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ATD Report 66-123 scg 5 October 1966

Surveys of Foreign Scientific and Technical Literature

HEMODYNAMIC INDICES DURING THE ACTION OF SUPER-HIGH FREQUENCY ELECTROMAGNETIC FIELDS

Monayenkova

(*Translation*

by

Sheila Penners)

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FOREWORD

This translation has been prepared in response to an ARPA request. The article was originally published as follows:

Monayenkova, A. M., and M. N. Sadchikova. Gemodinamicheskiye pokazateli pri vozdeystvii elektromagnitnykh poley sverkhvysokikh chastot (Hemodynamic indices during the action of super-high frequency electromagnetic fields). Gigiyena truda i professional'nyye zabolevaniya, no. 7, 1966, 18-21.

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Association: Institute of Industrial Hygiene and Occupational Diseases, Academy of Medical Sciences, Moscow

Currently available experimental and clinical data indicate that chronic exposure to radio frequencies principally affects the functional state of the nervous and cardiovascular systems. The study of the effect of radio frequencies on the cardiovascular system was based on one or two hemodynamic indices, mainly on EKG data and arterial pressure measurements.

The purpose of the present study was to conduct a more thorough investigation of the functional state of the circulatory system. For this reason general clinical examinations were supplemented by the use of the mechanocardiograph developed by N. N. Savitskiy which provides accurate recordings of some of the more important hemodynamic indices, i.e., minute blood volume, peripheral resistance, average and actual arterial pressure, and especially the degree of tonic strain in the smooth muscle of various vessels.

Thirty-four persons (30 men and 4 women) periodically exposed to intense SHF radiation (up to several mw/cm^2) during their working hours were studied. Their ages ranged from 30 to 49, and the length of their occupationsl exposure to SHF from 5 to 15 years or more. All those examined exhibited symptoms of chronic exposure to SHF electromagnetic fields. Eight persons exhibited initial radiation effects in the form of mild asthenic symptoms and autonomic shifts, 17 had moderately severe symptoms, and 9 suffered from pronounced autonomic-vascular disruptions accompanied by occasional diencephalic disorders.

The clinical evaluation took into account the subject's medical history and any other factor which might affect the functional state of the circulatory system. A considerable number of subjects, principally those with moderately severe and severe symptoms of SHF effect (25 persons), conplained of unpleasant pricking sensations in the cardiac region, stabbing and constriction pains, and tachycardia. Physical and x-ray examinations showed no pathological deviations.

Tacho-oscillographic measurements of arterial pressure showed the maximum (Mx), true lateral (Mw), mean dynamic (My), and minimum (Mn) pressures of most subjects to be within the normal range (in the control group Mx was 105—130 mm, N was 96—115 mm, My was 80—100 mm, and Mn was 60—90 mm). Only 5 subjects showed pressures above normal (Mx up to 156 mm, Mw up to 140 mm, My up to 112 mm, Mn up to 100 mm). Repeated multiple measurements of arterial pressure using the Riva-Rocci method revealed lability of maximum and minimum pressures with a tendency either to decrease (in 5 subjects) or increase (in 17 subjects), indicating an increase in vascular tonus. Examination of the fundus oculi showed constriction of the retinal arteries (in 22 subjects), which to some extent indicates an increase in tonus in the internal carotid artery system.

The elastoplastic properties of the walls of the large arteries may most accurately be determined by the rate of pulse-wave propagation in elastic and myogenic type vessels (Ye. A. Moshkin; V. P. Nikitin; N. N. Savitskiy, and others). In the group studied, pulse-wave velocity in vessels of the elastic type (V_e) in the segment from the carotid to the femoral artery fluctuated between 550—850 cm/sec (against 500—800 cm/sec in the control group); in myogenic type vessels (Vm) in the segment from the brachial to the radial artery and in the segment from the femoral to the posterior tibial artery, pulse-wave velocity averaged between 1090—1050 cm/sec, fluctuating between 850—1520 cm/sec and 830—1250 cm/sec respectively (compated to a range of 600—1000 cm/sec in the control group). More than half of the persons studied (19 subjects) had accelerated pulse-wave velocities in myogenic-type vessels, and a few individuals showed slight pulse-wave acceleration in elastic-type vessels.

Pulse-wave propagation values provide a means for determining the elastic modulus of vessel walls, this being a more accurate index of vessel elasticity.[1] It was found that though in a considerable number (21) of the subjects studied the elastic modulus of myogenic-type artery walls (E_m) was higher than normal, i.e., an average of 9950 dyne/cm^2 (against a normal value of 4300—9000 dyne/cm^2), the elastic modulus of the walls of elastic-type vessels (E_e) was within the normal range (3700—8600 dyne/cm^2) in all but 2 subjects, in whom it was slightly higher (up to 9700 dyne/cm^2). Twenty-two persons showed an increase (above 1.30) in the elastic modulus ratio E_m/E_e — the ratio between the elastic moduli of the walls of myogenic and elastic type vessels — indicating an increase in the elastic properties of the walls of myogenic type vessels.

[1] the elasticity modulus is understood to express that effort which must be applied to reach the elastic limit of deformation of a body.

Minute blood volume values were of particular interest, since according to G. F. Lange they more fully reflect the intensity of operation of the entire circulatory system. These values were obtained with the Broemser-Ranke formula:

$$V = \frac{0.6 \times Q \times T \times A \times \Delta P \times 1333}{C(T - A)},$$

where V is the systolic cardiac volume, Q is the cross-section area of the aorta, T is the time of complete cardiac involution, A is the length of the systolic expulsion phase, P is the pulse pressure, 1333 is the conversion factor for pressure in mm Hg, and C is the pulse-wave velocity along the aorta. In healthy persons, the range of variations in minute blood volume under conditions of basal metabolism is rather wide: from 2.6 to 4.5 l/min.

N. N. Savitskiy proposed that the baseline minute cardiac volume value used in estimating the circulatory volume of an individual be computed from values obtained from basal metabolism tables which account for age and sex related variations in the intensity of metabolic processes. Circulatory minute volume agreed with the computed volume in only 3 subjects; in the remainder it was either greater (in 10 subjects) or less (in 13 subjects). The degree of deviation of actual minute volume from the computed value was from 12 to 40%.

In connection with the above, it was of interest to determine the relationship between changes in the elastoplastic properties of the arteries and peripheral resistance, i.e., the resistance which the blood encounters in its passage through peripheral vessels, especially the precapillaries.

Ease of passage through precapillaries was determined from N. N. Savitskiy's formula for specific peripheral resistance, i.e., total resistance within the system of peripheral vessels leading to the surface of the body. According to this formula, specific peripheral resistance in arbitrary units is equal to:

$$\frac{\text{mean pressure} \times \text{body surface}}{\text{minute cardiac volume}}.$$

Both actual resistance and normal standard specific peripheral resistance (peripheral resistance for a healthy organism under basal metabolism conditions) were determined.

The results showed that in a large number (19) of the subjects studied, the actual specific peripheral resistance exceeded the computed normal specific peripheral resistance by 11—60%, indicating increased resistance in the precapillary system.

To determine how the circulatory system carries out its main function, i.e., the transportation of blood to the tissues, requires the simultaneous examination of two main hymodynamic indices: minute circulatory volume and specific peripheral resistance. A strict physiological relationship exists between minute cardiac volume and resistance to flow in the precapillatires: the magnitude of peripheral resistance depends on the magnitude of the minute cardiac volume. With mean pressure constant, peripheral resistance decreases as minute volume increases. If the operation of the various circulatory systems is properly coordinated, changes in precapillary flow will correspond strictly to changes in minute volume. In pathological cases, this regulatory balance is disturbed, with the result that new ratios between these hemodynamic indices are established. A comparison of actual minute volume values with actual peripheral resistance showed a correlation between these indices in 26 subjects; only 8 subjects showed a lack of such correlation.

An EKG analysis showed sinus bradycardia to be particularly prominent. More than a third (13) of the subjects showed 60 or more systoles per minute. Delayed intraventrical conductivity in 7, and delayed intra-aurical conductivity in 3, combined with sinus bradycardia were noted. Four subjects had changes in the T wave. Lowered T waves recorded in 2 or more chest leads, combined with clinical data, indicate changes in the myocardium. The latter occurred in combination with other symptoms of hemodynamic imbalance (changes in minute volume, peripheral resistance, and pulse-wave velocity) and were observed in persons with moderate and severe symptoms of chronic SHF exposure.

The data obtained showed that exposure to SHF of considerable intensity not only causes pathological changes in the nervous system, but brings about deviations in the functional state of the circulatory system as well. In the clinical picture of patients with moderate and pronounced symptoms of SHF exposure, neuro-circulatory disorders with a tendency to hypertension are dominant. Analysis of pulse-wave velocity in myogenic and elastic type vessels, of the elasticity modulus, and of the ratio between the elastic moduli of the two types of vessels, indicates that the elasticity of the walls of myogenic type vessels increases during all stages of chronic exposure to SHF electromagnetic fields. Data on peripheral resistance showed increased resistance in the precapillary system, and EKG analysis revealed changes in intra-cardiac conductivity and sinus bradycardia, due apparently to disturbances in the extracardiac regulation of cardiac activity.

Analysis of the data yielded by clinical and physiological studies of the cardiovascular system did not permit establishment of a firm correlation between hemodynamic disorders and pathological deviations due to SHF exposure. However, in subjects with moderate and pronounced symptoms of exposure, changes in hemodynamic indices were found to occur much more frequently.

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