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HUMAN RESPONSES TO MICROWAVE IRRADIATION - A REVIEW OF AND EVALUATION OF PUBLISHED REPORTS*

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INTRODUCTION

There has been a plethora of world literature on the biological effects of electromagnetic radiations in the 100 MHz to 300,000 MHz region since 1937. Considering the import and ever-increasing uses of microwave energies in the military, commercial enterprises, industry, medicine, and the general population, reliable reports on human effects, especially in an occupational setting, are comparatively few. The data reported are inadequate for drawing meaningful conclusions regarding what biological effects constitute reversible or irreversible damage to the human organism. Though it is well recognized that the production of heat on a macroscopic, microscopic, or molecular level is one way, if not the only way microwave energies affect biological materials, the possibility of more subtle interactions of this energy with biological matter, commonly designated as "non thermal," has been reported. Though unproven, if these "non-thermal" mechanisms exist, their effects must be described and hazard potential investigated. We must learn if these effects, if present, have hazard potential for the general and working populations exposed to microwave energies.

Normally, there is a natural background of electromagnetic energies in our environment to which all living things "learn" to adapt in order to survive, and to which there are many normal imperceptible physiological adjustments. To this normal state man has added additional energies of his own manufacture. All organisms respond to this additional energy exposure within their own functional and latent reserve capabilities when required. There is a point, however, where the reserves for response can be exceeded, and at this point what is normally a biological effect is now expressed as damage to the organism, and the causal agent becomes a hazard. When a hazard potential exists, risks and potentials for risk are minimized or prevented by staying within certain standards for exposure to the causal agent. These standards are based on known effects, and the extent to which the effects are damaging to the organism.

In the case of microwave radiations, most of the reporting of occupational health hazards has been in Soviet and Eastern European literature, with an increasing quantity appearing in Western literature. From the outset, one is struck by the great philosophical differences and variances in approach. Almost all points made are controversial, though some authors have suggested that when viewed in perspective, these disparities may be more apparent than real (1).

Since this is in the realm of occupational medicine, some of the problem of what not to believe and accept can be resolved by subjecting all reports of human effects to epidemiological, statistical, and medical criteria for reporting such data. If these criteria are not met, then the conclusions drawn are not to be accepted. This does not mean that the effects reported do not occur; they may, indeed, and every attempt must be made, thoroughly and objectively, to determine if they do occur.

The effects reported in Soviet literature are primarily central nervous system responses to microwave emanations. Though, superficially, this seems to be a simple statement, in reality, it is extremely complex, and lies at the root of many discrepancies in Western and Soviet literature. To even understand Soviet literature, one must be aware of the concepts of Pavlovian conditional responses, "Nervism," and the fact that their frame of reference concerns the central nervous system as the functionary, the integrator, and the initiator of all bodily functions. This includes such seemingly remote physiological activities as cellular response to injury, hematopoiesis, and specific organ responses to local metabolic changes. In a context of illness or injury, this contrasts with a Western-trained biologist's or physician's orientation toward pathophysiology, and organic etiologic approaches toward disease.

HUMAN EFFECTS

To list every reported effect, much less discuss the respective hazard potentials, is an impossibility. To serve as examples, the general categories of each are enumerated.

The Soviets report descriptive syndromes in microwave workers consisting of direct central nervous system reaction, manifested by neurohumoral responses, and indirect neuro-circulatory reflex arcs. The syndromes are, in order of

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increasing severity; neurasthenia syndrome, autonomic dystonia, and the diencephalic syndrome. These syndromes are entirely reversible with little or no time lost from work. Mm waves apparently cause more pronounced cardiovascular changes, consisting of vaso-vegetative responses. The signs and symptoms produced by this are due to "indirect" CNS stimulation by peripheral nerves causing vaso-motor instability, dermographism, and ECG alterations. Cm and dm wavelengths, because they penetrate further, are postulated to act directly on the central nervous system. Symptoms produced tend to be functional, covered by the term, neurasthenia. These relate to subjective complaints with reports of associated EEG changes; as well as peripheral pulse and blood pressure lability; decreased circulating histamine; increased RAI-uptake with thyroid enlargement, but no thyrotoxicosis; and other lesser signs.

Most significantly, these effects are said to occur at "low levels" of exposure, in less than thermogenic power flux density ranges below 10 mW/cm^2. These effects are reported to be enhanced by chronicity and intensity of exposure also. A theory of direct interaction of microwaves with neural tissue has been evolved by the Soviets (to which some authors refer as proven), which denies the existence of thermogenic activity at these low levels.

These syndromes, as well as most of the local organ responses described in Soviet literature, have not been observed by Western physicians. Based on our understanding of how dm. to mm. wavelengths interact with biological material, it is believed that the basic hazard of microwave energies resides in its ability to produce selective volume heating, which is reflected in our exposure guide. Of all of the reported effects, Western occupational medicine tends to accept the potential for effects on the lens of the eye, and possibly, the testicle, based on these structures' inability to tolerate heat.

Without judging mechanisms invoked, the nature of medicine, or ideological differences, critical analysis shows much of the work does not withstand scrutiny in testing the hypothesis that microwaves caused the effects observed. An example of Soviet reporting of data is from a table compiled by Sadchikova and Orlova in 1958 and 1962 of 525 microwave workers exposed to UHF irradiation, and the symptoms and signs noted. Immediately, one can see what is wrong: there is no mention of population at risk or how the case group was selected. No specific wavelength or exposure data is given. The 100 controls are not occupationally related and we have no sex or age breakdown in the table, related to exposure time. It is apparent from the data that no statistical testing at all is employed. Other things are wrong, but the point is that no conclusions can be made from this regarding microwave effects in an occupational setting.

Western occupational health surveys and specific reports of cases of harmful effects are few in number. There are too few to draw final conclusions regarding existing hazards with certain exceptions. Most studies have been on the lens of the eye, and it is generally recognized that microwave exposures to thermogenic levels can produce cataracts and microscopic lens abnormalities. Also, the testicle has been reported as being damaged because of its functional heat sensitivity. These appear to be the most sensitive structures according to Western observations, and no deleterious effects should be suffered if exposure is kept within 10 mW/cm^2 M.P.E.

Other possible effects currently under study include genetic effects, an apparent statistical correlation to mongolism in paternal radar exposure, epidemiological prospective and retrospective surveys, and experimental research on behavior and function in man and animals. Reviewing Western occupational surveys and single case reports demonstrates similar faults and omissions contained in Soviet reporting. Also, there are fewer surveys because the same effects have not been observed. The world literature in general, then, leaves much to be desired, and does not allow many meaningful conclusionsto be drawn.

CONCLUSIONS

What can be done? Education of physicians in occupational areas of responsibility regarding known and possible hazards is one priority. Included in this should be suggestions for implementing programs in industry and the military services for safety instruction, personal dosimetry, as well as "watchdog" medical programs for exposed personnel. Detailed records will have to be kept on high risk and marginal high risk exposure groups regarding type of exposure, intensity, duration, waveform, and type of generating equipment used. Personnel should be evaluated at appropriate intervals with attention paid to psychopathology, and medical, genetic, and medication history. Thorough physical examinations should be performed before, during, and after employment, including an ophthalmologist's slit lamp examination, ECG, baseline EEG, sperm counts and analysis, and appropriate blood studies, including parameters of neuroendocrine function. All this is necessary to identify subtle effects if they are present, and assess the hazard potential for these effects relative to exposure history. Only this kind of careful rational approach, kept within a proper perspective of what constitutes a hazard, will enable us to identify and isolate subtle effects of microwave energies. It goes without saying that reporting of this information must be precise, objective, and of the highest quality to be of any value.

REFERENCE

1. Milroy, W.C. and Michaelson, S.M. The microwave controversy. Int'l. Journ. Environ. Studies (In Press, Spring, 1972).