EFFECTS OF ELECTROMAGNETIC RADIATION ON BLOOD PROTEINS

Prague PRACOVNI LEKARSTVI in Czech Vol 26, No 8, Sep 74 pp 292-295
Manuscript received 1 Feb 74

[Article by Jana Pazderova, Jana Pickova, Vera Bryndova, Clinic of Occupational Diseases, Faculty of General Medicine, Charles University, Prague, Head Prof Dr K. Rejsek; Research Institute for Communications, Director F. Svoboda: "Blood Proteins in Personnel Chronically Exposed to Electromagnetic Radiation of the Order of 300 Kilohertz to 300 Megahertz"]

[Text] In our preceding studies (12, 13) we investigated the influence of electromagnetic radiation (further referred to as e.r.) on the health of people chronically exposed to it. We examined thoroughly 140 employees of TV and radio stations, compared the results of clinical and laboratory findings to findings made on people not exposed to radiation, and statistically evaluated the results. We found no signs of damage due to e.r., or changes in the health of the people we examined; we noticed only small, statistically important differences in average values of some components of the protein spectrum.

We could not be sure whether these differences were due to e.r., or whether they were caused in part also by other factors. Employees of the radio stations lived in various parts of the country, most frequently in mountainous regions in villages and small towns, and differed from the control group, formed by inhabitants of Prague, by their style of life, food habits, and so on. We also decided to be careful with our evaluation of the results, because blood samples were analyzed in the central biochemical laboratory where the usual approach does not guarantee the accuracy which is needed for a sensitive investigation.

In order to eliminate sources of inaccuracy and clarify a possible influence of e.r. on blood proteins, we investigated in our second study 153 technicians of TV and radio transmitting stations of Bohemia, who were exposed to radiation for more than 5 years. The results of this investigation were compared with findings in a control group of 100 people whose age, life style, origin, and social background were similar to that of the

investigated group. The results of this study are submitted in the present article.

Material and Methods of Investigation

Data concerning age, nature, and period of exposure, and numbers of investigated people are given in Table 1. Because blood proteins and the composition of individual fractions do not depend on sex, we are not listing separately results obtained on men from those obtained on women.

Table 1. Data Covering Age, Nature of Radiation, and Periods of Exposure of Investigated People

(1) Druh expozice	(2) Počet vyšetřených	(3) Průměrný věk	(4) Směr. odchylka	(5) Průměrná doba expozice	(6) Směr. odchylka
TV (7) (50–230 MHz)	51	34,82	7,50	10,59	3,60
KV (8) (3–22 MHz)	51	37,08	7,08	14,43	6,31
SV (9) (630–1600 kHz)	51	41,73	10,27	16,71	5,60
Kontrola (10)	100	35,20	10,25	—	—

Key:
1. Nature of radiation
2. Number of people investigated
3. Average age
4. Meaningful difference
5. Average period of exposure
6. Meaningful difference
7. Television station
8. Short-wave radio station
9. Medium-wave radio station
10. Control

In our past study (12, 13) we found no damage to health, and therefore we conducted our clinical investigation only with the aim of finding diseases which are known to change the composition of blood proteins (cholangitis, chronic liver diseases, and so on). We conducted our examinations directly at the facilities of the transmitting stations, in rooms adjacent to the transmitting equipment. Blood was therefore taken within electromagnetic fields.

Intensity of the electromagnetic field was measured by means of the LB-038 meter designed for hygienic purposes; this is a high frequency transistor voltmeter, which can take measurements in the frequency region of 10 kilohertz to 300 megahertz in V/m (according to the conversion table). The inaccuracy of the measurements method was $\pm$ 30 percent. Because the field was not homogenous, measurements were taken on various spots, usually so that they would take place on the spot where the investigated personnel

are located during their working activity; the height above the floor was 50, 80, 120, and 155 cm.

Apart from the intensity, determined for each worker, we also determined by calculation the hours of exposure for one calendar year, and these served to prepare an overall group average (calculation methods are given in references 12, 13).

Microclimatic conditions and the noise were investigated by the methods usually employed in hygienic services.

Each blood sample was analyzed twice in our chemical laboratory; total proteins were calculated on the basis of nitrogen balance, and determined by Nessler's colorimetric method (7). Protein spectrum was determined by the electrophoresis method on paper (14). Difference for a patient did not exceed 1 percent.

For the statistical evaluation of the findings F-test and Duncan's test were used; calculations were made at the 5 percent level of reliability.

Results of Investigation

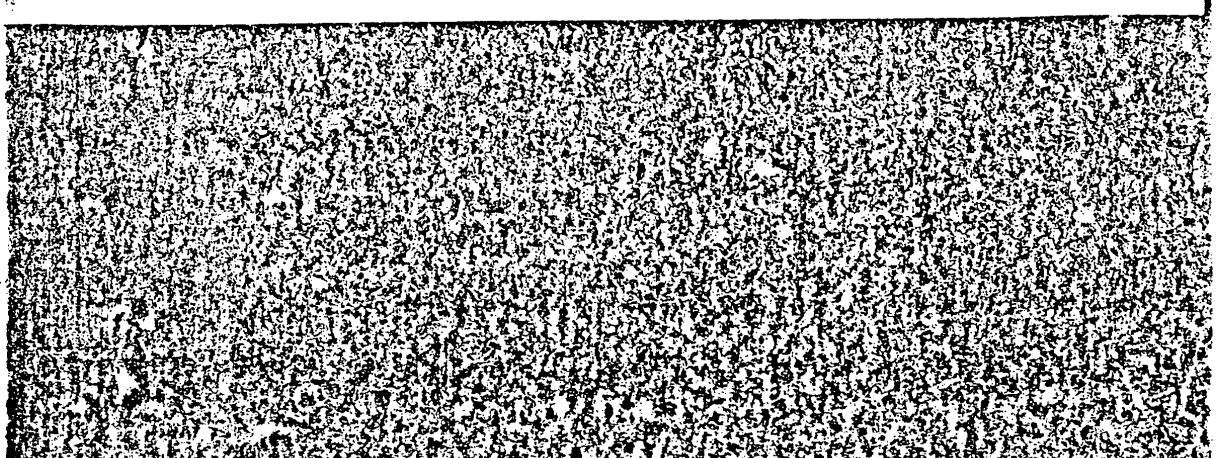
Average values of intensity of the electromagnetic fields and the values of irradiation in the television and radio stations are given in Table 2.

Table 2. Average Intensities of the Electromagnetic Field and Doses of Irradiations Per Calendar Day at Individual Transmitting Stations

(1) Intenzita V/m	Maximum	Minimum	(2) Priemór	(3) Smór. odchýlka	n
(4) TV	37,00	0	4,91	6,20	7
(5) KV	150,0	0	15,50	17,84	3
(6) SV	60,00	0	7,01	9,51	7
(7) Ožiarenie V/m.hod.					
(4) TV	87,33	0	35,74	23,12	7
(5) KV	480,20	38,80	191,48	180,21	3
(6) SV	138,88	12,16	82,72	39,52	7

Key:

1. Intensity
2. Average
3. Significant difference
4. Television station
5. Short-wave radio station
6. Medium-wave radio station
7. Irradiation
8. V/m. hours



In broadcasting rooms of television stations optimum temperature was exceeded by 2°C, in radio stations the microclimatic conditions were within the region of comfort. The noise level in television stations was within the limits of N 65-81, in radio stations N 65-71. The noise consisted predominantly of tones of low frequency produced by the air-conditioning equipment. The work has the character of routine mental activity with average requirements of intelligence, awareness, and concentration. The weekly working hours are 40.5 in shifts; the working space is attractively decorated, well lighted and air-conditioned.

The average values of the overall blood proteins for the whole groups, and individual fractions of the proteins are given in the summary Table 3. The individual values and the overall group averages are within physiologically usual values.

Table 3. Values of Overall Blood Proteins and of the Protein Spectrum

		(1)	(2)	(3)	(4)
(5)	Celková bílkovina	7,26 K	7,28 TV	7,43 SV	7,47 KV
(6)	Albuminy	56,14 SV	58,00 K	58,10 KV	57,05 TV
(7)	Alfa 1-globuliny	5,57 KV	5,58 K	5,05 TV	5,97 SV
(8)	Alfa 2-globuliny	8,58 KV	8,85 K	8,05 SV	9,21 TV
(9)	Beta-globuliny	10,66 K	10,76 TV	10,94 SV	11,29 KV
(10)	Gama-globuliny	17,35 TV	17,70 KV	18,30 K	18,93 SV
	A/G	1,23 SV	1,31 K	1,32 KV	1,33 TV

Values lying on a common sector of a line do not differ significantly from each other.
Values of total proteins are given in gram percentages, of individual protein fraction in relative percentages.

Key:
1. Control
2. Television stations
3. Medium-wave stations
4. Short-wave stations
5. Total protein
6. Albumins
7. Alpha 1-globulins
8. Alpha 2-globulins
9. Beta-globulins
10. Gamma-globulins

Discussion

Our present investigation was conducted so that the possible sources of errors in the selection of the control group and inaccuracy in the laboratory results were reduced to a minimum. The people in the control group did not differ substantially in age or life style from the test group with the only exception that they generally work in places open only during the day. We could, however, find no reference in literature which would indicate that working in a three shift system would affect in any way the content of blood proteins. The results confirm information published previously, that is that the e.r. affects blood proteins to a certain extent (1, 3, 4, 5, 6, 8, 10, 11, 12, 13, 15, 16). To our great surprise we did not find an increase in the content of gamma-globulins which was considered typical (1, 5, 6, 8, 10, 16, 17). On the contrary, in workers in television transmitting stations we observed lower contents of these compounds. Generally blood proteins are significantly higher in employees of short-wave radio stations, while Sacchitelli (16) on the contrary observed lowering of these values in workers operating radar installations. Albumino-globulin quotient was lowered in workers employed in medium-wave-lengths radio stations, and this was due to a lower content of albumins, and an increase in alpha 1, and beta globulins. Singatullina (17) also observed a slight increase in the overall protein content, reduction of albumins, and increase in alpha 1, and also of gamma globulins when she irradiated rabbits with a wave length of 6 meters and 50 V/m intensity. Differences between these data and those published in literature may be explained by variations in frequency, field intensity, and time of exposure.

The question remains as to why we have found differences between our previous investigation in 1966-1968 (12, 13), and our present work. It was either due to the selection of an unsuitable control group, or the routine differentiation between normal and pathological values, which was not suitable for determination of value differences as small as those present in the investigated changes.

The conditions of hygiene and working environment did not change at any of the transmitting stations, with the exception of a single one; although the values of fields intensity found at present are more favorable than the past ones, it is not due to improved conditions, but to a change in the method of measurements (original measurements were made by a wide-span universal voltmeter B 388A with a method of inaccuracy of $\pm$ 100 percent, the present measurements were made with a transistor voltmeter LB-038 which operates with an accuracy of $\pm$ 30 percent). It is possible that the differences may be due to the fact that originally blood samples were taken during hospitalization at a clinic, which took place at least 24 hours after the end of the exposure, while during the present study the samples were taken while the subjects were still within the electromagnetic field.

We wonder whether the differences between the individual irradiation sources (TV, short-wave and medium-wave) are really responsible for the differences because of the varying lengths of the e.r., or whether the periods of exposure also play a role; exposure is shortest in employees of television transmitting stations, and longest in technicians employed at medium-wave radio stations.

These are only discussion problems, and we have no ready answers. We are inclined to judge the facts with a great reserve as during the preliminary evaluation of the results of a part of the present group, using an identical statistical method, the data obtained for some groups, were again different (control 50 people, TV group 30 people, short-wave 19, and medium-wave 39 workers).

We tend to believe that a limited influence on the blood proteins is exerted by irradiation of the frequencies and intensities investigated, but that this influence is very small, and its statistical importance will be affected by the number of the investigated workers, and by the selection of the control group.

The results are not typical for exposure to e.r.; similar reactions of the organism are observed during investigations of other influences, such as chemical and biological ones. It would be an error to attach too much importance to these findings and to classify them as pathological.

The repeated clinical and laboratory study gives us only an opportunity to make the findings, and compare the results to those which we obtained previously, and which may be found in literature, but we have no way in which we could clarify and explain these results. Some physicists attempt to explain the effect of e.r. on a molecular level, and their opinions are expressed in symposia which were accessible to us (3, 4, 8, 9, 11).

Our clinical investigation is not likely to give us any more information, and it is necessary to study the problem experimentally at somewhat higher field intensities, so that the differences would become more distinctive, and so that we could analyze them further by more accurate methods of investigation.

The authors would like to take this opportunity to thank Ludmila Dankova, the laboratory technician, for her help.

BIBLIOGRAPHY

1. Bach, S. A., A. J. Luzzio, A. S. Brownell, "Effects of R-F Energy on Human Gamma Globulin," J. MED. ELECTRONICS, 1961, pp 9-14.

2. Bollinger, J. N., "Detection and Evaluation of Radiofrequency Electromagnetic Radiation-Induced Biological Damage in Macaca Mulatta," Final report: "Potential Hazards and Safety Considerations in Human Exposure to Non-Ionizing Radiant Energies," by Sol. WHO, M. Michaelson, 1973.

3. Cleary, S. F., "Considerations in the Evaluation of Biological Effects of Exposure to Microwave Radiation," AMER. INDUSTR. HYG. ASSN., No 31, 1970, pp 52-59.

4. "Final Report on Biological Effects of R-F on Macromolecules," DA 18-108-CML-7061, U.S. Army Chemical Center, Maryland, quoted by S. F. Cleary in No 3.

5. Grzesik, J., F. Kumaszka, Z. Paradowski, M. Puchalik, K. Zajusz, "Wplyv pola elektromagnetycznego srednej czestotliwosti na organy miaszowe i bialka krwi bialych myszy," MED. PRACY, Vol 11, 1960, No 5, pp 323-330.

6. Guskova, A. K., P. P. Dvizkov, E. A. Drogicina, "Profesionalnye Bolezni Vyzvanye Vozdejstviem Lucistoj Energii." In the book by A. A. Letavet and colleagues: "Profesionalnye Bolezni," Moscow, Medicina, 1964.

7. Horejsi, J., "Fundamentals of Clinical Biochemistry," Prague, SZdN 1963.

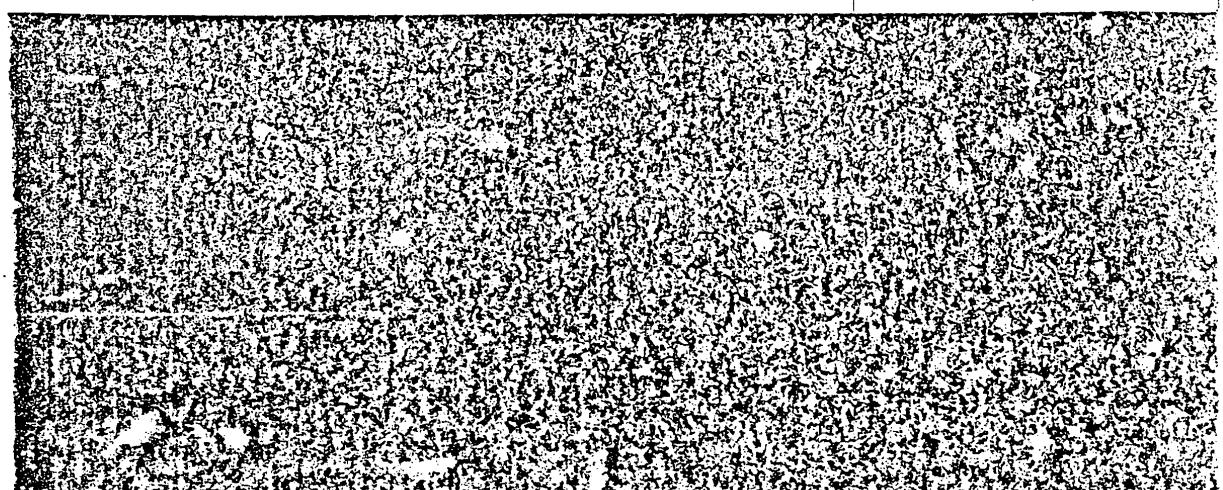
8. Marha, K., "Biological Effects of High Frequency Electromagnetic Waves," PRAC. LEK., No 15, 1963, pp 387-393.

9. Michaelson, S. M., "Biological Effects of Microwave Exposure," in "Biological Effects and Health Implications of Microwave Radiation," Symposium proceedings, Richmond, Virginia, 17-19 September 1969.

10. Nikogosjan, S. V., "Vlijanie 10 santimetrov voln na soderzanie belkov i belkovych frakcii v syrovotke krovi zivotnych," GIG. TRUD. PROF. ZABOL., Vol 8, 1964, No 9, pp 56-57.

11. Pazderova, J., "Influence of Electromagnetic Radiation of the Order of Centimeters and Meters on Health of Man," PRACOV. LEK., No 20, 1968, pp 447-457.

12. Pazderova, J., V. Bryndova, J. John, E. Lukas, M. Nemcova, J. Zubrik, "Conditions of Health of Workers Chronically Exposed to Electromagnetic Radiation in the VKV Frequency Range (30-300 megahertz)," PRAC. LEK., No 23, 1961, pp 265-271.



13. Pazderova, J., R. Fischer, K. Formanek, J. John, E. Lukas, V. Styblova, "Health Conditions in Workers Chronically Exposed to Electromagnetic Radiation on the Order of Meters," PRACOV. LEK., No 21, 1969, pp 348-361.

14. Pechar, J., M. Havlova, "Electrophoresis of Proteins on Paper II," CS. GASTROENT. VYZ., No 9, 1955, pp 205-210.

15. Slepicka, J., A. Slivova, O. Pochmon, E. Zapletalova, "Influence of Electromagnetic Radiation on the Order of Meters Wavelength on Workers of a Short-Wave Transmitter," PRACOV. LEK., No 19, 1967, pp 5-11.

16. Sacchitelli, F., G. Sacchitelli, "Sulla protezione del personale exposto alle microonde radar," FOLIO MED., Vol 43, 1960, No 12, pp 1219-1229.

17. Singatullina, R. G., "Vlijanie tokov ultravysokoj castoty na belkovye frakcii syrovotki krovi," BUL. EXP. BIOL. MED., No 52, 1961, pp 69-72.

2573
CSO: 8312/0411

END