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Original research

The effects of microwave radiation on rabbit's retina

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Abstract

Purpose: Mobile cell phones are used extensively these days, and their microwave (MW) radiation has been shown to affect the eye. The purpose of the present study was to evaluate the effects of MW radiation on rabbit retina.
Methods: This experimental study (concluded in 2015) was conducted on 40 adult white New Zealand rabbits. A Global System for Mobile Communications (GSM) cell phone simulator was used for MW irradiation. The rabbits were randomized into five groups (8 in each) and treated as follows: Group 1: no irradiation (sham); Group 2: irradiation at 10 cm for 1 day; Group 3: irradiation at 30 cm for 1 day; Group 4: irradiation at 10 cm for 3 days; and Group 5: irradiation at 30 cm for 3 days. Scotopic and photopic electroretinography (ERG) responses were obtained at baseline and 7 days after the last exposure. Then all the rabbits were euthanized, and their eyes were enucleated and sent for pathology examination. Kruskal–Wallis and Chi-Square tests were used to evaluate intergroup differences in ERG parameters and histological findings, respectively.
Results: ERG responses obtained 7 days after irradiation did not show any statistically significant difference between the groups ($P > 0.1$, for all tested parameters). There were statistically non-significant trends toward greater changes in the MW irradiated eyes. In pathological examination, retina was normal with no sign of degeneration or infiltration. Ciliary body congestion was observed in greater fraction of those who received higher MW doses. ($P = 0.005$).
Conclusions: Histopathologically, cell phone simulated MW irradiation had no significant detrimental effect on the retina. However, ciliary body congestion was observed in greater fraction of those who received higher MW doses. Although there was no significant difference between post-treatment mean ERG values, there were statistically non-significant trends toward greater changes in the MW irradiated eyes.

Keywords: Ciliary body; Electroretinography; Irradiation; Microwave; Retina

Introduction

Microwaves (MWs) are a subgroup of electromagnetic waves with frequencies between 300 MHz and 300 GHz.[1] Many modern devices, such as cellular phone transmitters and receivers, radars, radio and television transmitters, and video display terminals emit MWs.[2,3] Recent dramatic increase in the application of these devices has raised public concern about their possible detrimental effects on human health. Indeed, it has been well established that MWs affect the biological functions of living organisms at both cellular and molecular levels.[4,5] However, the underlying mechanisms are not fully understood.[6,7] In general, two main mechanisms have been proposed: thermal, and non-thermal.[2,8] MWs are capable of generating heat within living tissue with subsequent

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health implications. They may also affect cell growth, cell cycle progression, and DNA synthesis through unknown non-thermal mechanisms.[8,9]

Because of its natural sensitivity to radiation, the eye has been evaluated for possible complications after experimental MW irradiation.[2,9,10] Actually, cataract has been described as the most frequent complication of MW exposure in men.[11] Previous studies have shown the role of thermal effect of MWs on their cataractogenesis.[12] However, recent studies have underscored the possible role of non-thermal effects of MWs in cataract formation as well.[1] Despite the extensive research regarding MWs and cataract, the possible impact of MWs on the retina has not been evaluated in detail.

To date, with the widespread use of cell phones, there is a strong rationale for determining the detrimental effect of MWs emitted from these devices on health. Because of the way they are used, cell phones are usually kept in the close vicinity of the eye for up to several hours a day. Considering its delicate structure, the eye may be the primary site of injury from these devices. We aimed to evaluate the possible side effects of cell phone simulated MWs on the retina of rabbits.

Methods

Animals

In this experimental study (concluded in 2015, Shiraz, Iran), forty healthy male New Zealand white rabbits (weighing 2–3 kg) were included. With an estimated power of 0.8 and 2-sided P value of 0.05, 8 rabbits were required in each group to detect a 25% change from the sham group in the ERG combined b-wave amplitude. Rabbits with any health issues were excluded from the study. The rabbits were kept in a controlled environment with suitable temperature (23–25 °C) and ventilation and a 12-h on/off light cycle. Food and water were provided as needed. The Animal Care and Use Committee of Shiraz University of Medical Sciences approved all aspects of this study, and the research protocol adhered to the Association for Research in Vision and Ophthalmology (ARVO) Statement for the Use of Animals in Ophthalmic and Vision Research.

Microwave irradiation

A Global System for Mobile Communications (GSM) cell phone simulator designed at the (School of Engineering, Shiraz University, Shiraz, Iran) was used for MW irradiation. The frequency of the device was set at 915 MHz, and the emitted power (circular space distribution) of the generator was fixed at 2 W during exposure. Before study, all devices had been checked and controlled in the lab to ensure that they produced constant wavelength for study duration. After baseline electroretinography (ERG), the rabbits were randomly assigned into five groups (8 in each), and treated as follows: Group 1: no irradiation (sham); Group 2: irradiation at 10 cm for 1 day; Group 3: at 30 cm for 1 day; Group 4: at 10 cm for 3 days; and Group 5: at 30 cm for 3 days. To make sure that the rabbits would receive MW irradiation as per protocol, each rabbit was confined within a restrainer during the irradiation period, and the device was placed in front of the animals' head (the above-mentioned distances were measured from the animals' eyes after putting into the restrainer). The dosage of irradiation was tried to set similar to routine GSM cell phones. The distance was set according to usual distance between the device and the human eye when the device is used on the ear as a voice call (10 cm) or as a video calls (30 cm). The selected durations of exposure (1 vs. 3 days) were chosen to imitate an exaggerated exposure, which had the potential to yield positive results.

Examinations

After anesthesia and pupillary dilation, standard scotopic (dark-adapted) and photopic (light-adapted) ERGs were done by masked trained operators at baseline and 7 days after the last exposure. The rabbits were dark-adapted for at least 1 h and were anesthetized about 10 min before ERG recordings. ERG waveforms were obtained using the RETI-port (®) system (Roland, Wiesbaden, Germany). The ERG recordings were obtained according to the International Society for Clinical Electrophysiology of Vision (ISCEV) standards. ERG has been validated as a safety measure for experimental investigation in several previous studies on rabbits.[13–15] All recordings were performed while the rabbits were under general anesthesia induced by intramuscular injections of ketamine hydrochloride (35 mg/kg) and xylazine hydrochloride (5 mg/kg). Pupils were dilated using topical tropicamide 0.1% and phenylephrine hydrochloride 2.5%. The following ERG parameters were recorded and analyzed: scotopic b-wave amplitude, combined a-wave amplitude, combined b-wave amplitude, photopic b-wave amplitude, 30-Hz flicker n1p1 amplitude, and 30-Hz flicker p1 implicit time.

Immediately after the 1-week ERG, the animals were euthanized with intracardiac pentobarbital overdose (200 mg). Then the eyes were enucleated and fixed in 10% formalin for 24 h. All histologic sections were evaluated by an expert pathologist. Following gross examination, semi-thin sections through optic nerve head and macula were provided and stained with hematoxylin and eosin for light microscopic evaluation.

Data analysis

Only data from the right eyes of the animals were used for statistical analyses. Data were analyzed using IBM SPSS software version 21 (SPSS Inc., Chicago, IL, USA) and MedCalc version 12.2.1 (MedCalc Software, Mariakerke, Belgium). Kruskal–Wallis and Chi-Square tests were used to evaluate intergroup differences in ERG parameters, and histological findings, respectively. P values < 0.05 were considered statistically significant.

Results

Figure. 1 summarizes ERG responses at baseline and after treatment for all groups. The baseline mean ERG parameters

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