fibrinoid impregnation and fibrosis of the stroma, as well as penetration of fibrin usually phagocytized by the AM into the alveolar space (Fig. 3,a). As a rule, the cytoplasm of such cells is packed with multiple secondary lysosomes.

The SR hyperactivity was confirmed by the corresponding ultrastructural reorganization of the organelles and high phagocytic activity directed at the engulfment of destroyed hepatocytes and blood cells. However, sometimes labilization of the lysosomal membranes occurred, resulting in the release of hydrolytic enzymes into the cytoplasm, digestion of its structures, and finally cell death (Fig. 3,b).

It is important to stress, when estimating the ultrastructural alterations in the cells of the MPS liver and lung compartments as a whole, that along with the clearly adaptive reaction of the macrophages [1] fulfilling a protective function in endotoxemia, the accumulation of them in the liver and lungs is considered by some workers as one of the leading injurous factors. Indeed, activated macrophages participate in tissue destruction by means of increased production of catabolic enzymes elastase and collagenase [15]. Activation and exocytosis involve lysosomal enzymes and substances with a broad spectrum of biological action: acid phosphatase, products of arachidonic acid metabolism, cachectin (tumor necrosis factor), monokines, pyrogens, etc. [11-13].

Thus, the state of AM and SR to a great extent determines the characteristic features and the progression of various target organ alterations during the action of endotoxin. The blockade of MPS cells with lipopolysaccharide, fibrin, destroyed cells, and cell debris promotes the manifestation of DIC syndrome and intensifies the morphological signs of tissue damage. Ultrastructural alterations in the microcirculatory bed, pneumocytes, and hepatocytes depend on the potencies of MPS cells for taking part in the catabolic processes. The presence of microsystems consisting of organ-specific macrophages and specialized parenchymatous cells increases the clearing function of the lungs and liver, especially in the initial phase of endotoxemia.

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Effect of Microwaves of Thermogenic Intensity on the Structure of the Blood-Retina and Blood-Brain Barriers

S.V.Logvinov

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The neurobiological effects of microwaves and the selectivity of their effect with respect to nervous tissues are due substantially to the primary influences of radiation on the membrane elements of the neuron [8]. The contribution of vascular reactions and changes on the part of the blood-brain barrier to the nervous tissue mechanisms of the effect of SHF energy on the CNS has been variously appraised [1, 9].

The goal of the present investigation was to study the nature and dynamics of the structural changes in the blood-retina and blood-brain barriers (BRB, BBB) after the effect of microwaves of thermogenic intensity in various parts of the visual analyzer, taking into account the high sensitivity of the latter to the given range of electromagnetic radiations [4].

MATERIAL AND METHODS

The experiments were run with sexually mature mongrel guinea pigs and white rats of both sexes, 79 of the former and 30 of the latter, of which 50 and 20

Department of Histology and Embryology, Siberian State Medical University, Tomsk
(Presented by Academician E.D.Gol'dberg of the Russian Academy of Medical Sciences

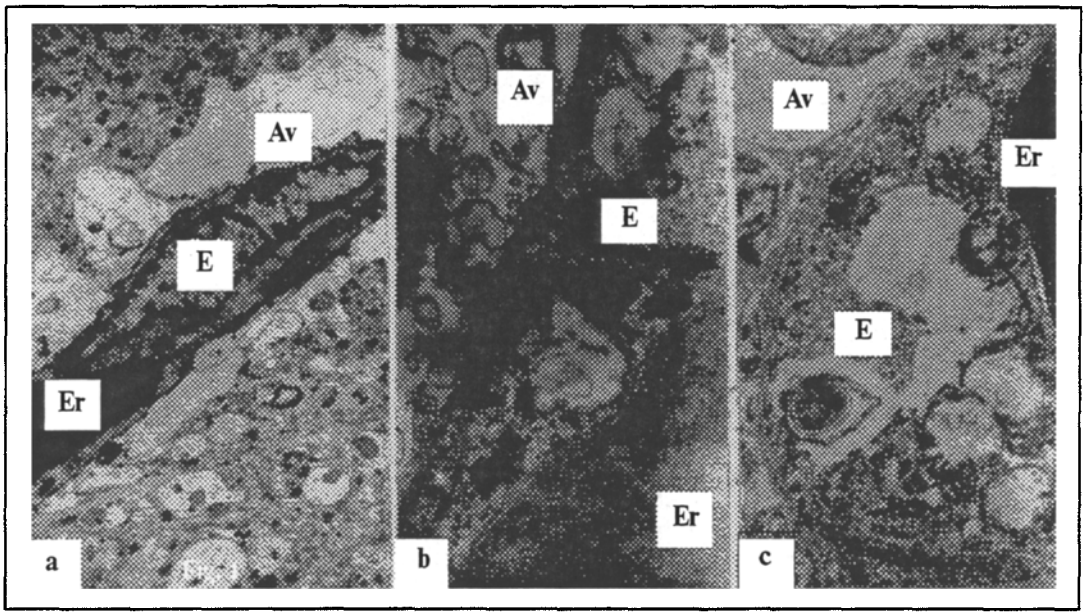

Fig. 1. Ultrastructural changes in BBB in visual centers after the action of microwaves at 60 mW cm^{-2}. a) edema and vacuolization of pericapillary astrocyte processes in VC six hours after irradiation; b) foci of destruction, autophagosomes in cytoplasm of capillary endotheliocyte, nonuniformity of thickness of basal membrane, numerous membrane complexes in vascular process of astrocyte in LGC one day after irradiation; c) large focus of destruction, myelinlike body in cytoplasm of endotheliocyte, focal thinning and loosening of basal membrane of capillary in VC one day after irradiation. Magnification: a) 4800x; b and c) 19,000x. Er: erythrocyte; E: endotheliocyte; Av: astrocyte vascular process.

animals, respectively, were subjected to single whole-body UHF radiation at 60 $mW \cdot cm^{-2}$ (frequency 2375 MHz, wavelength 12.6 cm) with an exposure of 10 min. The irradiation in an anechoic chamber was unidirectional (lateral), with the longitudinal axis of the animal parallel to the magnetic vector of the electromagnetic wave. The specific absorbed power by measurements on multichamber phantoms of rats was about 8 $W \cdot kg^{-1}$. The controls were animals subjected to "imaginary" irradiation and subsequently held together with the experimental animals under identical vivarium conditions with the customary light regimen.

The irradiated guinea pigs and rats were decapitated after 1 min, 6 h, 1, 5, 10, 25, and 60 days simultaneously with the control animals. The dorsal wall of the eyeball and pieces of the brain were fixed in Carnoy fluid and 10% neutral formalin and were embedded in paraffin. The frontal sections of the brain at the level of the dorsal nuclei of the lateral geniculate body (LGB) and the visual cortex (VC), and vertical sections of the retina were stained with hematoxylin and eosin. The unfixed material stored in liquid nitrogen after division into sections with the aid of a cryostat was used for determining the activity of alkaline phosphatase (AP) after Berston. Microdensitometry of AP activity in the endothelium of capillaries was performed in a Univar scanning cytophotometer (Austria). The specific length of the capillaries marked when running the reaction for the AP, was conducted stereometrically taking into account the random orientation of the given microobjects. The Student test was employed for statistical analysis. The objects studied were fixed by immersion into 2% glutaraldehyde on a 0.2 M cacodylate buffer (pH 7.2) with postfixation in a 1% solution of osmium tetroxide for electron microscopy. Part of the material was fixed by perfusion. All the samples were impregnated and embedded in araldite. Ultrathin sections were prepared in a Model LKB-111 ultratome, contrasted with uranyl acetate and lead citrate, and examined under a JEM-100 CX electron microscope.

RESULTS

Microwave irradiation causes brief reactions of the BRB structures that are reversible during one to five days. They are mainly of an adaptive and compensatory nature and are directed at activation of the transport processes. For example, with respect to the nonvascular type of retina of guinea pigs, the detected changes in the BRB components on the first day after irradiation included chorioideas, swelling of the epithelium, an increased microvesicle content in the pigmentoepitheliocytes, and a focal increase in their basal plicate nature. The basal complex (Bruch's membrane) retains the conventional ultrastructural organization. The intraretinal vessels in the retinas of rats during the first minutes after irradiation are hyperemic, while after six hours edema of the glial processes is noted along some part of them. A comparative analysis, simultaneously and at later periods, of the changes in the neuronal

TABLE 1. Changes in the Specific Length of a Capillary Canal Determined in the Deep Layers (IV, V) of the Visual Cortex in Running a Reaction for Alkaline Phosphatase after the Action of Microwaves at 60 mW cm^{-2}

Duration of experiment	Control I	1 min	1 day	5 days	Control II	10 days	25 days	60 days
Specific Length	9.5±0.2	10.1±0.4	10,8±0,3 $p<0.05$	12.0±0.3 $p<0.05$	9,9±0,3	9,6±0,3	10,1±0,3	12,5±0,4 $p<0.05$

and glial elements in the retinas of guinea pigs and rats, which differ sharply in the degree of vascularization, points to the important thermoregulating adaptive role of the vascular factor in the nervous tissue mechanisms of the effect of microwaves of the intensity used.

In the visual centers of the brain in the first minutes after irradiation, pronounced phenomena of venous polyemia, hyperemia, and stasis of the formed elements of the blood were discovered in some of the VC capillaries. These changes occurred to a lesser extent in the LGB. In a study of the activity of AP, reaction product is detected not only in the wall of the capillaries and precapillary parts of the arterioles, but also in the form of very fine granules. It diffuses into the perivascular spaces.

Ultrastructural changes in the vessels and BBB on the first day and six hours after irradiation manifest themselves in edema and vacuolization of the astrocyte processes forming the pericapillary sleeve, and focal swelling of the endothelium, as a result of which the opening in some capillaries is narrowed (see Fig. 1, a). After the indicated periods and especially on the first day after irradiation, a number of features are discovered pointing to "breakthrough" of the BBB. In particular, the endotheliocytes exhibit activation of pinocytosis and an increased microvacuolization that are not typical of normal cerebral capillaries and point to the transport of plasma via the BBB into the brain tissue [2,3,5]. In the cytoplasm of some endotheliocytes, large areas of destruction are discovered. They sometimes extend through almost the entire thickness of a cell from the luminal surface to the basal layer. Large myelinlike bodies and numerous phagosomes appear. Glycogen granules sometimes accumulate, indicating pronounced disturbances of metabolism in the described endotheliocytes (Fig. 1, b, c). The simultaneously observed nonuniform thinning and change in the ultrastructure and electron density of the basal membrane, ruptures of the contacts between the pericapillary glial processes, and degenerative changes in the latter chiefly in the VC are, in the view of some authors, criteria of structural and functional damage to the BBB [6]. Ultrastructural disorders of the astrocyte and capillary complex are among the earliest to develop, and they increase during the first day after UHF irradiation. In view of the important role of the glial components of the BBB [2, 7], this can also affect its permeability.

At the same time, the above disorders of the BBB are repaired quite rapidly, by the first to the fifth days, and are regularly accompanied in the VC by a compensatory increase in the specific length of the fiunctioning capillary canal (see Table 1) having AP activity. Alkaline phosphatase is an enzyme used in histochemistry as one of the indexes of active transport in a capillary wall [5, 7]. During the period of the most intense repair on the fifth day, the activity of AP increased by 34.7±9.4% in comparison with the control ($p<0.05$) and remained stable during the remainder of the experiment. A second increase in the specific length of the capillaries distinguished by alkaline phosphatase activity in the visual cortex on the 60th day is evidently associated with the phase course and the incompleteness of the repair processes of the neuronal and glial complexes in the indicated part of the visual analyzer [4].

Consequently, the effect of microwaves of thermogenic intensity produce vascular changes in various parts of the visual analyzer that are not identical in nature. They point to focal damage to all the ultrastructural components of the BBB and less significant changes in the BRB with an adaptive direction that determine to a considerable extent the different degree of alteration and repair of the nervous tissue elements in the retina and visual centers.

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