THE EFFECT OF GENERAL ANESTHESIA ON THE THRESHOLD DECISION OF OCULAR SIDE EFFECTS INDUCED BY MICROWAVE RADIATION IN RABBIT EYES

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ABSTRACT

Forty-three Dutch rabbits were exposed to a 2.45 GHz microwave for 60-120 minutes (300 mW/cm^2) with and without anesthesia. Changes in the anterior segment were quantitatively measured. Eye segment temperatures were measured during exposure. Temporally induced anterior segment inflammation and lens changes were observed. The systemic anesthesia group showed stronger symptoms than those treated without anesthesia. The ocular temperature during exposure was the highest in the vitreous, followed by the anterior chamber and retrobulbar cavity. The acute high intensity microwave exposure temporally induced anterior segment inflammation and lens changes. The influence of general anesthesia on ocular changes should be considered.

INTRODUCTION

There is much concern about the possible hazards on human health from microwaves irradiated from mobile phones. Ocular hazards are among the several health effects from microwave exposure and investigations into the subject started in the 1950s [1].

Guy et al. [2] investigated the effect of continuous microwave exposure to the lens in albino rabbit eyes under general anesthesia with 2.45 GHz, 150 mW/cm^2 incident (138 W/kg peak absorption) for 100 minutes in 1975 and proposed a threshold microwave level for inducing lens opacification (cataract). Saito et al. (1998) [3] performed the same kind of

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experiment using white rabbits under non-anesthesia conditions with 26.5 W/kg SAR for 160-240 min., and found no cataractous changes. Furthermore, Kues, et al. [4] found corneal endothelial abnormalities under systemic anesthesia conditions with 20-30 mW/cm^2 (2.45 GHz continuous waves (CW)) exposure. In contrast, Kamimura et al. [5] performed the same kind of study without anesthesia, and reported that no corneal endothelial cell abnormalities were observed.

To clarify the above mentioned discrepancy, the efficacy of general anesthesia on ocular side effects induced by microwave radiation under the same experimental conditions was investigated.

MATELIALS AND METHODS

Forty-three young adult male pigmented rabbits (Dutch, 1.8-2.2 kg, 13-16 weeks old) were kept in a specific pathogen-free animal room. The animals were fed a sterilized commercial diet and sterilized water ad libidum. A dielectric loaded open-waveguide antenna (12.6×18.5 mm^2, dielectric property: 5.5, exposure distance (antenna to cornea): 40 mm) was used to expose the rabbits to the microwaves. The eyes of the rabbits were exposed unilaterally to a 2.45 GHz microwave (CW) for 60 to 120 minutes (300 mW/cm^2, SAR 108 W/kg (average of ocular fields)) either under anesthesia (ketamine hydrochloride (5 mg/kg, inter muscle) + xylazine (0.23 mg/kg, inter muscle)) or without anesthesia. The rabbits were fixed in a rabbit holder (made of polycarbonate) during microwave exposure and two rabbits (anesthetized and non-anesthetized) were exposed simultaneously as one set. Three sham-exposure sets were treated as a control. Changes in the anterior segment were observed before exposure and 1, 3, 7, and 14 days after. Changes in the cornea and crystalline lens were objectively evaluated by the density values which corresponded to the scattering light intensity of the cornea and lens. Damage to the corneal endothelial cells was observed through a specular microscope (CSP-580). Inflammation of the anterior segments was observed by a slit lamp microscope, and the degree of inflammation was objectively evaluated by a laser flare cell meter (FC-2000). To measure the rise in temperature during microwave exposure, the temperatures of the eye segments were measured by a Fluoroptic Thermometer (Luxtron 790). The rabbit eyes were anesthetized with 4% oxybuprocaine hydrochloride, then, thermometer probes (0.5 mm diameter) were inserted into the anterior chamber, vitreous, and retrobulbar cavity of the orbit. The temperature in the intestine as an internal deep direction temperature, and room temperature were also measured. Fifteen minutes after the thermometer probes were inserted into the eye (after the anesthesia of the eye had worn off), the eyes were exposed to 300 mW/cm^2 microwaves for one hour, after which there was a cooling time of 1 hour. Fifteen minutes after systemic anesthesia administration, the rabbits were again exposed to 300 mW/cm^2 for one hour.

RESULTS

The irradiated eyes temporally showed miosis, conjunctival congestion, and corneal edema. All the symptoms disappeared within a week. An increase in the light scattering of the anterior shallow cortex of the lens on the exposed side was observed by slit lamp examination for one day after exposure (Fig. 1A). The rise in the scattering light peaked

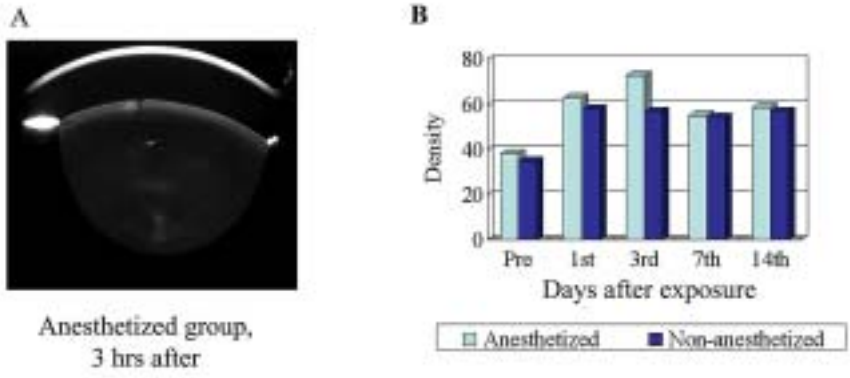

Figure 1: Light scattering changes of lenses

three days after exposure, and decreased within 7 days after exposure (Fig. 1B).

The group under general anesthesia showed stronger symptoms than those treated without anesthesia (Fig. 1B).

The exposed eye of the anesthetized rabbit showed a higher degree of inflammation (483±331 photon count /millisecond: pc/ms) compared to the non-exposed eye (9.2±6.9 pc/ms) immediately after exposure. In contrast, the non-anesthetized rabbits showed a lower degree of inflammation 215.3±315.6 (exposed eye), 6.9±4.5 (non-exposed eye), respectively. The inflammation of the exposed eye of the non-anesthetized group returned to a level equivalent to that of the non-exposed eye 3 days after exposure, while the exposed eyes of the anesthetized group showed a degree of inflammation about 4 times higher than that of the contra-lateral eye.

The highest temperature during exposure was seen in the vitreous, followed by the anterior chamber, and the retrobulbar cavity of the orbit. The above temperatures of the rabbits under systemic anesthesia were 2-9 ºC higher than those without anesthesia. The intestinal temperature of the non-anesthetized group showed an increase of 1 ºC during the exposure.

DISCUSSION

Although many studies have been performed on the ocular hazards of microwave exposure, the reports on the cataract development of anesthetized and non-anesthetized experimental animals during microwave exposure differ. Additionally, between the 1970s and early 1990s, experimental methodology applied to this kind of study has remarkably progressed. Therefore, we aimed to perform the same kind of study applying different approaches.

The threshold dose of microwave that induces lens opacification (Guy described “a milky band in the posterior cortex, and this change was often reversible” [2]) on anesthetized rabbits was 150 mW/cm^2 for 100 minutes (SAR 138 W/kg). The authors confirmed that the same kinds of lens changes were noticed with 300 mW/cm^2 exposure for 120 minutes (SAR 108 W/kg) only under anesthetized conditions, but not on non-anesthetized rabbits. Of course, the authors’ results do not directly correspond to those by the previous authors, since there were several differences in the experimental methods. These differences are 1) Distance between the antennae and the surface of the rabbit cornea. 2) Difference in

the antennae shape (no description was found in the previous study). 3) Albino and pigmented animals. In the previous study albino rabbits were used, but in this study only pigmented rabbit were used. It is well recognized in the ocular toxicological study field that pigmented animals are appropriate subjects. 4) With and without anesthesia. Guy et al. [2] performed their experiments under general anesthesia. However, Saito et al. [3] performed their investigation with the same aim as Guy and did not apply general anesthesia. Referring to these prior investigations, the authors made two types of experiments, namely, microwave exposure under general anesthesia and without anesthesia.

The authors presently consider that a significant difference, that is, the lack of cataractous change observed in the non-anesthetized rabbits, might be induced by the above different methodological points. Since the accuracy of our method to detect lens change is higher than those applied in the 1970s, it is almost impossible to overlook the cataractous changes that occur in the lenses. Multi-causal factors might relate with differences due to the above-mentioned discrepancy. The authors considered that among the above causes, general anesthesia had the main influence on the appearance of cataractous changes.

In order to understand the relationship between intraocular temperature changes and anesthesia, the ocular temperatures were measured during exposure under conditions with and without anesthesia. As described in the results, intaraocular temperatures were significantly higher in the group with general anesthesia than in the group without anesthesia. The cooling effect of regular blood circulation on the eyeball may be disturbed by general anesthesia, although the authors still do not known how deeply it is disturbed.

Based on the authors own studies up to now and the previous investigations by Guy et al. and Saito et al., the authors consider that the threshold level which induces organic changes in ocular tissues such as the cornea and lens, would be lower when calculated under experimental conditions with general anesthesia than without general anesthesia. The results gained from this study may be useful for future studies in this field.

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