

COMBINED EFFECT OF IONIZING RADIATION AND A SUPERHIGH-FREQUENCY FIELD ON THE BODY

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Abstract

Prolonged investigations of white mice and white rats showed fractional combined X-ray longwave (30 r of single exposure) and SHF (5 mw/cm², 20 min) irradiation to be responsible for more pronounced effects, than those caused by these factors, acting independently. The differences detected were in body and some other organs weight, in lisozimes liters of serum, in productibility of animals and in chromosomal aberrations number in bone marrow.

At combined X-ray, short-wave and SHF-irradiation the intensification of effect was not found.

Observations showed that combined occupational effect of X-rays of different energy and SHF irradiations caused more frequency deviations of organism functional state than SHF field irradiation only.

Introduction

Under conditions of occupation a man is subjected not to single but to several environment factors. Adequate estimation of the possible consequences would account for every factor under consideration. The peculiarities of the combined effect have to be considered also.

The necessity of expansion of investigations in the field of radiation protection, in direction of combined effects study, was pointed out in the I European Congress of Radiation Protection (Menton, 1969) and in the II International Congress of Radiation Protection (Brighton, 1970).

One of the most widespread variants of combined professional effects is combination of roentgen and high frequency (SHF) electromagnetic irradiations^{1,2,3}.

However, till recently the investigations of combined action of X-ray and SHF radiations were represented in a few papers^{4,5,6}. In these papers the effects of strike momentary combined action were mainly considered.

The results of experiments with the laboratory animals which have been performed during 1967-72 years and the results of clinical-physiology observations of persons during 1962-72 are presented in this paper. The purpose of this work was to study the effects of prolonged combined and isolated X-ray and SHF irradiations.

I. The Experiments with Animals

Materials and Methods

The experiments have been carried out with white female mice and white female rats. Mice and rats weighed 13-20 g and 180 - 200 g respectively at the beginning of experiments.

The longwave X-radiation was provided by 60 kV X-ray generator operated at 15.5 kV with 0.17 mm Al and 1.2 mm perspex filters, HVL 0.1 mm Al. The exposure rate was 10.5 r/min. The animals were irradiated from the ventral side of body.

The shortwave X-radiation was provided by 200 kV X-ray generator operating at 187 kV with 0.5 mm Cu and 1.0 mm Al filters, HVL 0.83 mm Cu. The exposure rate was 24.5 r/min.

Nonscattering chamber with SHF radiation generator "Looch-58" (wave length 12.6 cm) was used for continued exposure of animals body ventral side.

The investigations with animals in all series of experiments were performed simultaneously in control groups (unaffected) and in these subjected to X-rays, SHF and combined irradiations. The interval between two consequent exposures was equal to 48 hours. The intervals between X-ray and SHF irradiations were equal 5 - 15 min.

The following tests were used for estimation of the biological action of radiations: survival and average longevity, weight of body and of some organs, stability to the physical loading, productivity and reproduction factors, weight of the month age posterity, the counts of chromosome aberrations in cells of bone marrow the counts of blood cells. Stability of animals to physical loading was determined with our early elaborated method⁷

The complex of immunologic reactions describing a state of nonspecific, specific immunity, allergic and autoallergic reactivity was studied. The factors of nonspecific immunity were bactericidity, titers of lisozyme and complement of serum. Specific immunity was studied after immunization of animals with sheep's eritrocytes. Production of gemagglutinins and of hemolysine were studied. In animals inverse anaphylexic reaction (by Joffe) and complement-fixing autoantibody formation were studied too.

Results of Experiments

Influence upon the fractional shortwave X-rays at 60 r for a single exposure combined with fractional SHF-radiation at 40 mw/cm² delivered during 15 and 18 minutes led to death of half quantity of the animals in more early stages than it occurred from X-ray irradiation only. X-irradiation became a main factor with SHF exposure being reduced up to 11 minutes. In this case the decrease of body weight of mouse was 2.4-2.8 g, intermediate between that of mouse, subjected to each factors taken separately.

In the following series of experiments X-ray single exposure have been reduced up to 30 r and SHF-radiation power density to 6 mw/cm² for 30 minutes. Under these conditions decreasing longevity and body-weight of the animals had few differences in groups of X-ray and combined exposure. Most of animals died after 3 months from experiments beginning. SHF irradiation alone caused death of animals not exceeding 15 per cent. After 100 days observation the body weight of the animals was found rather sharply and statistically reliably decreased for the animals exposed to X-rays and in particular to combined radiation. The body weight

of mice exposed to SHF radiation later was close to control level.

Study of the peripheral blood cells composition of rats subjected to SHF irradiation was performed at 50 mw/cm² and 10 mw/cm² for 20 min and shortwave X-ray irradiation with single exposure 60 r. Whole exposure duration was 45 days. Statistically reliable leucopenia was registered in animals subjected X-ray and comine radiation. Of great interest is great dispersion of leucocytes number of animals exposed to SHF only and combined radiation. However, in the latter case this dispersion was notably decreased with X-ray dose accumulation.

Significant changes of immunologic reactivity of rats exposed to fractionated SHF radiation at 50 mw/cm² for 20 min of single exposure have not been resistered. But short-time decrease of lisozyme titer, some intensification of complemental activity of serum, phase variations of antibody formation and excessive creation of complement-fixing autoantibody were found to occur. At the same time shortwave X-ray exposure at 60 r led to conspicuous suppression of all factors studied of nonspecific and specific immunity, decrease of total immunological reactivity and rise of antibody formation. Combined influence was responsible for some decrease of radiation breaking of nonspecific immunity as well as for oppression of serum bacterioidity. Decrease of serum lisozyme titer was less conspicuous than at X-ray irradiation only.

Shortwave X-ray radiation was established to influence mainly upon mice stability to physical loading at the levels of combined short X-ray and SHF irradiation chosen by us. However, decrease of animal stability to the physical loading occurred earlier (on the 41-st day) at combined radiation than at X-ray irradiation only.

Under fractionated irradiation conditions the experimental animals revealed the considerable alterations of spermatogenesis in all stages, in particular, at shortwave X-ray and at combined irradiation. The earliest alterations were noticed in the initial stages of spermatogenesis. So, at some stages of investigations spermatogonia, spermatocytes, spermatids and spermatozoa were absent completely or almost completely and testis bubules were devastated.

Thus, the investigations of the animals reactions to influence of fractionated shortwave X-ray and SHF irradiations did not allow to find clear intensification of effects at combined irradiation. Predominant affect of one of those factors was noted depending on their levels.

When studying the longwave X-ray (30 r dose of single exposure) and SHF (5 mw/cm², 20 min for single exposure) radiation influence, fractional irradiation of mice in different series of tests lasted from 2.5 to 6 months.

The X-ray longwave irradiation (by the dose mentioned) have never resulted in animals' weight decrease during the investigations. As a result of SHF irradiation animals' weight had reliable decrease only on the 110-th day from the beginning of irradiation. Combined irradiation being used, beginning from the 15-th day of irradiation the mice weight have been decreased in comparison with that of unaffected (control) group.

The obtained data of one-factor disperse analysis showed that in spite of negligible influence of isolated X-ray irradiation on the body weight, with combined irradiation it becomes essential.

A tendency have been observed for weight increase of mouse's liver and spleen, when subjected to combined irradiation, pro-

bably because of intense blood filling.

As a result of combination of mentioned irradiation of two kinds decrease of serum lizozime titers in comparison with unaffected group of animals and those under separate irradiation was detected.

In three series of experiments the factors of productivity of mice were studied. In the first two series mice (both males and females) received 31 exposures. In the third series they received 82 seances of exposure. For the last 15 days before the end of irradiation male and female mice were in the same cages (15 female and 5 male mice in each cage). After this male mice were separated from female ones.

The following parameters were determined as the factors of productivity : per cent of delivering females reproducibility factors (per one female under investigation) k_1 - according to the number of mice born, k_2 - according to the number of mice born, which lived up to 30² days age.

The series of tests showed some increase in the number of delivering female mice and in the reproduction coefficients in groups of animals exposed to separate irradiation. There were no pronounced differences between these and control groups in the second series of tests (Table 1). On the contrary, the combined irradiation showed the statistically reliable (in comparison with control) decrease of delivering female per cent and marked (30-40 per cent) decrease of reproducibility factors.

Statistical processing using criteria of Wilcoxon showed reliable difference in the values of reproducibility factors for the groups exposed to combined irradiation in comparison with those unirradiated and mostly with the groups exposed to isolated X-ray or SHF irradiation. The chromosome aberration frequency for all groups of animals under investigation exposed for 2-5 months had notable increase in comparison with control. The maximum value of this factor exceeding 2.4 and 10 times the number of spontaneous aberration was obtained for the groups exposed to combined irradiation.

Thus, experimental study made it possible to derive pronounced effect of combined fractional X-ray longwave and SHF irradiations in comparison with isolated irradiation by a number of essential parameters.

II. Person Observations

Organization and Method

For examination and observation of the workers the latter were chosen engaged in the field of adjustment and testing of the electronic devices. These people were divided into the following 3 main groups according to forms of occupational factors:

I group - 50 persons working under conditions of combined X-ray longwave and SHF irradiation;

II group - 47 person working under conditions of combined X-ray shortwave and SHF irradiation;

III group - 50 persons working under conditions of SHF irradiation.

The central group (55 persons) included those who work under conditions with no professional irradiation.

The average age of every groupe person examined was 38-39 years for men and 35-38 years for women. Industrial record was

13-18 and 12-15 years respectively. The average age and average term of work of persons dealing with X-ray and SHF sources as well as persons in the control groups were similar.

The program of medical observations and clinical physiological examinations of the workers' groups consisted of investigations: functional conditions of neural and cardiovascular systems; state of blood, state of organs of vision and analysis of illness and complaints.

Observation Results

Among workers of the first 3 groups complaints of asthenic-vegetative type prevailed, namely: abnormal high tiredness, sleep disturbances, head ache. The number of those complaints in the I and II groups (combined irradiation) reliably exceeded that in the III group (1.16-1.5 times). In the first two groups the number of second medical admices exceeded 2-4 times the same factor for other groups. It was established by means of objective investigation of persons who worked under combined irradiation conditions that deviations in neural system functional state were observed more often than for those who was exposed to SHF irradiation only, and to control group. For example the number of cases of hands fingers and lashes termor in the first two groups notably exceeded the same factor in the 3-rd and control groups.

E.E.G. examination showed that the frequency of deviations in these curves in the I and the II groups exceeded ones in the III-rd and control groups.

Arterial blood pressure levels in all groups under investigation were within the limits of normal values. Only light decrease of maximal arterial pressure was noticed for the I group persons examined in the first stage of observations.

E.C.G. - examinations made it possible to find notable increase of the number of cases with sinus arrhythmia and conduction disturbances for those who worked under combined irradiation.

As a result of capillaroscopy it was found that the frequency of spastic-atonical capillar state detections in the I, II, III and IV groups in equal to 62, 53, 47 and 25 per cent respectively, having statistically reliable differences between the first two groups and the III one as well as unaffected group.

While studying the capillar resistance using Nesterov method, the second (higher) reaction degree appeared reliable more often for persons worked in the conditions of combined irradiation than for ones of the III-rd and control groups.

Those who were exposed to combined irradiation had more frequent occasions of decrease of leucocytes number (less than 4200 in 1 mm³ of blood) and of trombocytes number (less than 200 thousand in 1 mm³ of blood) comparing with unirradiated groups; the average is not different from normal.

As a result of investigations of the vision organ state it was found that the frequency of cases of vascular dystonia of eye's bottom in the main groups of persons was not large (of 10-18%) still it had some deviations from the control group (6-10%).

While biomicroscopical studying the transparent eye's medium the lenticular opacity was observed more often in the I and II groups than in the control one. This opacity didn't affect the sharpness of sight in general.

Some immunological deviations were observed in the I group

of persons in comparison with those of the control group, namely, pronounced variation of skin microbes, increasing of C-reactive protein and serum autoantibody formation.

Comparing the disease incidents in the irradiated and in the control groups no essential differences between them were found.

No cases of occupational pathology caused by X-ray or SHF irradiation were observed for all period of investigations.

Thus, according to the most indices of functional state of neural and cardiovascular systems as well as to indices of humoral nonspecific immunity notable effects of X-ray longwave or shortwave irradiation combined with that of SHF were found for workers.

These differences are revealed in the increase of deviation frequency in comparison with the control group as well as with group of workers who were irradiated by SHF only.

Numerous medical observation data showed that the main contribution to functional variations occurrence is the result of occupational factors affects, which took place in the first period of work (before 1960-1961).

In the main groups in 1970 it was found that the degree of the same earlier observed deviations had notably decreased and in general the factors of functional body state did not lie beyond the limits of physiological variations.

Conclusion

The following effects for animals were found as a result of experiments performed. Pronounced intensification of biological effects were observed for the case of combined SHF and X-ray longwave irradiations. Combined SHF and X-ray shortwave irradiations didn't result in any effects intensification for most of the factors under control.

X-ray irradiation was found to be dominant for changes observed during combined irradiations.

Clinic-physiological observations of the persons occupied in the conditions of combined X-ray and SHF irradiations showed higher frequency of investigated factors deviations than that of those occupied in conditions of SHF irradiation only and for the control (unaffected) group.

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