-rats were exposed to 900 MHz EMF for 60 minutes a day for 30 days. Sham-controls were not applied EMF. After the rats were sacrificed under the anesthesia, their livers were removed and processed for light microscopic evaluation. Liver sections stained with histochemical dyes (H&E, PAS and Masson's trichrome) displayed many histopathological alterations in both of the EMF-exposed groups, including foci of necrosis, inflammation, excessive vacuolar degenerations and apoptosis in hepatocytes, apparent vascular expansions and haemorrhage. Additionally, mononuclear cell infiltrations, biliary hyperplasia, fibrosis in periportal and centrilobular areas and decreased Kupffer cell population were determined in the chronic EMF exposure group. In contrast, the amount of the Kupffer cells were much more in the acute exposure group. Our findings suggested that both acute and chronic exposure to 900 MHz EMFs can lead to hepatic injury in rats.

Keywords: apoptosis; cell injury; electromagnetic field; histology; liver; microscopy; microwave; rat

1. Introduction

Everyone is exposed to electromagnetic fields (EMFs), both at home and at work, from the generation and transmission of electricity, domestic appliances and industrial equipment, to telecommunications and broadcasting [1]. In many countries, over 50% of the population uses mobile phones. The average age of beginning mobile phone use has decreased rapidly to elementary school age, and durations of exposure to EMFs are also increasing [2,3]. The frequency band used for transmitting data varies from country to country [2]. Generally, the GSM (Global System for Mobile Communications) mobile phones use 900/1800 MHz frequency bands [3]. Low-frequency EMFs (LF-EMFs) influence the human body just as they influence any other material made up of charged

particles. Most biochemical reactions from digestion to brain activities go along with the rearrangement of charged particles. LF-EMFs induce circulating currents within the human body. If sufficiently large, these currents could cause stimulation of nerves and muscles or affect other biological processes [1]. The International Agency for Research on Cancer (IARC) classifies low-dose EMFs as “possible carcinogen” for humans [4]. In this study, we aimed to investigate possible hazardous effects of 900-MHz EMF on rat liver in acute and chronic exposure durations at microscopic level.

2. Materials and Methods

Twenty-four adult 12-week old male Wistar Albino rats were obtained from Sakarya University Experimental Medicine Application and Research Center (SÜDETAM, Sakarya, Turkey). The Sakarya University Animal Care and Ethics Committee approved the experiments and procedures. Rats were housed in standard transparent polycarbonate cages equipped with wood-shaving bedding at a temperature of 22 ± 1 °C under controlled lighting (12 h light/12 h dark cycle). Rats were allowed access to food and water ad libitum. The rats were randomly divided into sham-control group (Group I), acutely EMF-exposed group (Group II) and chronically EMF-exposed group (Group III). The number of rats was eight ($n = 8$) in each group. Rats of the group II and III were exposed to EMFs produced by a 900/1800 MHz Microwave Lab Test Transmitter (Model: GHz 2011x, Set Electronic Ltd., Samsun, Turkey, info@setelektronik.com.tr). A one-monopole antenna connected to the EMF generator was placed at the top of the rat cage. The acute-EMF group was exposed to 900 MHz EMF during 24 h continuously just for one day. The chronic-EMF group was exposed to 900 MHz EMF for 60 minutes a day for 30 days. Sham-controls were not applied EMF. At the end of the experiment, the rats were sacrificed under the general anesthesia with 75 mg/kg intraperitoneal ketamine hydrochloride (Ketasol® %10 injectable flacon, Interhas A.Ş., Ankara, Turkey by permission of Richter Pharma AG, Wels, Austria) and 8 mg/kg xylazine HCl (Basilazin® 2% injectable flacon, Bavet ilaç A.Ş., Tuzla/Istanbul, Turkey by permission of aniMedica GmbH Senden-Bösensell, Germany). Their livers were removed from the abdominal cavity and processed for histologic evaluation. Paraffin sections (4–5 mm thickness) of the livers were stained with haematoxylin and eosin (“H&E”, Cat. No. 105174 and 109844, Merck Millipore, Darmstadt, Germany), periodic acid-Schiff (“PAS”, Cat. No. 395B-1KT, Sigma-Aldrich Chemie GmbH, Steinheim, Germany) and Masson’s trichrome (KT 034-100-Trichrome stain, Diagnostic BioSystems, Pleasanton, CA, USA) dyes, and then examined under a light microscope (Nikon Eclipse Ni-U, Nikon Corporation, Tokyo, Japan) equipped with a digital color camera attachment (Nikon DS-Fi2, Nikon Corporation, Tokyo, Japan).

3. Results

Hepatocytes of the control livers were normally arranged in cords that were one or two cells thick separated by capillary sinusoids. The hepatocytes were polygonal, and had abundant eosinophilic cytoplasm and a central round nucleus (Figure 1A,B). Severe degenerative changes in the hepatic microarchitecture were seen in both of the EMF-exposed groups (Figure 1C–F) in contrast to that in the control group. These findings were as followings: excessive cytoplasmic vacuolization in the hepatocytes surrounding the central vein, prominent dilatations in both central veins and sinusoidal capillaries, haemorrhage, inflammation, foci of cellular degradation and necrosis characterized by swollen and appeared like empty hepatocytes, disintegration in lobular organization of some hepatic cords, apoptotic hepatocytes sporadically scattered within the hepatic lobules. Additional to these, mononuclear cell infiltrations, hyperplastic biliary ducts nearby the portal areas and a prominent increase in the connective tissue especially surrounding the portal and centrilobular areas, suggesting the fibrosis were determined in the chronically EMF-exposed group. Interestingly, an apparent increase in amount of activated Kupffer cells in the acute-EMF group were observed in spite of a decrease of them in the chronic-EMF group.

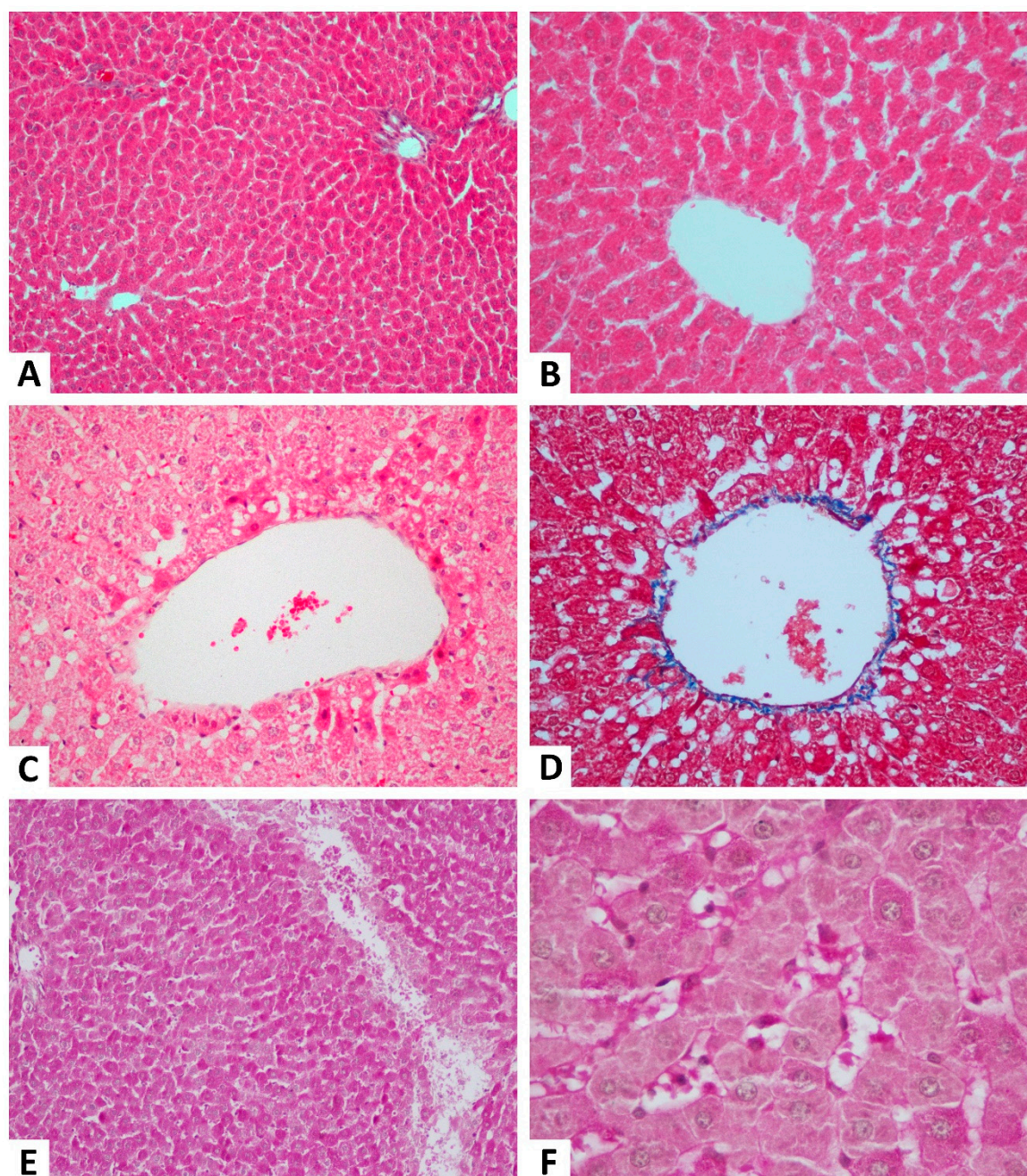


Figure 1. Light micrographs from the livers of control (A,B), chronically EMF-exposed (C,D) and acutely EMF-exposed (E,F) rats. Centrilobular apoptotic hepatocytes (C), degenerative cellular vacuolizations (C,D), fibrosis (in D), tissue inflammation and vasodilatations (E) and a number of activated Kupffer cells (F) were seen. **Stains:** H&E (A–C), Masson’s Trichrome (D), PAS (E,F). **Objectives:** 10× (A,E); 20× (B–D); 40× (F).

4. Discussion

All types of electrical and wireless equipment that used daily, generate EMF and have invisible environmental pollutants on human health [2,4]. There are some reports of associations between health problems and exposure to EMFs, such as reports of prematurity and low birth weight in children of workers in the electronics industry. Some reported symptoms to EMF-exposure include headaches, anxiety, depression, nausea, fatigue and loss of libido. Heating is the main biological effect of EMFs [1]. Heating of tissue due to EMF-exposure and the resulting physiological response in the body may lead to deleterious changes [5]. Our findings of vasodilatation and hemorrhage in the EMF-groups may be occurred due to excessive tissue heating. The interaction of the living organisms and

EMF can occur via changes the activation of the channel and pumps in the cell membrane, so the cell ionic balance is rearranged [6]. EMF changes cell function via mainly oxidative stress biochemical cascades, intense apoptosis and other vital properties [7,8]. Reactive oxygen species (ROS) occurs in oxidative reactions to produce energy in metabolic and physiological processes in the organism. Massive ROS which can damage cellular components such as membrane lipids and DNA may occur because of EMF exposure. So, we suggested that cellular degenerations, necrotic and apoptotic alterations and fibrosis which we found in the EMF-exposed groups can be caused by oxidative stress. We saw apparently activated Kupffer cells, one of the special macrophages of the body, in the acute-EMF group. In contrast to this, the amount of Kupffer cells decreased in the chronic-EMF group. Therefore, we thought that chronic exposure to EMF may lead to suppression of the immune system. Some studies investigating the adverse effects of mobile phones have indicated that EMF disables the immune system, which is responsible for eliminating harmful proteins and toxins in the blood [5].

5. Conclusions

In conclusion, the results of our study suggested that both acute and chronic exposure to 900 MHz EMF is deleterious to liver and causes to excessive hepatic histopathological alterations.

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