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CONTENTS PAGE

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CERTAIN DATA ON CEREBRAL AND PERIPHERAL BLOOD CIRCULATION IN RADIOWAVE DISEASE ACCORDING TO RHEOGRAPHIC RESEARCH RESULTS

[Article by M. N. Sadchikov, V. G. Osipova, Z. N. Durneva, Institute for Industrial Hygiene and Vocational Illnesses, USSR Academy of Medical Sciences; Moscow, Gigiyena Truda i Professional'nyye Zabolevaniya, Russian, No 9, 1972, submitted to press 22 September 1971, pp 12-15]

In the clinical picture of radiowave illness caused by prolonged action by ultra-high frequency (UHF) electromagnetic fields, according to the opinion of native investigators (E. A. Drogichina and M. N. Sadchikova; N. V. Tyagin and N. V. Uspenskaya; N. V. Tyagin; P. P. Fofanov, and others), the leading disorders are asthenic and automatic-vascular.

Our previous observations (A. M. Monayenkova and M. N. Sadchikova; K. V. Glotova and M. N. Sadchikova) have shown that in patients with moderate and severe forms of the disease there are functional circulatory changes which are expressed in unstable arterial pressure with hypertensive and angiospastic reactions, elevated visco-elastic state of muscular vessels, rarely of the elastic type and an increase in peripheral resistance as well as changes in cardiac activity that are related to disturbances in extracardial regulation.

Inasmuch as the functional neurovascular disorders were concerned with the system of the internal carotid artery (changes in retinal vessels), we believed it would be useful in the future to investigate intra- and extra-cranial as well as peripheral circulation. In the literature we could not find publications on the intensity of pulse hyperemia of cerebral and peripheral vessels in stimulation by UHF electromagnetic fields.

The present work presents the results of examinations of 59 patients (58 men, 1 woman) with radiowave disease, who in the process of their work, particularly in the initial years, were exposed to a comparatively intense action of UHF electromagnetic fields (up to several milliwatts per 1 cm^2). These persons were controllers, carpenters and electrical repairmen who had 5-10 years of experience or more. The age of the patients was not greater than 45 years (62 percent were under 40 years).

In accordance with the clinical manifestations the patients were divided into two groups: 1st- 11 patients with an asthenic syndrome. 2nd- 43 patients with an astheno-autonomic and 5 patients with hypothalamic syndromes. A characteristic of the patients in the first group was the combination of asthenic reactions with autonomic-vascular shifts in the vagiotonic direction and vascular hypotension. Characteristic of the patients in the second group were autonomic-vascular disorders that were related to a predominance of excitability of the sympathetic segment of the autonomic nervous system, hypertensive and angiospastic reactions, and diencephalic type crises.

For an objective study of the functional condition of brain and peripheral circulation we utilized, along with the generally accepted method of clinical examination of patients, the rheographic method -- recording changes in resistance of tissues that take place in connection with changes in their hyperemia in each pulse wave.

The rheographic examination in the morning with the patient in a lying position. The rheogram was recorded on a 4-channel electrocariogram produced by the "Al'var" firm with the aid of a rheographic attachment RP-2 or a 4RG-1A on transistors. In investigating the pulse hyperemia of the cerebral hemispheres electrodes were placed on the fronto-mastoid and temporal positions (the electrodes size was 3 x 1.5 cm). In investigating the pulse hyperemia of the hands and feet, circular brass electrodes were utilized. The intensity of the pulse hyperemia was evaluated by the magnitude of the rheographic index (at a calibrated impulse of 0.1 cm) and by the angle of the inclination in the anacrotic segment of the curve (in degrees). The vascular tone was determined by a tonic tension index -- the ratio of basic wave amplitude of dicrotic elevation in millimeters (Yu. N. Fedorovskiy), as well as by the curved structure: the apex form, the position of the dicrotic wave and the character of the catacrot.

In the descriptive characteristic made by the majority of the investigators (V. N. Shtok; Kh. Kh. Yarullin and N. I. Levchenko; A. A. Burdov; V. L. Anzimirov and B. G. Spirin, and others) a well defined rounding of the apex, a high location, in the upper third of the dicrotic wave or the disappearance of catacrotic details was taken as an increase in vascular tone. Apical acuity, and a shift in the dicrotic wave to the base of the curve and a high definition of catacrotic detail was evaluated as a reduction in tone. Phenomenon in venous flow difficulties were expressed in the curve to a significant reduction of the systolic wave during a simultaneous abrupt increase in the diastolic wave with its increase over the first. In this case the anacrotia acquires the form of a multi-staged increase with the appearance of two and sometimes three postsystolic waves as well as presystolic waves (F. L. Dzhenkner; Kh. Kh. Yarullin and others).

An analysis and variational statistical processing of the research results on intra- and extra-cranial blood circulation has shown that the intensity of post hyperemia of intracranial vessels in patients of the first group did not differ from that in persons of the control group. However,

in four patients (out of 11) there was an insignificant reduction in the rheographic index and a decrease in the angle of the ascending segment of the curve. The tone of the intracranial vessels, according to the tonic tension index, was increased in only three patients (out of 11) which was confirmed by the change in the form of the rheoencephalogram.

A 48 percent reduction in the intensity of post hyperemia of intracranial vessels was noted in the patients of the second group (index 0.73±0.06 under normal conditions 0.97±0.05). The difference in the average values was statistically reliable ($P < 0.01$). The steepness of the slope in the ascending segment of the curve in those persons was also lower than in the persons of the control group.

Changes in vascular tone were particularly sharply defined. Thus, the index of tonic tension was significantly reduced in 70 percent of the patients which indicated a vascular tone increase. Whereas its value was equivalent to 2.0 for persons of middle age under normal conditions, it corresponded to 1.2 in patients of the given group. The difference in average values was statistically reliable ($P < 0.001$).

The quantitative characteristic of the increase in tone was confirmed by the change structure of the rheograms. The most frequent apex of the curve was "lemon-shaped" or "saddle shaped," the diastolic segment of the curve was elevated above the isoline, the dicrotic wave was shifted toward the apex of the curve, and was rarely smoothed out.

Disturbances in venous cerebral circulation, according to the rheoencephalogram data, were noted only in a few patients (6 percent).

A comparison of the rheoencephalogram with the clinical characteristics, particularly with the neurovascular disorders, indicated an increase in tone in patients with autonomic-vascular hyperactivity (acute dermographism, hyperhydrosis, pulse instability and arterial pressure instability with abrupt fluctuations tending toward increase, particularly during periodic crises, and angio- and coronary-spastic reactions).

Upon examination of the extra cranial vessels in patients of the second group (38) also demonstrated was a reduction in the intensity of pulse hyperemia by 48 percent (index 0.69±0.04 under normal conditions 1.0±0.06) and an increase of 57 percent in vascular tone (index of tonic tension 1.3±0.04 under normal conditions 2.0±0.13). The difference in the average value was statistically reliable ($P < 0.001$).

Hemispheric rheograms were recorded during a nitroglycerin test for the purpose of differential diagnosis in a number of patients (22).

It is known that the effect of vascular dilation after taking nitroglycerin is conditioned by its direct action on the smooth muscles of the vascular wall and suppression of the vasomotor centers (N. V. Kaverina).

Upon taking a half tablet of nitroglycerin sublingually there was observed in 20 patients (out of 22) an increase in the intensity of pulse hyperemia and primarily a normalization in the curve's form. The amplitude of the rheogram markedly increased, the apex became acute and the diocritic wave was positioned in the middle third of the descending segment of the wave and the convexity of the catacrotia disappeared.

The functional character of the intracranial vascular changes to a certain degree was confirmed by the absence of organic deviations in the neurological state of the patient.

Only in two patients with hypothalamic syndromes in whom frequently repeating crises were observed did nitroglycerin not fully restore the intensity of blood filling and vascular tone.

Upon examination of the peripheral critical circulation of the second group (29) there was demonstrated an intensity of pulse hyperemia and vascular tone of the hands and feet that was within the limits of normal physiological ranges. The index of hand hyperemia was 1.4 ± 1.1 under normal conditions 1.4 ± 0.08, the index of foot hyperemia -- 1.3 ± 0.08 under normal conditions 1.3 ± 0.06. The index of tonic tensions of hand vessels corresponded to 1.9 ± 0.06 under normal conditions 2.1 ± 0.05 and that of the foot vessels -- 2.0 ± 0.1 under normal conditions 2.1 ± 0.06.

In this way, the rheographic examination of radiowave disease patients indicates cerebral hemodynamic changes which are manifested in a reduction of pulse blood filling intensity, and primarily in an increase of tone in the intra- and extra-cranial vessels.

The described changes bear a functional character and are easily restored upon nitroglycerin administration.

They primarily relate to patients in whom the clinical picture is predominated by neurovascular disorders of a sympathotonic tendency.

The peripheral hemodynamics in radiowave disease patients is retained in functional changes in cerebral circulation.

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IMMUNOLOGICAL REACTIVITY OF ANIMALS IN PROLONGED IRRADIATION BY ULTRA HIGH FREQUENCY RADIOWAVES

[Article by I. S. Dronov, A. D. Kiritseva, Central Scientific-Research Laboratory, Medical Institute; Moscow, Gigiyena Truda i Professional'nyye Zabolevaniya, Russian, No 9, 1972, submitted to press 24 March 1971, pp 15-18]

At the present time it has been proven that electromagnetic oscillations of radio frequencies at comparatively large intensities influence immunological reactivity (A. V. Ponomarev and O. I. Kombarova; B. A. Chukhlovin; Ye. I. Smurova; S. A. Vartanov; Nicolau and co-authors Sacchitelli and Lerza). The influence of ultra-high frequency (UHF) low intensity radiowaves on the immunological reactivity has been very little studied up to the present time.

The task of the present work was to investigate the injurious action of chronic irradiation on immunological reactivity by low intensity microwaves whose action takes place under industrial conditions.

The experiments were conducted on rabbits which were irradiated with UHF radiowaves at a current strength density of 50 microvolts/cm^2 and 10 microvolts/cm^2. The irradiation was carried out in special cages with the aid of a horn type antenna. The intensity of the irradiation was measured by a "medik" instrument (PO-1). The animals were irradiated four hours daily for a period of four months. The investigation was conducted on 40 rabbits of which twenty were control animals and 5 were irradiated with waves of 10 microvolts/cm^2, and the remaining 15 by 50 microvolts/cm^2. The latter were divided into three groups of 5 animals each. In the first group the animals were irradiated in the process of immunization, and in the second group of rabbits the animals were immunized before irradiation, and in the third group immunization was done after three months of irradiation. The animals which were exposed to irradiation by 10 microvolts/cm^2 waves were immunized in the process of irradiation.

For evaluating the immunobiological changes, examinations were made of the phagocytic activity of the neutrophil leucocytes of the blood, the specific antibody complement and titer in blood serum. The complement in

the blood serum was evaluated colorimetrically in the modification by A. B. Gabrilovich and S. V. Soboleva. The phagocytic activity of the neutrophil leucocytes was determined by the generally accepted method. The phagocytosis object was a heat-killed typhoid culture in physiological solution. The percent of phagocytosis was computed, i.e. the amount of active neutrafils per 100 counted leucocytes.

The antibody titers were found with the aid of the Vidal agglutination reaction, the indirect hemagglutination reaction, and the separation of macroglobulin antibodies with a constant sedimentation of 19 S from the microglobulin antibodies with a sedimentation constant 7 S was done with the aid of cysteine (Ye. V. Chernokhvostov).

The phagocytic activity of neutrophils in the animals of the first group bore a phasic character. In the third week of irradiation the phagocytic activity of the leucocytes decreased to 29±1.96 percent, and in the control group -- to 38.2±1.5 percent ($P < 0.01$). An analogous reduction in phagocytosis was observed in the 7th week of irradiation. It remained reduced until the end of the experiment and ranged from 21±2.2 to 12±1.68 percent; in the control group its level fluctuated from 32.6±1.07 to 22.2±1.07 ($P < 0.01$). In the 5th week of irradiation the phagocytic activity in the animals of the 1st group did not differ from that of the control group ($P > 0.05$).

The phagocytic activity in rabbits immunized before UHF wave irradiation of the same intensity as the animals of the 1st group, was significantly lower than in the control. Beginning with the 3rd week of irradiation it was 15±0.42 -- 10.6±1.07 percent ($P < 0.05$), and in the control group of animals -- 25.6±1.5-16.6±1.07 percent.

Irradiation of animals at an intensity of 10 microvolts/cm^2 for 4 months did not have any effect on the condition of neutrophilic phagocytic activity. The indices of the latter in no way differed from those of the rabbits in the control group.

Examination of the complement content in the rabbit's blood serum made it possible to discover its change in relation to the intensity of ultrahigh frequency radiowave irradiation and the term of animal immunization. When immunization was effected prior to irradiation, the complement content in the serum in the 1st, 3rd and 5th weeks of observation was reduced. The initial complement content in serum of this animal group was 13.02±0.90 $C^1 H_{50}$ (ml), after a week of irradiation the complement content was reduced on the average up to 6.6±0.50 C^1H_{50} (ml), ($P < 0.001$), and in the 3rd and 5th weeks of irradiation -- up to 5.2±0.75 C^1H_{50} (ml) ($P < 0.05$) and up to 6.3±0.55 C^1H_{50} (ml) ($P < 0.001$) respectively. In the 6th week of irradiation the complement content was restored to the original values and equaled 12.7±2.18 C^1H_{50} (ml).

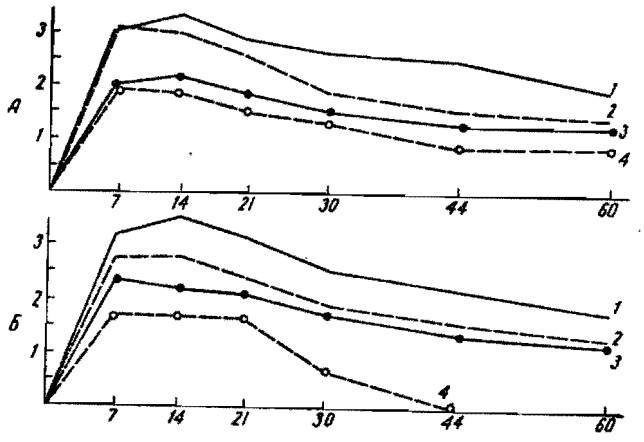
Subsequent investigations indicated that the complement's content did not change before the end of the irradiation period and ranged on the

average from 12.7±2.18 to 14.4±1.41 C^1H_{50} (ml), whereas in the control group it was from 13.7±1.38 to 16.4±2.3 and C^1H_{50} (ml).

The determination of the complement level in rabbits exposed to immunization after 3 months of irradiation, made it possible to establish a reduction in its content only after 8 weeks of irradiation. The initial complement content in the rabbit serum was 14.2±1.4 C^1H_{50} (ml), and after 8 weeks of irradiation -- 9.2±1.63 C^1H_{50} (ml) ($P < 0.05$). With all other conditions equal the amount of complement in the rabbit control group fluctuation from 13.4±1.18 to 13.9±0.66 C^1H_{50} (ml). Subsequent investigations indicated that the complement content in comparison to its content in the control group was reduced. Thus, on the 14th day after immunization it decreased to 8.9±1.9 C^1H_{50} (ml) ($P < 0.05$).

The complement content remained reduced up to the 44th day after immunization. Its amount was restored to the original level by the 60th day. An examination of the complement level in animals subjected to immunization with a simultaneous irradiation at an intensity of 10 microvolts/cm^2 for a period of four months, did not disclose any differences from the control group.

At the present time a total determination of antibody titer is insufficient to characterize an organism's immunological reactivity during the action of environmental factors. This problem has not yet found elucidation in the literature. We therefore studied the separate synthesis of macro and microglobulins of blood serum in order to analyze in greater detail the action of UHF radiowaves on antibody formation.



Change in Macro and Microgoobulin Antibodies in Rabbits During Irradiation by UHF Radiowaves (Current Power Intensity 50 Microvolts/cm^2).

Ordinate Axis -- Log of Titers; Abcissa Axis -- Time After Immunization (In Days); A - Second Group of Animals; B - Third Group of Animals 1 - 19 S Antibody of the Control Group; 2 - Experimental; 3 - 7 S Antibody of the Control Group; 4 - Experimental

The obtained data indicate that prolonged irradiation by low-intensity UHF radiowaves have an effect on the total antibody formation as well as on the synthesis of 19 S macroglobulin Antibodies and 7 S microglobulin Antibodies.

In determining the antibody titers in animals immunized simultaneously with an initial chronic irradiation, a reduction was observed in the antibody titer in both the hemagglutination reaction and the agglutination reaction -- in comparison to the control group (I. S. Dronov and co-authors). Low antibody titers in the experimental group were noted before the 35th day after immunization in the hemagglutination reaction and before the 49th day in the agglutination reaction. An increase in the antibodies number was observed in the subsequent period in comparison to the given index in the control group.

A reliable reduction in antibody titer was established in the 2nd group of animals subjected to immunization followed by irradiation beginning with the 3rd week after immunization and up to the end of the observation period. A separate determination of 19 S and 7 S antibodies indicates their reduction in animals of the 2nd group in comparison with the indices of the control group. From the diagram (A) it is apparent that the synthesis of macro and microglobulin antibodies is reduced during the action of all UHF waves. A more acute supression of antibody formation in comparison to that of the control group animals was observed in the 3rd group of animals which initially were irradiated for 3 months and then immunized and irradiated again. A reliable reduction in the total antibody formation in the experimental animals was already noted on the 7th day of immunization. An even greater supression of antibody formation was exhibited during the determination of 7 S antibodies which completely disappeared on the 44th day after immunization (see diagram B).

An examination of the immunological reactivity in animals subjected to irradiation by 10 microvolts/cm^2 intensity which was equal to the maximum permissible level, indicated that this intensity of microwave irradiation does not cause disturbances in the synthesis of macro and microglobulin antibodies. In this way, chronic irradiation by low-intensity UHF radiowaves plays a specific role in the immunoreaction condition of an organism. It is essential to note that preliminary irradiation of animals followed by immunization causes the greatest reduction in antibody synthesis.

The synthesis of microglobulin antibodies turned out to be more sensitive to chronic irradiation. Chronic irradiation of rabbits by UHF radiowaves of 10 microvolts/cm^2 intensity (the maximal permissible level) for a period of 4 months did not cause changes in the immunoreaction condition of the organism. This was convincingly demonstrated by a study of the phagocytic activity of neutrophilic complement content in blood serum, and the synthesis of macro and microglobulin antibodies in immunized animals.

Conclusion

1. A supression of antibody formation and a reduction in the phagocytic activity of neutrophilic are observed during chronic irradiation of animals by UHF radiowaves (50 microvolts/cm^2). An insignificant reduction in the synthesis of antibodies, of phagocytic activity of neutrophils, and complement content is observed in animals subjected to immunization followed by irradiation. Antibody formation and complement content in the blood serum is sharply suppressed during immunizations of previously irradiated animals.

2. Chronic irradiation by UHF radiowaves (50 microvolts/cm^2) of immunized animals causes a suppression of micro and macroglobulin synthesis predominated by a supression of microglobulin fraction synthesis.

3. Irradiation of animals by microwaves of 10 microvolts/cm^2 intensity does not effect antibody formation, phagocytic activity of neutrophilic and complement content in rabbit blood serum.

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