

Applying Resonant Electromagnetic Fields in Membrane Channels of Tumor Cells: The Future of Cancer Treatment

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ABSTRACT

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Mini Review

The starting point of the results summarized in this brief note is represented by the assumption that electromagnetic fields (EMFs) in the microwaves (MWs) range can interact with the sophisticated electromagnetic circuits of livings, in particular at some frequencies named 'natural resonant frequencies' [1-5]. Resonance phenomenon occurs if a material is forced mechanically, or electrically, or acoustically by an external forcing whose frequency is close to a natural frequency of the system, named natural resonance frequency. As a result, the oscillation of the system is amplified giving rise to very large vibrations that can destroy its structure. In the recent years some studies have shown that conventional methods for cancer treatment, in particular ionizing radiotherapy, often induce several bystander effects [6-16]. Taking a cue from this result, further researcher has been performed in order to investigate the effects of electromagnetic fields (EMFs) on patients affected by cancer. It resulted that the application of EMFs in cancer patients inhibited the disease progression prolonging the survival time of livings affected by cancer [17-22], even if these beneficial effects were not significant nor it was verified whether bystander effect was produced by this treatment.

Otherwise, resonance characteristic has led many scientists to hypothesize to use this phenomenon for inducing harmful effects on cancerous cells without damaging nearby healthy cells, avoiding bystander effect. To this aim, recent studies proposed a model to calculate natural resonant frequencies of cancer cells, so that an applied external EMFs working at one of such frequencies can interact with the system inducing resonance, damaging only cancer cells. Nevertheless, no experimental application of such theoretical models has been carried out up to now. Indeed, these models are based on civil engineering parameters like elasticity and tensegrity structures of a building in order to search different natural frequencies from that of an earthquake [23]. Starting from this point of view, other researchers assumed that the natural frequencies of cells would depend on mechanical properties such as elastic modulus, Young's modulus, density and shape of the cell, in order to search differences from natural frequencies of cancer cells [24,25]. Nevertheless, such models schematize cells by mechanical properties that cannot be considered representative in order to search natural frequencies of cancer cells, because cells are made up of billions of molecules each having its resonant frequency, so that a unique resonant frequency of a cell cannot be considered.

Anyway, we should make a choice. We should state what physical chemical mechanism can be considered as the most important among cellular functions, in order to search a resonance between this mechanism and an applied EMF aimed to damage cancer cells. This mechanism is the ions flux across cellular membrane channels. Indeed, it have been demonstrated that such mechanism has a relevant role in cellular functions of cancer cells as it can regulate cancer's initiation, progression and proliferation [26-31]. Indeed, ions flux alteration in cells membrane channels is induced by pharmacological therapy such as chemotherapy or immunotherapy for cancer treatment. Nevertheless, significant bystander effects are induced by such treatments, as specified at the top of this note. However, it was shown that displacement of proteins' α -helices in cells membrane channels are induced also by EMFs so that ions flux across cellular membrane channels change [32-34]. Hence, the authors of Ref.[32-34] have taken a cue from this result hypothesizing to emphasize this mechanism using EMFs at a frequency close to a natural resonant frequency of cellular membrane channel in cancer cells, inducing an amplification of change in ions flux across channels and a significant damaging of cancer cells. Otherwise, it was also demonstrated that there is a correlation between the displacement of cell channels α -helices and the frequency of an applied high frequency EMFs confirming this scenario [35].

In addition, a significant inverse relation between the mitochondrial transmembrane potential and the α -helices polarization was observed in SH-SY5Y neuroblastoma differentiated cells after exposure to a magnetic field associated to time exposure. Hence, another proof was provided represented by the result that an orientation of N-terminal helix in the Voltage Dependent Anion Channel (VDAC) is induced by a magnetic field even at low intensity, causing the channel to be prevalently in the open state. In addition, the mitochondrial transmembrane potential was observed to decrease because of decreasing in concentration gradient between outer and inner regions of mitochondrial membrane, following the Nernst-Planck equation [36]. This result also confirms the great dependence between EMFs and the displacement of proteins α -helices forming the walls of cellular membrane channels, a phenomenon that should be amplified at a resonant frequency. Neither healthy neighboring cells would be damaged, as they should have natural resonant frequencies different from those of cancer cells, unlike what happens in other cancer treatments. In conclusion, the results obtained so far in this topic, that were briefly summarized here, should encourage to continue research in this direction, leading to think that this may be the future of cancer treatment, or at least an adjuvant treatment to traditional cancer therapies.

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