

M. Emin ERDAL<sup>1</sup>  
Nurten ERDAL<sup>2</sup>  
Sibel OĞUZKAN<sup>1</sup>

## Chromosomal Aberrations in Peripheral Lymphocytes of a High-Voltage Power Lineman Exposed to Electromagnetic Fields

Received: May 12, 1998

<sup>1</sup>Departments of Medical Biology and Genetics  
<sup>2</sup>Biophysics, Faculty of Medicine, Gaziantep  
University, Gaziantep-Turkey

**Key Words:** Chromosomal aberrations,  
Human peripheral lymphocytes,  
Electromagnetic fields

During the last decade, several studies have focused on the adverse effects on health caused by exposure to electromagnetic fields (EMF). Some epidemiological studies of workers exposed to EMF have shown an increased risk of leukemia, and some found an elevated risk of brain tumors among "electrical workers" (1-4). Studies of the peripheral lymphocytes of humans have suggested that exposure to a magnetic field and/or radiofrequencies have no specific effect on the induction of the sister chromatid exchange (SCE) frequencies, but it can result in an increase in chromatid-type breaks and other chromosomal damage (5-8).

A recent study revealed comparing chromosome damage in the lymphocytes of employees in high-voltage laboratories revealed more than a threefold increase in chromosome breaks among the subjects exposed to EMF, but no effect was observed in the controls (9). In this study, the cytogenetic findings obtained from an index case and his wife, referred because of repeated miscarriages, is presented.

We studied some chromosome aberrations and mitotic indices in the peripheral blood lymphocytes of a nonsmoking, 32 year-old, high-voltage cable worker who had been working 8 hours a day for the previous 8 years in a power substation with exposure to 154 kV at 50 Hz EMF. The man and his wife were referred for cytogenetic investigation because of repeated miscarriages. Cytogenetic analysis was carried out at the same time for the husband and wife under the same laboratory conditions. The cytogenetic analysis was carried out on

the chromosomes obtained from 72 h peripheral blood lymphocyte cultures that were stained for solid and G banding, according to standard procedures (10). Endoreduplication, chromatid gap, chromatid break and mitotic index in the metaphase cells were evaluated. The mitotic index was scored in 1000 cells, and the other parameters in 85 cells.

Eighty-five metaphase plates were analyzed to determine the quantitative and structural aberrations in the chromosomes. The metaphases in the peripheral blood lymphocyte culture of the woman were observed to be normal. Twenty-three (27%) metaphases were observed being irregular in the culture of the index case. In irregular metaphases, 14(60.8%) were endoreduplication, 7(30.5%) were chromatid gaps, and 2(8.7%) were chromatid breaks. Of the total metaphases, the commonly observed aberrations were endoreduplication (16.5%) and chromatid gap (8.2%). A mitotic index was observed in 20 out of 1000 cells.

In the present study, an increased frequency in chromosomal aberrations was observed in the cultured lymphocytes of a nonsmoking, high-voltage cable worker with long-term exposure to 50 Hz EMF. This is in close agreement with previous reports indicating that in vivo and in vitro exposure of human cells (2, 6-8) as well as animal cells (11) to EMF may have clastogenic effects. Some studies have had negative results (12-14). However, in this study, the fact that the couple, who had repeated miscarriages, had a baby after genetic counseling, in which the cable worker was advised to

avoid exposure to EMF, supports the theory that EMF have clastogenic effects.

It can be suggested that the main reason for the increasing number of endoreduplications in the cultured lymphocytes is the damage to mitotic spindles, which is caused by radicals that occur because of high voltage. Because the mitotic spindles have important roles in the movements of chromosomes toward the poles during cell division, it can also be suggested that the increasing number of endoreduplications affects the formation of spermium during spermatogenesis, which causes frequent miscarriage. Considering all these aberrations, it would be useful in further studies to give genetic counseling to other high-voltage cable workers who are unable to have children.

To summarize previous research literature and this present study, it seems that EMF may be capable of producing chromosome aberrations. It is important that more investigations be carried out using various types of cells (e.g., spermium) under different experimental conditions in order to resolve the controversy concerning the possible risks associated with EMF.

*Correspondence author:*

*M. Emin ERDAL*

*Gaziantep University, Faculty of Medicine,*

*Medical Biology and Genetics Dept.*

*27310 Gaziantep-Turkey*

## References

- Murphy JC, Kaden DA, Warren J, Sivak A. International Commission for Protection Against Environmental Mutagens and Carcinogens. Power frequency electric and magnetic fields: A review of genetic toxicology. *Mutat. Res.*, 296: 221-40, 1993.
- Valjus J, Norppa H, Jarventaus H, Sorsa M, Nykyri E, Salomaa S, Jarvinen P, Kajander J. Analysis of chromosomal aberrations, sister chromatid exchanges and micronuclei among power linesmen with long-term exposure to 50-Hz electromagnetic fields. *Radiat. Environ. Biophys.* 32: 325-36, 1993.
- Blank M. Biological effects of environmental electromagnetic fields: Molecular mechanisms. *Biosystems*, 35: 175-8, 1995.
- Salvatore JR, Weitberg AB, Mehta S. Nonionizing electromagnetic fields and cancer: A review. *Oncology (Hunting)*, 10: 563-70; discussion 573-4, 577-8, 1996.
- Nordenson I, Mild KH, Nordstrom S, Sweins A, Birke E. Clastogenic effects in human lymphocytes of power frequency electric fields: in vivo and in vitro studies. *Radiat. Environ. Biophys.*, 23: 191-201, 1984.
- Garcia-Sagredo JM, Parada LA, Monteagudo JL. Effect on SCE in human chromosomes in vitro of low-level pulsed magnetic field. *Environ. Mol. Mutagen.*, 16: 185-8, 1990.
- Khalil AM, Qassem W. Cytogenetic effects of pulsing electromagnetic field on human lymphocytes in vitro: chromosome aberrations, sister-chromatid exchanges and cell kinetics. *Mutat. Res.*, 247: 141-6, 1991.
- Yamazaki E, Matsubara S, Yamada I. Effect of Gd-DTPA and/or magnetic fields and radiofrequency exposure on sister chromatid exchange in human peripheral lymphocytes. *Acta. Radio.*, 34: 607-11, 1993.
- Skyberg, K, Hansteen IL, Vistnes AI. Chromosome aberrations in lymphocytes of high-voltage laboratory cable splicers exposed to electromagnetic fields. *Scand. J. Work. Environ. Health.*, 19: 29-34, 1993.
- Gosden CM, Davidson C, Robertson M. Lymphocyte Culture. *Human Cytogenetics, A Practical Approach*. (Eds. Rooney DE, Czepulkowski BH), Oxford University Press, New York pp.: 35-9, 1992.
- Zwingelberg R, Obe G, Rosenthal M, Mevissen M, Buntenkötter S, Löscher W. Exposure of rats to a 50 Hz, 30-mT magnetic field influences neither the frequencies of sister chromatid exchanges nor proliferation characteristics of cultured peripheral lymphocytes. *Mutat. Res.*, 302: 39-44, 1993.
- Bauchinger M, Hauf R, Schmid E, Dresch J. Analysis of structural chromosome changes and SCE after occupational long-term exposure to electric and magnetic fields from 380 kV-systems. *Radiat. Environ. Biophys.*, 19: 235-238, 1981.
- Cohen MM, Kunska A, Astemborski JA, McColloch D, Paskewitz DA. Effect of low level, 60 Hz electromagnetic fields on human lymphoid cells: I. mitotic rate and chromosome breakage in human peripheral lymphocytes. *Bioelectromagnetics*, 7: 415-423, 1986.
- Rosenthal M, Obe G. Effect of 50-Hertz electromagnetic fields on proliferation and on chromosomal alterations in human peripheral lymphocytes untreated or pretreated with chemical mutagens. *Mutat. Res.*, 210: 329-335, 1989.