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SAFE ALTERNATIVE CANCER THERAPY USING ELECTROMAGNETIC FIELDS

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Abstract

This article highlights recent research on the beneficial use of selected low frequency electromagnetic fields (EMF) as a safe alternative therapy for treatment of cancer and other health problems. It is shown that EMF therapy provides a safe alternative and adjunct modality for the treatment of cancer and other health problems, and therefore, research in this field deserves more support. The paper also discusses some reports and hypothesis of potential risk of human exposure to low frequency EMF, mainly to the power line frequency of 60 Hz.

Key words: Bioelectromagnetics, cancer therapy, electromagnetic field (EMF), EMF risks, EMF therapy

Public concern about health risks of EMF exposure

Increased use and human exposure to electromagnetic fields (EMF) from electrical appliances, power lines, wireless communications, cell phones, radio and microwave technologies continue to concern the public about potential health risks. Each of these exposure systems is different, both in terms of frequency and energy level. EMF has a two component, an electric field and a magnetic field. Electrical appliances and power lines gives exposure to extremely low frequency electromagnetic fields, mostly in the 50 or 60 Hz range. The electric field emanating from such sources does not project very far from the source, while the magnetic field from electrical appliances is not so easy to shield. It is now well accepted that low frequency electric field is attenuated by the surface of any physical body, including biological bodies, while magnetic field of the same frequency penetrates the human bodies without any loses. (Markov, 2000). For that reason basic science, and especially epidemiological studies are more focused on the effects of low frequency magnetic fields, rather than the incident electric fields.

Some epidemiological studies suggested increased risk of initiation of malignancy, starting with childhood leukemia near power lines in the 5 to 300 mGauss range (Wertheimer and Leeper, 1979,Repacholi et al., 2005) up to brain cancer caused by use of mobile phone. Concern with cell phones, radio waves and microwaves has centered on their thermal effects. It should, however, be noted that most of the published epidemiological studies did not consider the possibility of biological effects by non-thermal mechanisms, but rather focus on the thermal effects as evaluated by SAR (specific

absorption rate). This obvious deficiency requires serious efforts in the harmonization of standards in occupational and every-day living conditions (Markov, 2006).

There are no epidemiological studies on cell phones usage that report increased risk of brain tumors but the risk is likely to remain before all concern of potential hazard is resolved (Schüz et *al*., 2006; Hepworth et *al*., 2006). This emphasizes the importance of applying precautionally principle, as suggested by the WHO.

Recently, Lahkola et al. (2007) published a paper on potential association between mobile phone use and risk of glioma as studied in five North European countries (Sweden, Norway, Denmark, Finland and southeast England) where cell phones have been widely used for at least a decade. The authors concluded that "results do not support mobile phone use for less than 10 years as a cause of glioma", buy they found "an indication of increased risk in relation to reported ipsilateral phone use of more than 10 years duration" which needs to be explored further. Research projects focused on the study of possible health effects of mobile phones, such as REFLEX, CEMFEC, PERFORM A, INTERPHONE, have been established by the European Commission.

In a recent study (Ivancsits et al. 2003), found some evidence of genetic damage by exposure of cells to power line EMF frequency conditions in the 200 mG to 10G range. The type of damage reported was obtained from a DNA comet assay. In attempt to reproduce Ivancsits' et al. experiments (Scarfi et al. 2005) extended to lower magnetic fields, in the 50Hz 1 mT or powerline EMF range. Scarfi and coinvestigators found no evidence of increased DNA damage using either the comet assay or a micronucleus assay in comparison to untreated (sham) controls. They suggest that discrepancy in results between the two study groups may be due to methodological differences such as: 1) use of

image analysis software rather than classification of results of comet assay by eye, and 2) the way micronuclei counts were done.

Most past reports on EMF on genetic material have given negative results. Even acceptance of negative findings of the effects of EMF on the genetic material does not mean EMF has no effect on living organisms (For review see Vijayalaxmi, 2004). Indeed there are numerous studies that show 50 to 60 Hz EMF can and does effect living organisms (for examples, see Cameron et al. 1985, 1993, Markov 1994).

In summary of health concerns of EMF exposure

1. Scientific evidence that continuous EMF exposure poses health risk is weak but cannot be totally discounted. Exposure safely below a magnetic field of 2 to 5 mG has been recommended by the U.S. Environmental Protection Agency (E.P.A.) whereas it has been suggested that fields that exceed 20G be avoided.
2. There is and should be continued debate surrounding potential harmful effects from EMF exposure.
3. What is needed now is more and better research on the potential hazard of exposure to EMF. In the meantime, we should follow government and expert agency exposure recommendations (guidelines) and practice avoidance when uncertain. Industry and business should work to minimize EMF exposure from power lines, electrical appliances, cell phones and wiring arrangements in homes.

Beneficial uses of EMF

During last two decades the emphasis of the scientific, media and public interest, at least in the USA, was on the hazard of EMF. However, the beneficial use of EMF for magnetotherapy has been subject of number of studies worldwide. Since the first book on contemporary magnetotherapy was published in 1982 (Todorov, 1982), a number of well designed studies and monographs were publish, most recent was the book "Bioelectromagnetic Medicine" (Rosch and Markov, 2004). The recent book contained 50 chapters authored by 86 scientists and clinicians from around the world. Review of literature in the preface of the book makes clear that the field of EMF therapy has had negative attitude from the side of mainstream medicine. Another impediment to progress in this field has been the inability to identify mechanism of action responsible for the beneficial therapy effects of EMF. In this regard it should also be noted that we do not know all the mechanisms of action of many drugs, nor do we fully understand their effectiveness or their side effects. Yet they are commonly used today.

One of the first proven benefits of EMF in the USA was use of an EMF device (as explained by Bassett, 1989) to promote the healing of nonunion (fractures that did not heal within 9 months). This device was approved by the U.S. Food and Drug Administration and has been successfully applied to hundred of thousands of patients. A number of other EMF therapies for pain, insomnia, depression, epilepsy, tinnitus, orthodontic/orthopedic inflammation, cancer and other disorders have been successfully used worldwide (Rosch and Markov, 2004).

Research on the use of EMF for cancer treatment has gotten much less public attention and funding than has research on the potential cancer risks from: power lines, household wiring or cell phone EMF exposure. Moreover, the publicity of potential hazard of EMF within scientific and general community significantly reduces the speed of development of magnetotherapy. Institutions, such as NIH and FDA are reluctant to allow the use of EMF as therapeutic tool to fight malignancy. Regardless, some biomedical researchers have managed to test applications of EMF as cancer therapy. (Rosch and Markov, 2004).

The goal of the research reported next is not just to kill cancer cells, which is the main approach of chemotherapy and of ionizing radiation therapy. EMF therapy also looks at systematic effects that alter tumor cell behavior to reduce the number of metastatic cells that leave the primary tumor or to enhance the immune system's response to the tumor cells. The systemic effect approach was discussed by Markov et al., 2006.

One target for EMF therapy has been to inhibit blood vessel growth (angiogenesis) needed for tumor growth (Markov et al., 2004). When cancer tissue outgrow the blood supply they need, and formation of new blood vessel is restricted, the cancer cells suffer lack of oxygen and nutrients, the growth of tumor is restricted and tissue necrosis occurs. The authors' current research is aimed at stopping new blood vessel growth to the tumor that will starve the cancer cells of oxygen and also deprive the tumor cells of new vascular pathways that the tumor cancer cells can use to leave the tumor and then to take up residence at distant sites within the body (metastasis). Metastasis is in fact usually thought to be the main killer of cancer patients.

The following is one brief account of the research and results of the effects of EMF therapy on tumor growth, angiogenesis and metastasis (Cameron et *al*., 2005a, b; Cameron et al., 2006). The experimental design included groups of tumor bearing mice that received a standard course of ionizing radiation (IR) with and without the daily EMFtreatment. Thus, the effects of IR and EMF when used alone and together could be determined. Both IR and EMF therapy were shown to inhibit tumor growth, angiogenesis and metastasis. However, while IR therapy did have harmful side effects. the EMF therapy had none. The continued use of EMF after the course of IR prevented tumor regrowth by suppression of angiogenesis and also gave the lowest incidence of metastasis. This suggests that selected EMF, described elsewhere (Williams and Markov, 2001) is a safe and effective adjunct therapy following IR therapy (Cameron et *al*., 2005a, b). A temporary cessation of the daily 10 minute EMF treatment for approximately 3 days prior to a second round of IR may be necessary to allow some tumor revascularization to oxygenate the surviving tumor cells, as the second course of IR therapy works best to kill cancer cells when oxygen is present.

In another cancer treatment study, Japanese researchers have used a magnetic stimulation device. (Yamaguchi et *al.* 2006) This device produces a magnetic field of 250 mT that is 17 times stronger than the EMF pulse signal used by the Cameron group mentioned above. Groups of tumor bearing mice were treated for 80 seconds per day with the 250 mT field. They reported that this EMF therapy suppressed tumor growth rate and resulted in longer survival time. Yamaguchi et *al.* (2006) suggest that EMF therapy stimulated an immune response that may have produced most of the anti-tumor effect.

Conclusions regarding therapeutic use of EMF

1. It can be predicted that bioelectromagnetics will rise to a therapeutic importance that will match or surpass conventional drugs and surgery. Besides the advances in cancer therapy, examples mentioned above, many other diseases are and can be successfully treated by EMF therapy (Rosch and Markov, 2004).
2. The field of bioelectromagnetic medicine faces an uphill struggle against pharmaceutical cartels with a vested interest in a monopoly for use of their products.
3. Cutting edge research, rigid clinical trials and funding opportunities for bioelectromagnetic therapy research are needed to realize the potential therapeutic value of EMF therapy.
4.

References

Bassett, CAL. 1989. Fundamental and practical aspects of therapeutical uses of pulsed electromagnetic fields (PEMFs). *Critical Review of Biomedical Engineering* 17: 451-529.

Cameron, I.L., Hardman, W.E., Winters, W.D., Zimmerman, S., Zimmerman, A.M. 1993, 'Environmental magnetic fields: influences on early embryogenesis', J of Cell Biochem. 51, 417--425.

Cameron, I.L., Hunter, K.E., Winters, W.D. 1985, 'Retardation of embryogenesis by extremely low frequency 60 Hz electromagnetic fields', Physiol Chem Phys Med NMR. 17, 135--138.

Cameron, I.L., Sun, L.Z., Short, N., Hardman, W.E., Williams, C.D. 2005, 'Daily pulsed electromagnetic field (PEMF) therapy inhibits tumor angiogenesis via the hypoxia driven pathway', Proc Amer Assoc Cancer Res. 46, 1236.

Cameron, I.L., Sun, L.Z., Short, N., Hardman, W.E., Williams, C.D. 2005, 'Therapeutic electromagnetic field (TEMF) and gamma irradiation on human breast cancer xenograft growth, angiogenesis and metastasis', Cancer Cell Int. 5, 23.

Cameron I.L., Short N.J., Markov M.S. 2006. Daily pulsed electromagnetic field therapy inhibits tumor angiogenesis via hipoxia driven pathway: therapeutic implications. In (P. Kostarakis, ed) Proceedings of Forth International Workshop "Biological effects of electromagnetic fields", Crete 16-20 October 2006, ISBN# 960-233-172-0, p.1285-1292.

Hepworth, S.J., Schoemaker, M.J., Muir, K.R., Swerdlow, A.J., van Tongeren, M.J., McKinney, P.A. 2006, 'Mobile phone use and risk of glioma in adults: case-control study', Br Med J. 332, 883--887.

Ivancsits, S., Diem, E., Jahn, O., Rudiger, H.W. 2003, 'Intermittent extremely low frequency electromagnetic fields cause DNA damage in a dose-dependent way', Arch Occup Environ Health. 76, 431--436.

Lankola, A., Auvinen A., Ratanen J., Schoemaker M.J., Christensen H.C., Feychting M., Jahansen C., Klaeboe L., Lonn S., Swerdlow A.J., Tynes T., Salminen T. 2007. 'Mobile phone use and risk of glioma in 5 North European countries' Int.J. Cancer 17; 120(8): 1769-1775

Markov, M. S. 1994. Biophysical estimation of the environmental importance of electromagnetic fields. Review of Environmental Health v.10, # 2, 75-83

Markov, M.S. 2000. Dosimetry of magnetic fields in the radiofrequency range. in (BJ Klauenberg and D Miklavcic, eds.) Radio Frequency Radiation Dosimetry, Kluwer Academic Press, New York, 239-245

Markov, M.S., Williams, C.D., Cameron, I.L., Hardman, W.E., Salvatore, J.R. 2004. Can magnetic field inhibit angiogenesis and tumor growth - In: Rosch P.J. and Markov M.S. (eds.) Bioelectromagnetic Medicine, Marcel Dekker, NY, 625-636.

Markov, M.S. 2006. Thermal vs. nonthermal mechanisms of interactions between electromagnetic fields and biological systems. In S. Ayrapetyan and M. Markov eds.) Bioelectromagnetics: Current concepts, NATO Advanced Research Workshops Series, Springer 1-15.

Markov, M.S., Hazlewood, C.F., Ericsson, A.D. 2005. Systemic effect: A new approach to magnetic field therapy. - The Environmentalist 25, #2/3, 121-130.

Repacholi, M., Saunders, R., van Deventer, E., Kheifets, L. 2005, 'Guest editors' introduction: is EMF a potential environmental risk for children?', Bioelectromagnetics. 7, S2--4.

Rosch, P.J. and Markov, M.S.: 2004, Bioelectromagnetic Medicine, Marcel Dekker, Inc., New York, 880 pp.

Salvatore, J.R., Markov, M.S. 2004. Electromagnetic fields as an adjuvant therapy to antineoplastic chemotherapy. in: Rosch P.J. and Markov M.S. (eds.) Bioelectromagnetic Medicine, Marcel Dekker, NY, 613-624.

Scarfi, M.R., Sannino, A., Perrotta, A., Sarti, M., Mesirca, P., Bersani, F. 2005, 'Evaluation of genotoxic effects in human fibroblasts after intermittent exposure to 50 Hz electromagnetic fields: a confirmatory study', Rad Res. 164, 270--276.

Schüz, J., Bohler, E., Berg, G., Schlehofer, B., Hettinger, I., Schlaefer, K., Wahrendorf, J., Kunna-Grass, K., Blettner, M. 2006, 'Cellular phones, cordless phones, and the risks of glioma and meningioma (Interphone Study Group, Germany)', Am J Epidemiol. 163, 512--520.

Todorov N - *Magnetotherapy* - Sofia: Meditzina i Physcultura Publishing House, 1982: 106 p.

Vijayalaxmi, and Obe, G. 2004. Controversial cytogenetic observations in mammalian somatic cells exposed to radiofrequency radiation. Rad Res 162: 481-496

Wertheimer, N. and Leeper, E. 1979, 'Electrical wiring configurations and childhood cancer', Am Epidemiol. 109, 273--284.

Williams, C.D., Markov, M.S., Hardman, W.E., Cameron, I.L. 2001. Therapeutic electromagnetic field effects on angiogenesis and tumor growth. Anticancer Res 21:3887-3892

Yamaguchi, S., Ogiue-Ikeda, M., Sekino, M., Ueno, S.: 2006, 'Effects of pulsed magnetic stimulation on tumor development and immune functions in mice', Bioelectromagnetics. 27, 64--72.