Original Article

Effect of Low Level Subchronic Microwave Radiation on Rat Brain

Pravin Suryakantrao Deshmukh[1], Kanu Megha[1], Namita Nasare[1,3], Basu Dev Banerjee[1,#], Rafat Sultana Ahmed[1], Mahesh Pandurang Abegaonkar[2], Ashok Kumar Tripathi[2], and Pramod Kumari Mediratta[3]

1. Environmental Biochemistry and Molecular Biology Laboratory, Department of Biochemistry. University College of Medical Sciences & G.T.B. Hospital (University of Delhi), Dilshad Garden, Delhi 110095, India; 2. Centre for Applied Research in Electronics (CARE), Indian Institute of Technology, Hauz Khas, New Delhi 110016, India; 3. Department of Pharmacology, University College of Medical Sciences & G.T.B. Hospital (University of Delhi), Dilshad Garden, Delhi 110095, India

Abstract

Objective The present study was designed to investigate the effects of subchronic low level microwave radiation (MWR) on cognitive function, heat shock protein 70 (HSP70) level and DNA damage in brain of Fischer rats.

Methods Experiments were performed on male Fischer rats exposed to microwave radiation for 90 days at three different frequencies: 900, 1800, and 2450 MHz. Animals were divided into 4 groups: Group I: Sham exposed, Group II: animals exposed to microwave radiation at 900 MHz and specific absorption rate (SAR) 5.953×10^{-4} W/kg, Group III: animals exposed to 1800 MHz at SAR 5.835×10^{-4} W/kg and Group IV: animals exposed to 2450 MHz at SAR 6.672×10^{-4} W/kg. All the animals were tested for cognitive function using elevated plus maze and Morris water maze at the end of the exposure period and subsequently sacrificed to collect brain tissues. HSP70 levels were estimated by ELISA and DNA damage was assessed using alkaline comet assay.

Results Microwave exposure at 900-2450 MHz with SAR values as mentioned above lead to decline in cognitive function, increase in HSP70 level and DNA damage in brain.

Conclusion The results of the present study suggest that low level microwave exposure at frequencies 900, 1800, and 2450 MHz may lead to hazardous effects on brain.

Key words: Brain; Cognitive function; Comet assay; DNA damage; HSP70; Microwave radiation

Biomed Environ Sci, 2016; 29(12): 858-867 *doi: 10.3967/bes2016.115* *ISSN: 0895-3988*

www.besjournal.com (full text) *CN: 11-2816/Q*

INTRODUCTION

Current exposure to microwave radiation (MWR) is comparatively high because of the heavy use of Wireless Fidelity (Wi-Fi) communication devices and mobile phones. Advances in mobile phone technology have been accompanied by a progressive increase in the intensity and frequency of the emitted electromagnetic waves without consideration of health consequences. This is leading to increased concerns about potential harmful effects of MWR on impairment of cognitive function such as learning ability and concentration[1-3]. Exposure to 900 MHz

#Correspondence should be addressed to Basu Dev Banerjee, Tel: 91-11-22135362, Fax: 91-11-22590495, E-mail: b.banerjee@ucms.ac.in

Biographical note of the first author: Pravin Suryakantrao Deshmukh, male, born in 1984, PhD, majoring in microwave radiation and health hazard.

electromagnetic field radiation for 28 d has been reported to impair spatial memory in rats by activating the mkp-1/ERK pathway[4]. Chronic microwave exposure also induces cognitive deficit and 5-HT system in rats[5]. Whereas, microwave exposure at 900 MHz has been reported to cause no effects on spatial memory in male rats at sub-chronic and chronic level[6]. In other few studies also no differences were observed in cognitive performance in response to microwave exposure and no clear evidences have been established that mobile phone signals affect cognitive function[7-8]. Thus, the reports on effects of MWR on cognitive function are still inconsistent and remain controversial.

Heat shock responses are activated by stress and a variety of other stimuli that are potentially harmful to cells and microwave radiation is one of the recent additions to the list of physical stimuli[9-10]. Heat Shock protein 70 (HSP70) is one of the most studied heat shock proteins and it is the central component of the cellular network of molecular chaperones and folding catalysts. HSP70 protects cell against a variety of environmental stressors[11]. The function of HSP in general is to act as molecular chaperones that bind the partially damaged or denatured proteins and this is important why HSP70 is itself one of the best examples of altered protein conformation[12]. Therefore, it is thought that HSPs are important markers of stress.

The effect of microwave radiation depends on the energy absorbed by biological tissue which varies with how the energy is delivered in space and time. Moreover, the effects of MWR depend upon its electromagnetic characteristics such as frequency, intensity and exposure duration. DNA is continuously damaged by endogenous and exogenous factors and then repaired by DNA repair enzymes. DNA damage and/or its faulty repair can result in accumulation of DNA adducts that can eventually lead to changes in cellular functions, cell death or cancer[13-14]. The damage can be in the form of single and double strand breaks. The genotoxic effects of MWR exposure for 30 and 60 d have been studied in our laboratory using most commonly used method called comet assay, where we have reported that low level MWR can induce DNA damage in rat brain[15-16].

The hippocampus is an utmost important part of brain which controls behavioural and cognitive functions including spatial and working memory and has been reported to be vulnerable to microwave exposure. Thus, the present study is focused on hippocampal region of brain[17-20]. Till date no study has reported effects of microwave frequencies (900 MHz, 1800 MHz, and 2450 MHz) at low power level for long duration on cognitive function, HSP level and DNA damage. Therefore, the current *in vivo* study was undertaken to investigate the effects of low level MWR at three different frequencies (900 MHz, 1800 MHz, and 2450 MHz) on cognitive function, HSP70 and DNA damage.

MATERIALS AND METHODS

Microwave Exposure Set Up and Dosimetry

The Gigahertz Transverse Electromagnetic (GTEM) cell was designed in collaboration with Center for Applied Research in Electronics (Microwave Laboratory), Indian Institute of Technology, New Delhi and Amitech Electronics Ltd. Sahibabad, Ghaziabad (Uttar Pradesh, India) to estimate biological effects of MWR exposure in experimental animals (Figure 1A & B). GTEM cell is a pyramidal tapered, dual terminated section with its outer cell dimension Length (L): 220 cm × Breath (B): 120 cm × Height (H): 80 cm. Microwaves are generated through microwave generator SMC 100 (Rhode & Schwarz GmbH & Co, Germany). The microwave source consists of a signal generator operating at frequency range from 9 kHz to 3.2 GHz, amplifier, Direct Current (DC) regulator and a power meter. During the exposure rats were restrained in closed boxes (dimension as L:30 cm × B:15 cm × H:20 cm) divided into 4 compartments with holes of 1 cm diameter to facilitate easy movement and breathing and kept at a distance of 100 cm from the source. The microwave chamber is lined with absorbers which minimize the possibility of any reflections. The electric field was experimentally checked using an electric field (E-field) probe inserted into the Transverse Electromagnetic (TEM) cell through a slit wall. Pre-exposure validation was conducted using spectrum analyzer to ensure the uniformity of the field strength across the volume of GTEM cell. The E-field strength was observed homogeneous inside GTEM cell. The microwave radiation used in the study is continuous wave and linearly polarized. The GTEM cell was placed in a temperature controlled room (22±2 °C) under constant lighting conditions. Specific absorption rate (SAR) distribution was calculated by the power balance method using following equation[21].

$$P_{abs/rat} = 1/n\ (P_{in} - P_{out} - P_{refl}) \quad (1)$$