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Effects of ultraviolet radiation on mole rats kidney: A histopathologic and ultrastructural study

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ABSTRACT

The purpose of this study was to realize the ultrastructural effects of ultraviolet radiation on the kidney tissue cells of mole rats (*Spalax leucodon*). The mole rats of 180–200 g body weight were divided into the control and radiation-trial groups. The control group was not given any radiation. The other groups were irradiated with artificially produced UVC radiation for 14, 28 and 60 days. The kidney tissue samples were prepared at the end of experiments and analyzed by the light and electron microscope. Several effects were observed in the kidney tissues cells analyzed in accordance with the dose magnitude of radiation. These results clearly show the detrimental effects of UVC radiation on kidney tissue cells in exposure periods dependent on radiation dose and exposure time.

1. Introduction

Ultraviolet radiation emitted from the sun is divided into three main spectral regions: UVA (400–315 nm), UVB (315–280 nm) and UVC (280–200 nm). They have been known to cause adverse effects on the organisms for a long time (Dong, Svoboda, Tiersch, & Monroe, 2007; Osman, Koutb, & Sayed, 2010; Stolarski et al., 1992; WHO, 1994).

UVA rays cause light brown tan in a short time; the subsequent darkening is due to melanin accumulating in the skin. UVB rays cause delayed but long-term tan mostly resulting in the melanin synthesis in the skin. It causes serious sunburn associated with intensified erythema and edema, ache and blister formation in less than one day exposure. UVC rays have biocidal and sterilizing properties, but on the other hand, they are especially detrimental for the eyes and skin. As this rays are absorbed by the ozone layer in the atmosphere, they

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usually do not reach the earth surface (McKenzie, Björn, Bais, & Ilyas, 2003; Morgan, Proniuk, Blanchard, & Noecker, 2001; Ravindran, Indrajith, Pratheesh, Sanjiviraja, & Balakrishnan, 2010; WHO, 1994).

The reduction of ozone in the stratosphere occures as a consequence of human activities such as chlorofluorocarbon and greenhouse gases as well as the cosmetic sprays leads to increase in the level of UVC radiation on the ground (Majumdar, Chintada, Sahu, & Chalapati, 2013; McKenzie et al., 2003; Osman et al., 2010; Sayed, Ahmed, Mekkawy, & Mahmoud, 2007; Stolarski et al., 1992).

UVC radiation has more detrimental effects on the living beings than the others. Fortunately, majority of this radiation is filtered by Ozone (O_3) layer. As thickness of this layer has reduced in recent years, it is estimated that the skin cancer, cataract and immune deficiency syndrome cases will increase in the near future (Mayer, 1992; McKenzie et al., 2003; Ravindran et al., 2010).

To our knowledge, plenty of data has been gathered concerning the effects of UVA and UVB radiations on biochemical, hematological or histopathological characteristics of animals (Salo, Jokinen, Markkula, Aaltonen, & Penttila, 2000; Verma et al., 2011; WHO, 1994), but similar studies done with UVC radiation on the renal cells have not been encountered. For this reason, our purpose was to determine the effects of UVC radiation on rat renal cells by the light and electron microscope.

For this reason, the mole rats were selected as they live in the underground galleries, and have no UV exposure in their habitat. Therefore, they were exposed to an artificially produced UVC radiation in lab, and the renal changes were compared with the control group.

2. Materials and methods

15 adult mole rats of both sexes, weighing 180–200 g were used in this study. All rats were caught from the rural areas of Ankara, Turkey. They were kept in the laboratory for 10 days at a stable temperature (20 ± 2 °C) in order to ensure adaptation to a new environment. The rats were housed individually in special cages called terrarium, and a constant UVC dose was applied. All animals were fed with carrot, potato, plant roots, and no special diet was given. Some of the rats died during the experiment.

A "Mazda TG" ultraviolet lamp of 30 W powers and in 90 cm length was placed to the upper cover of the terrarium. The intensity of UV rays emitted from the lamp was measured 254 nm in wavelength, and the energy in 1 s was found 0.0014 J/cm^2. Sunlight period was also taken into account, and rats were exposed to the artificial UVC radiation for 8 h per day (between 08.00 and 17.00 h). A feeding interval was given on mid-day for 1 h. A timer was used to control the UV exposure times. The animals were divided into four groups. Group I was separated as a control. Group II was exposed to 14, Group III was exposed to 28 and Group IV was exposed to 60 days of UVC radiation. The study groups, exposure times and dosage were listed in Table 1.

At the end of radiation periods of 14, 28 and 60 days, the rats were euthanized under ether anesthesia to detect and compare the kidney cell changes effected by UVC radiation.

Table 1 – Experiment groups, exposure times and dosages.

Study groups	Number of mole rats in experiment groups	Exposure times (days)	Total dosage (J/cm^2)
Group I (Control)	2	No radiation	00.00
Group II	3	14	564.48
Group III	3	28	1128.96
Group IV	3	60	2419.20

After euthanize, both kidneys were rapidly removed and bisected. Renal tissue was divided into small pieces. These samples were fixed in Bouin's solution and embedded in paraffin. Semi-thin (5 μm) sections were stained with Methylene blue-Azure II. 1-μm-thick sections of the plastic embedded tissue were stained with alkaline solution of toluidine blue and examined under a light microscope to select areas for histological studies.

For electron microscopy, tissue samples of 1 mm^3 were fixed in *glutaraldehyde* (3%) and phosphate buffered saline (pH 7.2) at 4 °C for 3 h and post-fixed with 1% osmium tetroxide for 1 h. Osmium tetroxide was washed away with the same buffer. Ethyl alcohol was used for dehydration and samples were embedded in Araldite CY-212. Thin sections were double stained with saturated uranyl acetate (20 min) and lead citrate (10 min) (Sato, 1967). Jeol JEM 100 CX-II electron microscope was used for the examination of the specimens.

The experiment was carried out in accordance with the Ankara University guidelines for the care of the experimental animals. Besides, guiding principles for experimental procedures presented in the World Medical Association's Declaration of Helsinki regarding animal experimentation were followed in the study.

3. Results

During the examination of semi-thin section of the kidney tissue cells of mole rats belonging to the control group, some structures such as glomerulus, proximal tubules, distal tubules and capillaries were distinguished in the kidney tissues (Fig. 1a). On the other hand, in the examination of thin sections with electron microscope, plenty of mitochondria, small vesicles and erythrocyte were seen in kidney cells (Fig. 1b). No significant structural changes were detected in the light and electron microscope levels.

In the semi-thin fraction obtained from the mole rat's kidney irradiated for 14 days, plenty of small vesicles were observed in the internal sections of the proximal tubules. In the epithelial cells around the glomeruli, electron transparency increased substantially. Besides, the expansion in capillaries' diameters was observed (Fig. 2).

In the semi-thin fraction obtained from the mole rat's kidney irradiated for 28 days, plenty of small vesicles occurred in the proximal tubular cells. Capillaries expanded more. Vast cavities occurred in capillaries in glomeruli (Fig. 3).

On the other hand, in the semi-thin fraction obtained from the mole rat's kidney exposed to UVC radiation for 60 days,