Non-Thermal Electromagnetic Radiation Damage to Lens Epithelium

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Abstract: High frequency microwave electromagnetic radiation from mobile phones and other modern devices has the potential to damage eye tissues, but its effect on the lens epithelium is unknown at present. The objective of this study was to investigate the non-thermal effects of high frequency microwave electromagnetic radiation (1.1GHz, 2.22 mW) on the eye lens epithelium in situ. Bovine lenses were incubated in organ culture at 35°C for 10-15 days. A novel computer-controlled microwave source was used to investigate the effects of microwave radiation on the lenses. 58 lenses were used in this study. The lenses were divided into four groups: (1) Control lenses incubated in organ culture for 10 to 15 days. (2) Electromagnetic radiation exposure group treated with 1.1 GHz, 2.22 mW microwave radiation for 90 cycles of 50 minutes irradiation followed by 10 minutes pause and cultured up to 10 days. (3) Electromagnetic radiation exposure group treated as group 2 with 192 cycles of radiation and cultured for 15 days. (4) Lenses exposed to 39.5°C for 2 hours 3 times with 24 hours interval after each treatment beginning on the second day of the culture and cultured for 11 days. During the culture period, lens optical quality was followed daily by a computer-operated scanning laser beam. At the end of the culture period, control and treated lenses were analyzed morphologically and by assessment of the lens epithelial ATPase activity. Exposure to 1.1 GHz, 2.22 mW microwaves caused a reversible decrease in lens optical quality accompanied by irreversible morphological and biochemical damage to the lens epithelial cell layer. The effect of the electromagnetic radiation on the lens epithelium was remarkably different from those of conductive heat. The results of this investigation showed that electromagnetic fields from microwave radiation have a negative impact on the eye lens. The lens damage by electromagnetic fields was distinctly different from that caused by conductive heat.

INTRODUCTION

Environmental stress, including electromagnetic radiation, has a negative impact on the lens and is considered a risk factor for cataracts [1,2]. Microwaves from modern technological devices such as cellular phone transmitters and receivers, radars, radio and TV transmitters and video display terminals are an important part of modern life [3,4]. While thermal effects of microwaves have been well characterized and guidelines for exposure to microwave radiation are clear, their non-thermal effects on eye tissues are not known [3]. Cataracts form when proteins in the lens begin to clump and scatter light, and can be induced at high temperature with conductive heat. According to the World Health organization, cataracts are the leading cause of vision impairment worldwide [5,6]. The ocular lens is exposed to environmental stress throughout the lifetime of an individual [7,8]. However, currently very little information is available on the effect of electromagnetic fields from high frequency microwave radiation. With the advent of cellular phones and other devices emitting high frequency electromagnetic radiation, there is a strong rationale for determining the damaging effect of electromagnetic fields generated from high frequency microwave radiation on the eye lens. It has also been recognized that a particularly vulnerable group might be children, as they are likely to have the highest cumulative exposure to radiowaves from mobile devices [9].

The ocular lens is a unique tissue with a distinctive cellular architecture. The lens consists of two cell types, the single layer of lens epithelial cells on its anterior surface, which are responsible for the growth and development of the entire lens, and the differentiated lens fiber cells, with elongated morphology that do not turn over their proteins throughout life. Lens epithelial cells provide metabolic support to the entire lens, and are also the first cells in the lens to be exposed to damaging radiation [10,11]. Moreover, the epithelium is the site at which metabolic enzymes and transport systems are concentrated, thus making these cells essential for maintaining lens homeostasis, and as the first line of defense against environmental damage [12].

Heat stress delivered by microwaves to an organism unavoidably entails exposure of the cells to oscillating electrical and magnetic fields, raising the possibility that non-thermal, direct electromagnetic field-mediated effects could cause different effects on cells than the effects of stress delivered by heat conducted from the environment. Indeed, it has been shown that microwaves (2.45 GHz) cause a significantly higher degree of protein unfolding than conventional heating for protein solutions [4]. High frequency electro-