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BRAIN RESEARCH

Research Report

Effects of 900-MHz electromagnetic field emitted from cellular phone on brain oxidative stress and some vitamin levels of guinea pigs

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ARTICLE INFO

Article history:
Accepted 9 July 2007
Available online 17 July 2007

Keywords:
Cellular phone
Electromagnetic field
Oxidative damage
Brain tissue
Guinea pig

ABSTRACT

This study was designed to demonstrate the effects of 900-MHz electromagnetic field (EMF) emitted from cellular phone on brain tissue and also blood malondialdehyde (MDA), glutathione (GSH), retinol (vitamin A), vitamin D_3 and tocopherol (vitamin E) levels, and catalase (CAT) enzyme activity of guinea pigs. Fourteen male guinea pigs, weighing 500–800 g were randomly divided into one of two experimental groups: control and treatment (EMF-exposed), each containing seven animals. Animals in treatment group were exposed to 890- to 915-MHz EMF (217-Hz pulse rate, 2-W maximum peak power, SAR 0.95 w/kg) of a cellular phone for 12 h/day (11-h 45-min stand-by and 15-min spiking mode) for 30 days. Control guinea pigs were housed in a separate room without exposing EMF of a cellular phone. Blood samples were collected through a cardiac puncture and brains were removed after decapitation for the biochemical analysis at the end of the 30 days of experimental period. It was found that the MDA level increased ($P<0.05$), GSH level and CAT enzyme activity decreased ($P<0.05$), and vitamins A, E and D_3 levels did not change ($P>0.05$) in the brain tissues of EMF-exposed guinea pigs. In addition, MDA, vitamins A, D_3 and E levels, and CAT enzyme activity increased ($P<0.05$), and GSH level decreased ($P<0.05$) in the blood of EMF-exposed guinea pigs. It was concluded that electromagnetic field emitted from cellular phone might produce oxidative stress in brain tissue of guinea pigs. However, more studies are needed to demonstrate whether these effects are harmful or/and affect the neural functions.

1. Introduction

The use of cellular phones has been increased rapidly worldwide during the last 15 years. It is now estimated that there is more than one billion cellular phones in use. Such rapid growth of mobile phone telecommunications has increased the scientific interest on biological effects of electromagnetic field (EMF) emitted from cellular phones and their consequences on human health. There are several reports which indicate that EMF may elicit a biological effect in target cells or tissues (Knave, 2001;

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doi:10.1016/j.brainres.2007.07.015

Bortkiewicz, 2001; Croft et al., 2002). However, it is not clear whether or not these biological effects lead to an adverse health effects.

It has been demonstrated that mobile phones affect neural function in humans (Croft et al., 2002). These effects range from changes in the permeability of the blood–brain barrier (Grigor'ev, 2005) to changes in electroencephalogram (EEG) pattern. Croft et al. (2002) suggested that exposure to an active cellular phone affects the resting EEG in humans. Cell phone exposure may also lead to brain cancer, and that link is via the heat shock response (French et al., 2000). Recurrent exposure through frequent cellular phone use may lead to chronic expression of heat shock proteins in the exposed brain. Heat shock response is recognized as a general response to a wide variety of stress, including oxidative stress (Wu, 1995).

Reactive oxygen species have been implicated in tissue injuries. They are directly involved in oxidative damage of cellular macromolecules such as lipids, proteins and nucleic acids in tissues. Malondialdehyde (MDA) is the breakdown product of the major chain reactions leading to the oxidation of polyunsaturated fatty acids and thus causing oxidative stress (Draper and Hadley, 1990). There are also antioxidant defense systems against different oxidants in the organism (Murray et al., 1993). These systems such as antioxidant vitamins (vitamins A, C and E), superoxide dismutase (SOD), catalase (CAT), glutathione (GSH), ceruloplasmin and glutathione peroxidase (GSH-Px) protect the cells against lipid peroxidation.

EMF of cellular phones may affect biological systems by increasing free radicals (enhancing lipid peroxidation), and by changing the antioxidant defense systems of tissues, thus leading to oxidative stress (Ilhan et al., 2004; Ozguner et al., 2005). By thinking that oxygen free radicals may also play a role in mechanisms of adverse effects of EMF in brain tissue, this study was designed to demonstrate the effects of 900-MHz EMF emitted from cellular phone on brain tissue and also blood MDA, GSH, retinol (vitamin A), vitamin D_3 and tocopherol (vitamin E) levels, and CAT enzyme activity of guinea pigs.

2. Results

Brain and also blood MDA, GSH, retinol (vitamin A), vitamin D_3 and tocopherol (vitamin E) levels, and CAT enzyme activity of control and EMF-exposed guinea pigs are shown in Tables 1 and 2, respectively. The MDA level increased ($P<0.05$), GSH level and CAT enzyme activity decreased ($P<0.05$), and vitamins A, E and D_3 levels did not change ($P>0.05$) in the brain tissues of EMF-exposed guinea pigs (Table 1). In addition, MDA, vitamins A, D_3 and E levels, and CAT enzyme activity increased ($P<0.05$), and GSH level decreased ($P<0.05$) in the blood of EMF-exposed guinea pigs (Table 2).

Table 1 – Brain tissue MDA, GSH, retinol (vitamin A), vitamin D_3 and tocopherol (vitamin E) levels and CAT enzyme activity of control and EMF-exposed guinea pigs ($n=7$)

Parameters	Groups	
	Control	EMF-exposed
MDA (nmol/g)	110.331±2.961	124.030±2.956*
CAT (k/g protein)	1.120±0.024	0.796±0.032*
GSH (μmol/g)	1.301±0.067	1.069±0.044*
Vitamin A (μg/g)	0.098±0.018	0.182±0.032
Vitamin E (μg/g)	7.554±0.487	7.890±0.953
Vitamin D_3 (μg/g)	0.366±0.083	0.523±0.199

Values are expressed as mean±SEM.
* Denotes a significant ($P<0.05$) difference between control and treatment group.

Table 2 – Blood MDA, GSH, retinol (vitamin A), vitamin D_3 and tocopherol (vitamin E) levels and CAT enzyme activity of control and EMF-exposed guinea pigs ($n=7$)

Parameters	Groups	
	Control	EMF-exposed
MDA (nmol/ml)	1.657±0.196	2.383±0.131*
CAT (kU/l)	7.120±0.229	8.037±0.233*
GSH (mg/dl)	25.956±0.959	21.246±0.663*
Vitamin A (μg/ml)	0.328±0.022	0.746±0.1315*
Vitamin E (μg/ml)	1.980±0.217	2.861±0.251*
Vitamin D_3 (μg/ml)	0.808±0.064	1.147±0.074*

Values are expressed as mean±SEM.
* Denotes a significant ($P<0.05$) difference between control and treatment group.

3. Discussion

The results of the present study indicated that EMF of cellular phones was associated with increased free radical production and lipid peroxidation levels in both brain tissue and blood. Electromagnetic radiation from cellular phones has considerable effects on a variety neurological effects such as headaches, change in sleep patterns, modification in the electroencephalogram (EEG) and increase in blood pressure (Ilhan et al., 2004). It has been suggested that various neurodegenerative disorders such as Parkinson's disease, Alzheimer's disease and amyotrophic lateral sclerosis are causally linked to the formation of the reactive oxygen species (ROS) and oxidative stress (Fahn and Cohen, 1992; Benzi and Moretti, 1995; Bergeron, 1995). Reactive oxygen species, including partially reduced forms of oxygen, are produced as natural consequences of oxidative cell metabolism and their generation is controlled by a large number of biological antioxidant defense systems, which act as protective mechanisms. Disturbances of the oxidant/antioxidant balance resulting from the increased production of ROS are causative factors in the oxidative damage of cellular structures and molecules, such as lipids, proteins and nucleic acids. In particular, biological membranes that are rich in unsaturated fatty acids are cellular structures susceptible to free radical attack (Mascio et al., 1991; Kehrer, 1993; Riley, 1994). Therefore, increased blood and also brain MDA levels in this study might be due to the higher rate of oxidative metabolic activity, and higher concentration of readily oxidizable membrane polyunsaturated fatty acids of neuronal cells than other organs (Halliwell and Gutteridge, 1984).

Irmak et al. (2002) investigated the effects of 900-MHz EMF emitted from a cellular phone on the oxidant and antioxidant levels in rabbits. Inconsistent with our result, they observed