ACTION OF CENTIMETER WAVES ON THE EYE

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(Received May 3, 1955. Presented by A. A. Letavet, Member, Acad. Med. Sci. USSR).

Eye injuries have been reported in the foreign literature as resulting from exposure of animals to intense centimeter wave irradiation.

Thus Richardson et al [3] found that a single exposure to undamped 12.25 cm waves from a generator of output power 100 W placed at a distance of 5 cm from a rabbit's eye for 15 minutes, was followed within 3-9 days by development of cataract.

The same effect is reported by these authors [4] after a single irradiation with 3 cm waves from an impulse generator of average power 67 W at a distance of 5 cm from the eye; opacity of the lens followed within 2-60 days.

Daily et al [1] found that cataract resulted from irradiation of dogs' eyes with 12 cm waves from a 94 W generator; these authors reported considerable temperature rises in the eye during irradiation, amounting to 2.6-5.7° in the vitreous humor, and 2-4.3° in the aqueous humor.

It may hence be concluded that high power centimeter waves can cause serious injury to the eye, and that this injury is connected with the thermal effect.

The case reported by Hirsch and Parker [2], of eye injury suffered by a person working with microwave apparatus (wave length 9-18 cm; average power 100 W, with 50% utilization), is of interest.

While they do not fully elucidate the pathology of this condition, as being due to the energy content of the high frequency emission, the authors nevertheless feel it necessary to draw the attention of specialists to this problem.

The present paper describes the results of a study of the effects on the eyes of animals of exposure to centimeter waves many times less powerful than used by the above authors, although much more powerful than is ordinarily encountered by personnel working with centimeter waves.

A group of 25 gray rabbits, weighing 3.5-4 kg, was taken for the experiments. All the animals were first subjected to an ophthalmoscopic examination, and some to slit-lamp ophthalmoscopy. The animals were exposed to 10 cm wave irradiation, with an energy flux density * of 110 mV/cm^2.

The rabbits were placed in a metal box with an opening for the head. A wire gauze headpiece with an opening for one eye was placed over the head. The pupils were dilated 40 minutes before the experiment by administering 1% homatropine. The eyelids were kept open by retraction with adhesive tape.

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*Energy flux density is the energy flux per square cm per second.

Two series of experiments were performed – chronic and acute.

Group I: Acute experiments. The rabbits were subjected to 1-7 exposures, each of one hour's duration. The intensity of irradiation, expressed as energy flux, was 110 mV/cm^2.

Inspection of the eye immediately after irradiation showed a reddening of the conjunctiva, chiefly within the palpebral fissures. Above, and going towards the posterior pole of the orbit, was a sinuous red band of dilated vessels, which was more or less distinct in different animals. The conjunctiva was somewhat edematous. The cornea was somewhat dull and edematous in most of the exposed animals. Infiltration of the cornea, extending to its deeper layers, was seen in some rabbits (Rabbit No. 9).

Different animals exhibited various degrees of injection of the pericorneal vessels. The pupil was strongly contracted following exposure. The capsule of the iris was hyperemic. The fundus showed slight hyperemia, with dilation of individual vessels. Signs of hyperemia disappeared within 24 hours, and injection of vessels within 4-5 days. No changes could be seen in the lens by transmitted light, but when observed by means of a slit-lamp opacities could be seen in some of the animals, in the shape of zigzag bands traversing the lens in various directions; these bands were usually situated in the anterior or posterior capsular layers. (Rabbit No. 13). In addition, regions of slight clouding of the lens are sometimes seen, towards the posterior wall (Rabbit No. 14).

In one case (Rabbit No. 8a) a faint cloudy band appeared in the posterior part of the capsule on the 6th day after the third exposure. Six weeks later after 7 exposures, this band had a chainlike appearance.

In some cases there were also seen isolated white points or threads, located in the more central parts of the lens.

Observation of the rabbits was continued for 4-5 months, at the end of which no further changes were registered.

Group II: Chronic experiments. The same intensity of irradiation (110 mV/cm^2) was used, and the rabbits were exposed daily for 10 minute periods for 6 weeks.

We observed slight irritation of the anterior parts of the eye after the first exposure, and this became somewhat more pronounced after the third. Pericorneal injection was most marked in Rabbit No. 6, and the central part of the cornea was edematous.

Changes in the lens developed much more slowly in these animals than in Group I, usually after 15-17 exposures (21 days); these changes resembled those found for Group I. Thus, vertical bands of opacity were seen in the anterior cortical layer of the lens of Rabbit No. 7. A delicate, diffusely outlined white band was located in the posterior cortical layer, running parallel to the equator, but somewhat closer to the center.

Cloudy opacities placed near the posterior pole of the lens were seen in Rabbit No. 6; these appeared 23 days after the first exposure.

The fundus did not show any deviations from normal in any of the rabbits.

Our observations were confirmed by morphological examinations performed together with P. P. Dvizhkov and E. F. Levkoeva.

Our findings are illustrated by the following two morphological descriptions for one rabbit from each group (Rabbit No. 9 of Group I, and Rabbit No. 7 of Group II):

Rabbit No. 9 (acute series). The continuity of the corneal epithelium is disturbed in places. Desquamation is evident over a large area of the cornea, with necrobiotic and necrotic features. Subepithelial round cell infiltration of much of the cornea is evident (Fig. 1), in places in the form of considerable foci, with necrotic changes in the round cells. The outlines of Bowman's membrane are indistinct.

The orderly arrangement of the layers of the substantia propria is disturbed. Isolated infiltrations are visible in the deeper layers, with ingrowth of a small number of vessels. The endothelium is virtually absent.

These changes amount to keratosis, with subsequent scaly desquamation.

Infiltration of round macrophages, with sporadic polynuclear forms, is evident throughout the subepithelial layers of the cornea. The nuclei of some of the infiltrated cells in the vicinity of the ulcer are in process of breaking down. The morbid process in the cornea extends to the conjunctiva, where edema and infiltration are evident.

Development of iritis, with signs of edema, infiltration, and new formation blood vessels, is to be seen.

Subcapsular changes are evident in the lens, in the form of hydration of the cortical layers.

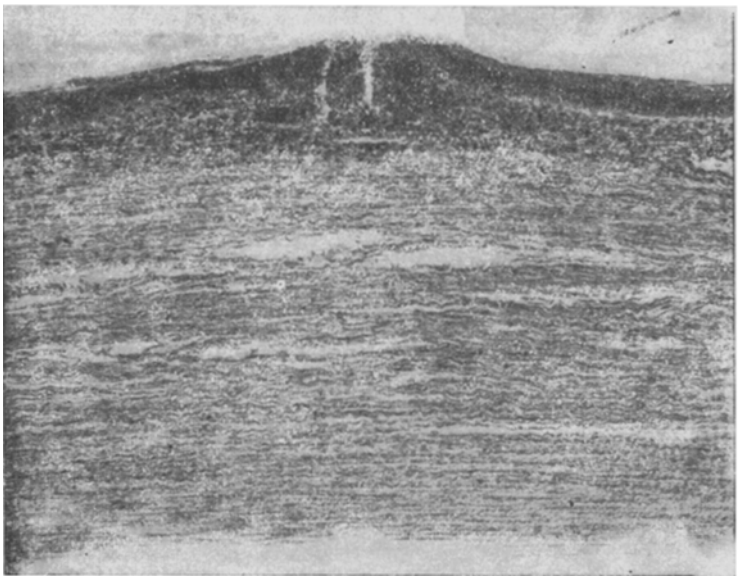

Fig. 1. Changes in rabbit cornea following exposure to 10 cm waves. (Acute experiment).

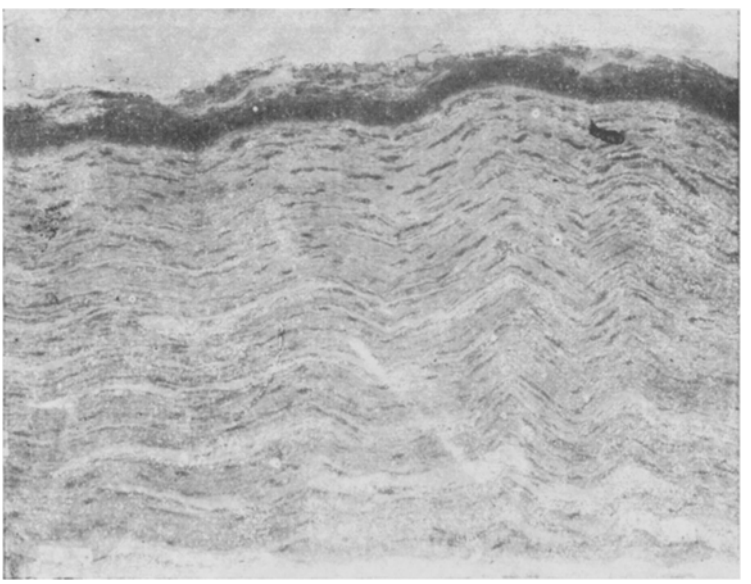

Fig. 2. Changes in rabbit cornea following exposure to 10 cm waves. (Chronic experiment).

Rabbit No. 7 (chronic series). The cornea is in good condition, but a tendency toward keratosis and desquamation is evident in the superficial layers. There are only insignificant changes in the substantia propria. Some surface layers are detached, and there is a certain amount of proliferation of local epithelial cells into the stroma (Fig. 2). Hydration of the cortical layers of the lens is evident.

Thus Rabbit No. 7 exhibits early stages, and Rabbit No. 9 advanced stages of injury.

The foreign authors consider that the injuries to the eye are the result of thermal effects of exposure to centimeter waves. This view may apply to their experiments, since they applied very high intensities of irradiation.

The intensity of irradiation was about 30 times smaller in our experiments, but it was still too high to allow of the exclusion of thermal effects as the explanation of the eye changes observed.

We intend in further experiments to study the action on the eye of very weak centimeter wave irradiation, and to elucidate the mechanism of the action.

LITERATURE CITED

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