IN VITRO STUDY ON THE GENOTOXICITY OF 2450 MHz MICROWAVE IRRADIATION IN HUMAN PERIPHERAL BLOOD LYMPHOCYTES

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ABSTRACT

A cytogenetic analysis was performed on human peripheral blood lymphocytes exposed to 2450 MHz microwaves during 30 and 120 minutes respectively. The exposure system developed allows a temperature control by means of a temperature probe put in the blood sample which gives feedback to a microcomputer. In the present study irradiation was performed at a constant temperature of 37°C for the whole exposure period. We found a marked increase in the frequency of chromosomal aberrations as well as micronuclei. On the other hand microwave irradiation did not influence the cell kinetics nor the sister chromatid exchange frequency.

INTRODUCTION

Microwaves have, like other non ionizing radiations (NIR), a lot of industrial, medical and other applications. They are for example widely used for communication purposes (satellite communication, radar, radio/TV,...), therapy, cooking and a lot domestic or industrial heating procedures. As a consequence everybody is exposed to microwaves. Harmful (and also beneficial) effects on the living organism are sometimes reported but are often questionable[1,2,3,4]. Although there is much evidence in favor of the non-genotoxicity of microwaves, it

was reported in some papers that microwaves may be mutagenic[5,6,7]. In order to verify this assumption we performed an in vitro cytogenetic analysis in human peripheral blood lymphocytes exposed to 2450 MHz microwaves. This paper describes some of our preliminar results.

MATERIAL AND METHODS

A freshly obtained blood sample from a 38 year old male donor was divided into three test tubes and resp. irradiated with 2450 MHz microwaves for 30 or 120 minutes, or kept at 37°C in a warm water bath. The exposure system used was developed to provide two modes of operations: temperature control and electric field control[8,9]. In this study we used the temperature controlled mode in order to work at the constant temperature of 37°C. Therefore a temperature microprobe was put into the blood sample. Connected with a microcomputer it results in automatic adjustment of the microwave output allowing to rapidly obtain and closely maintain the prescribed temperature (37°C) within 0.05°C for the time of irradiation.
After irradiation cells were cultivated during 48 or 72 hrs according to standard methodologies for analysis of chromosome aberrations[10], micronuclei[11], cell kinetics and sister chromatid exchanges (SCE)[10].

RESULTS

Results of this preliminar cytogenetic study are summarized in tables 1-3. A marked increase in the frequency of chromosomal aberrations is observed, especially after a 120 minutes irradiation period. These aberrations comprise dicentric chromosomes and acentric fragments that are usually found after ionizing radiation exposure (table 1). The frequency of micronuclei increased equally for both irradiation periods (table 2). Differential staining of BrdU incorporated chromatids allows analysis of the cell kinetics and SCE. Table 3 shows that the cell kinetics nor the SCE frequency were significantly influenced by the microwave irradiation.

	CHROMOSOME ABERRATIONS (per 200 metaphases)							
	gaps	breaks	acentric fragments	dicentrics +/- ac. fragm.	other aberr.	number of cells with 1 aberration	2	3
CONTROLS	2	2	1	0	0	3	1	0
30 min. irrad.	4	1	3(2)	1+	0	9	0	0
120 min. irrad.	7(1)	9	13(3)	1+	3(4)	19	6	2

Table 1: Chromosome aberrations in 2450 MHz microwave irradiated human lymphocytes at a constant temperature of 37°C. (1): including two isogaps, (2): here all acentric fragments are single chromatid fragments (but apparently no chromatid break present), (3): including one acentric ring, (4) includes two translocations and one centromere splicing (no particular staining was used to detect translocations; those mentioned are only the very obvious ones due to a striking chromosome morphology).

	MICRONUCLEI (per 1000 binucleated cells)		
	Number of cells with 1 micronucleus	with >1 micronucleus	Total number of micronuclei
CONTROL	3	1(1)	5
30 minutes irrad.	23	0	23
120 minutes irrad.	11	2(2)	17

Table 2: Number of micronuclei in cytochalasine B blocked human lymphocytes irradiated with 2450 MHz microwaves at a constant temperature of 37°C. (1) and (2) : resp. cells with 2 and 3 micronuclei.

	CELL KINETICS (200 metaphases)						SCE FREQUENCY
	48 hr cultures			72 hr cultures			in 50 M2 figures
	% of M1	M2	M3	M1	M2	M3	(mean per cell)
CONTROL	91	9	0	14	41	45	5.88
30 min. irrad.	93	7	0	19	47	34	5.56
120 min. irrad.	88	12	0	20	40	40	7.16

Table 3: Frequency of 1st, 2nd or 3rd metaphases and SCE frequency in human lymphocytes irradiated at a constant temperature of 37°C with 2450 MHz microwaves and cultivated during 48 and 72 hours.

DISCUSSION

In this study irradiation was performed at a constant temperature of 37°C which could be obtained by adaptation of the microwave power output. The power intensity was thus variable but low enough as to maintain irradiation at non-thermal conditions. In this respect it is rather surprising to observe chromosomal aberrations. Indeed, 2450 MHz microwaves have a wavelength of 12.2 cm in free space and a photon energy which is much less than 12 eV. This means that even the weakest chemical bond in DNA is not likely to be broken by the microwaves. However, our results are in agreement with others presenting data for other frequencies and power densities[5,6,7].

The present study is only a preliminar stage in a series of experiments aimed at better understanding the microwave effects on biological systems, especially on the genetic material of mammalian cells.

REFERENCES

1. Cleary, S.F., 1983, Bioeffects of microwave and radiofrequency radiation, In: F.K. Storm (ed.), Hyperthermia in cancer therapy, G.K. Hall Medical Publishers, Boston, Massachusetts, pp. 545-561.
2. WHO, 1983, Radiofrequency and microwaves, Environmental Health Criteria 16, 134 pg.
3. Foster, K.R. and Guy, A.W., The microwave problem, Sci. Am., 255, 32-39.
4. Wilkening, G.M. and Sutton, C.H., 1990, Health effects of nonionizing radiation, Med. Clinics North America, 74, 489-507.
5. Léonard, A., Berteaud, A.J. and Bruyère, A., 1983, An evaluation of the mutagenic, carcinogenic and teratogenic potential of microwaves, Mutation Res., 123, 31-46.
6. Garaj-Vrhovac, V., Horvat, D. and Koren, Z., 1990, The effect of microwave radiation on the cell genome, Mutation Res., 243, 87-93.
7. Garaj-Vrhovac, V., Horvat, D. and Koren, Z., 1991, The relationship between colony-forming ability, chromosome aberrations and incidence of micronuclei in V79 chinese hamster cells exposed to microwave radiation, Mutation Res., 263, 143-149.
8. De Wagter, C., Gheeraert, P. and Van Loock, W., 1985, Narrowband microwave generator using a commercial magnetron, Proc. 20th Annual Microwave Power Symposium, Chicago, 124-127.
9. De Wagter, C., Martens, L., Verschaeve, L. and Maes, A., 1992, Computer controlled microwave exposure system: results of an in vitro cytogenetic study on human peripheral blood lymphocytes, Proc. 1st World Congress for Electricity and Magnetism in Biology and Medicine, in press.
10. IAEA, 1986, Biological dosimetry: chromosome aberration analysis for dose assessment, International Atomic Energy Agency, Vienna, pp. 69.
11. Van Hummelen, P. and Kirsch-Volders, M., 1990, An improved method for the 'in vitro' micronucleus test using human lymphocytes, Mutagenesis, 5, 203-204.