Cancer Prognostics and Diagnostics

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Research Article

Analysis: Human Mammary Carcinoma (MCF-7/HTB-126) Cell Studies Suggest Possible Target-Specificity of Nonionizing Magnetic Fields

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Abstract

Background: The literature is reviewed briefly concerning the possible biological effects of non-ionizing radiation, including picoTesla magnetic resonance energies.

Methods and Materials: To study the possible effects of picoTesla electromagnetic fields on mammary carcinoma cell populations (MCF-7/HTB-126) in-vitro. Helmholtz coils were prototyped and characterized. To evaluate the potential for magnetic resonance target-specificity, a novel particle-wave equation, mc2=BvLq, was utilized for calculation of the flux densities, and cyclotron resonance, f= qB/2πm was utilized to calculate correspondent frequencies for specified target molecules of relevance: telomeres/ telomerase.

Results: PicoTesla range magnetic resonance protocols, including multiple frequency and multiple amplitude schedules diminished the viability and/or proliferation rate of MCF-7/HTB-126 cell populations, by 31%-35% over (7) replicate studies with only 2.5 hours of exposure time compared to negative reference controls. Additionally, mRNA expression profiles were altered, also yielding differences in membrane-associated complexes.

Discussion: Theoretical evaluation of a novel magnetic resonance approach to cancer includes the possibility that telomerase inhibition was induced via telomeric stabilization with a non-ionizing, non-invasive methodology.

Conclusion: While still in its infancy, magnetic resonance therapy holds promise to possibly target critical molecular species non-invasively, indicating need for ongoing research.

Keywords: *PicoTesla Magnetic Resonance, Target-specificity, Cancer, Photon-Phonon Transduction Piezoelectric Effect, Telomeres and Telomerase Inhibition*

Background

There has been a prevailing view in the engineering and physical sciences that non-ionizing electromagnetic fields (EMF's), below the kT level of photonic energies, cannot induce biological effects. Thermodynamic models have indicated that only energies producing heating can affect living systems [1]. However, over the past 30 years a plethora and diversity of basic science studies have indicated a contrary view. Some examples of studies using low level, extremely low frequency EMF's include: enhanced DNA synthesis [2], alterations in RNA transcripts and translated proteins [3-5], changes in the growth related enzyme ornithine decarboxylase [6], increased cytotoxicity of t-lymphocytes [7], alterations in ionic membrane channeling [8,9] and modulation of developmental processes [10].

More particularly, the magnetic fields of a nerve impulse, magnetic profiles associated with human brain waves and the heart have been measured with superconducting quantum interference detectors (SQUIDs) or atomic magnetometers to be in the range of about 0.5 picoTesla to about 100 picoTesla (PT) [11,12]. One PT is about 50 million times weaker than the geomagnetic field, at about 5 x 10^{-5} Tesla. Yet, these investigators believed they were measuring magnetic noise emanating from stronger interactions occurring within bodily tissues. Nevertheless, based upon a novel particle-wave equation mc^2=BvLq, theoretical analysis indicates the possibility that PTEMFs are physiologic, and various positive experimental outcomes appeared to support this hypothesis [13-17]. Studies included regulation of heart rate and rhythmicity in canine models, revealing a potential for suppression of atrial fibrillation inducibility [18,19], faster and more substantial healing of sutured and non-sutured wounds in rats [20], regeneration of nerve ultrastructure, including myelin sheath, axonal membrane, mitochondria, neurofilaments, microtubules and Golgi bodies of Schwann cells in mice, after poisoning with neurotoxins; and with concomitant restored functionality as measured by a force gauge meter [14], reported positive clinical studies in epilepsy [21,22], Parkinson's disease [23] and multiple sclerosis; [24] and diminished viability and/or proliferation rate of mammary carcinoma cells in vitro [13]. Yet, the initial physical mechanism is considered to be unknown, while various hypotheses have been proposed by a number of investigators [25-29].

It appeared that only quantum mechanics, which is concerned with a totality of systems and not the single process, could yield a possible explanation. In this theory, very small perturbations may

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Received: November 16, 2016; **Accepted:** December 13, 2016; **Published:** December 16, 2016

affect a totality of systems in the physical condition of a system to provide responses of great magnitudes. Indeed, the possibility of photon-phonon transductions, representing the single process might explain amplifications of weak triggers by a factor of 10^{12} [30].

Further to this end, it was hypothesized that the equation, mc^2=BvLq, might account for the demonstration of possible target-specificity in a dual resonance model. This hypothesis was tested in-vitro with MCF-7/HTB-126 cell populations and represents the purpose of this review: to analyze the various possibilities relating to the fundamental mechanism of interaction [13].

With consideration given to the current level of interest in telomerase inhibition in actively dividing cancer cells, we propose a possible, novel and holistic approach in this regard, utilizing non-ionizing EMFs based in magnetic resonance theory [13,30, 31-34].

Methods and Materials

In order to study the potential effects of picoTesla range EMFs on human mammary carcinoma cell populations in 48 well tissue culture plates, we utilized a magnetic field delivery system that could provide homogeneous isotropic fields. Helmholtz coils 22 inches in diameter were prototyped and characterized by NASA engineers at the Stennis Space Center in Mississippi. An HP 3345 power generator was connected in series to a high resistance attenuator to reduce the strength of the electrical current by a factor of one million; whereas the attenuator connected in series to the Helmholtz coils provided the specified coil current to establish the particular flux densities and frequencies for protocols. Protocols were established utilizing the Jacobson Magnetic Resonance equation, mc^2=BvLq [13-17, 35-38].

The method of calculation utilizes then specific target molecular masses considered relevant to the model in question. Wherein, the intrinsic/rest energy of the mass m is equal to mc^2, when C is the velocity of light. A dual resonance system is established by setting mc^2 equal to BvLq, where B is the magnetic flux density, V is the inertial constant velocity motion of the Earth, 3×10^6 cm sec^{-1}, L is the longest dimension of a human, about 177cm, and q is normalized as a single ab-coulomb in the CGS system of physical units. BvLq represents the electromagnetic interaction energy, i.e. wave energy. The hypothetical construct assumes that a photon-phonon transduction will occur, thus involving a coherent excitation of the targeted mass to therein affect the collection of said targets. The rationale for using the Earth's orbital velocity is that the organism will move at this constant velocity motion while the force carriers (photons) of the magnetic field will move at the speed of light, independent of the coordinate system of reference, i.e. the source; noting that Newton's laws of motion do not distinguish between celestial and terrestrial velocity. And as per Einstein's Special Theory of Relativity [14,17,44], electromagnetic radiation travels at speed C independent of its inertial frame of reference. Normalization of charge is established by defining electromotive force as energy per unit charge. Furthermore, the total length of the human organism is chosen for calculation based upon empirical observation that specific tissues, while separated from the whole organism, maintain flux density profiles. Theoretically, this observation is construed to be a result of magnetic resonance harmonies, and was noted to be the case in nerve growth and repair studies conducted at the Weil Medical College of Cornell University. During this study, sections of sciatic nerves were studied in-vitro, whereas the integrity of same was noted as a result of magnetic field immersion. These sections grew longer and wider, while unexposed nerve segments degenerated [14].

Thus, sinusoidal waveforms were utilized with Master schedules consisting of several signal parameter sequences within the picoTesla range. Correspondent extremely low-frequencies were established using the ion cyclotron resonance equation

$$f = qB/2\pi m.$$

Targets of relevance included cytokines: IL-1α, IL-1β, IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IFN-α, IFN-β, IFN-δ, TNF-α, TNF-β (lymphotaxin), peptide trophic factor NGF, P53, as well as integral multiples of the telomeric prime unit TTAGGG, and various proteins contained in the telomerase enzyme. Investigations included twenty multi-frequency PTEMF schedules screened for their ability to alter the viability and/or proliferation rate of human mammary carcinoma cell populations (HTB-126 and MCF-7) in multi-well tissue culture plates. Proteomics studies at Mississippi State University employed 2D-PAGE analysis and LC/mass spectrometry methods and detected a range of biological proteins produced by breast cancer cell types that have specified expression profiles that were studied [13,14,17].

Results

Two out of twenty multi-frequency picoTesla electromagnetic field protocols consistently diminished the viability and/or proliferation rate of MCF-7/HTB-126 cell populations over seven replicate studies, compared to negative reference controls, the level of diminution ranging from 31%-35%. It is of importance to note that the cancer cells were only exposed to the protocols for 30 minutes each time, whereas five exposure sessions to the PTEMF schedules were accomplished within a week. The negative reference controls were placed into the magnetic field device in the same fashion without the device being turned on. Thus, the total exposure time was 2.5 hours. It is relevant to note that empirical testing had revealed a more profound biological effect the greater the time of exposure. For example, for the in-vivo radial nerve regeneration studies in mice at Cornell, the total exposure time was 17 hours during a course of 8.5 weeks. A profound effect was noted in this study in terms of restoration of nerve ultrastructure [13,14]. The implication is that with greater exposure time, the biological effect may have been greater.

More particularly, membrane-associated complexes were noted to be expressed at elevated or decreased levels in MCF-7 cell populations; and several mRNA sequences (n=3) detected were observed to be expressed at elevated levels (n=1) or expressed uniquely (n=2).

Considering the collective interpretation of these preliminary experimental findings, it was possibly revealed that a multi-frequency picoTesla range protocol may have diminished the viability and/or proliferation rate of MCF-7/HTB-126 cancer cells. Additionally, alterations of expression profiles were noted in cytosol-soluble as well as membrane associated protein fractions. Transcription of mRNA sequences were noted and these alterations appeared to vary when experimental samples were quickly processed following the final exposure session.

Different and somewhat more subtle changes were noted when there was an intentional delay in preparation of samples. Perhaps maximum alterations occurred during or shortly after the exposures. There were also differences in the outcome when single signal sets, i.e. flux density and frequency, were utilized instead of a complete protocol containing multiple signal sets. It appears that these preliminary studies may serve as a foundation for future studies. Exposure times, variation of effects from dose-response studies, possible concomitant effects from other molecular species of approximately the same molecular mass as targeted masses and identification of other critical signal sets are some of the concerns for future research [13,17].

Discussion

The human body may be considered a veritable world comprised of trillions of atomic structures, organized and incessantly communicating via electromagnetic waves to retain global functionality. The multitude of interactions are in constant flux about a steady state system. As such, reversible processes are possible ostensibly as part of a global

electromagnetic defensive system. Whereas, the congealing of atomic structures creates the molecular species and aggregations thereof to create a biochemical immune system. Yet, all the while electromagnetic forces capable of long range communication maintain this global integrity, while stochastic mechanisms remain short range and key-lock in nature. It is hypothesized that various biological structures having uninterrupted reticulum may be piezoelectric, that is they convert EM oscillations to mechanical vibrations and vice versa, which might represent that connection between EM waves and biochemical events. And, this notion may lead to some understanding of telomeric relevance, i.e. our biological clocks [31-34].

It has been suggested by some investigators that examples of piezoelectric structures might include keratin, collagen, bone, and proteins having nearly polyhedral spherical geometry, possibly rendering them quesi-crystalline, e.g. alpha helices and beta sheaths [27,37]. Specialized cells sensitive to heat, pressure and sound may convert such energies into the electrical energy of neuronal impulses [15]. Perhaps DNA is piezoelectric? If so, the non-coding telomeres which are end-stops for chromosomes may communicate via electromagnetic waves. Telomeres are bound by single and double-strand DNA binding protein, and as they shorten with cellular divisions as a result of lagging strand DNA synthesis telomeres and the binding protein may communicate via EM signals secondary to quantum entropy; and as a result of oxidative damage and end processing events. In other words, there may be a photon-phonon transduction system responsible for communicating errors at the domain walls of chromosomes, which increases alterations in the rest of the DNA. This notion presumes the piezoelectric nature of DNA/protein structures. If the foregoing is true, then EM targeting of telomeres/telomerase could prove effective [17,31-34].

In accordance to the method and theory outlined previously, we may speculate that targeting telomeres and/or telomerase to imbue coherent excitation of energetic states may result in the desired outcome, i.e. telomerase inhibition in actively dividing cancer cells. But, it appears likely that the quantum environment would dictate a positive or negative outcome. Thus, we see the necessity for empirical study and a multiplicity of replicate analyses. Nevertheless, a diversity of studies have revealed a predictability for the method, and further explication is required.

Suggested Target Masses for Magnetic Resonance Research

Without additional cellular alterations, DNA damage signals accompany telomere shortening, and one might expect tumor suppression. Senesence, including oncogene-induced senesence, generally stops cells from proliferating with progression to neoplasia. Yet, in the presence of specific cell-cycle regulatory pathway alterations, e.g. Inactivation of P53 and the P16/pRB pathways, cells can continue to divide with telomeres that are critically shortened. These cells still exhibit activated DNA damage. This is a bypass of senescence termed MI, and the result is an extended lifespan. With continued progression of telomeric shortening, end-end chromosomal fusions may then occur which produce chromosomal- breakage-fusion bridge cycles termed M2 or crisis. This condition represents a hallmark of cancer. Therein, cells are balanced between life and death, wherein certain rare cells are then encouraged to continue their growth, in spite of having terminally shortened telomeres [31-34].

These rare cells that continue to proliferate manifest both telomere stability and reactivation of telomerase. It appears sensible to speculate that such rare cells with extensive DNA damage and critically shortened but stabilized telomeres have superseded the normal cell's defensive mechanism of telomerase up-regulation. Then, if magnetic resonance energies can target telomeres to stabilize them, perhaps telomerase inhibition would result. The question would then become: Would telomerase inhibition be produced with magnetically stabilized telomeres to stop the growth of these rare cells? And, would tumor suppression result from said telomerase inhibition, in addition to encouraging such cells to die?

In order to answer the foregoing conundrum, we shall first consider how to target the telomeric prime and multiples thereof.

The telomere prime unit is TTAGGG, equal to 1,681.032 dalton (Da). Note $1\,Da = 1.67\times10^{-24}\,gm$.

Given $mc^2 = BvLq$,wedesire

$$\left(1,681.032\,Da\right)\left(1.67\times10^{-24}\,gm\right)\left(9\times10^{20}\,cm^2\,\sec^2 = mc^2 = \left(B\right)\right)$$

$$\left(3\times10^{6}\,cm\sec^{-1}\right)\left(177cm\right)\left(1ab-coulomb\right) = BvLq$$

And, $B = 4.7581\times10^{-9}$ Gauss or 0.47581 PT

~ 0.5 PT was measured with atomic magnetometer to be associated with alpha brain waves, inferring that the human body maintains harmonics of EM frequency [13,14,16].

And, $mc^2 = BvLq$ notates normalization of electric charge q as 1 ab-coul in CGS. To convert to MKS(SI) we see $mc^2 = BvLq$ (10q), because 10 coulomb = 1 ab- coulomb. Therefore, when employing cyclotron resonance, an SI expression, we must utilize:

$f = 10qB/2\pi m$, and we note:

$$f = \frac{\left(10\right)\left(1.6\times10^{-20}\,ab-c\right)\left(4.7581\times10^{-9}\,Gauss\right)}{\left(6.2832\right)\left(9.11\times10^{-28}\,gm\right)}$$

Whereas, $f = 0.133Hz$

Recalling, q is the charge of an electron and m is its mass.

Additionally, we note the CGS system is utilized, because in CGS force is measured between stationary charges, and in MKS force is measured between moving charges [13,14].

It is now hypothesized that integral multiples of the telomeric prime unit may possibly be related to molecular species of critical concern. While the foregoing speculation may be fortuitous, we note Table I which lists said integral multiples. We note that human length chosen, L=177 cm, merely represents a somewhat arbitrary average. Nevertheless, we see correlations of integral multiples of the telomere prime to cytokines, growth factors and p53, targeted masses in our cancer cell study. Protocols utilized to treat MCF-7/HTB-126 cell populations began with the stronger B fields and incrementally decreased to the weaker, lower frequency B fields. One protocol utilized started with Table I, #32 (15.22 PT @4.2615 Hz) targeting p53, and worked incrementally down to #7 (3.33PT @0.932 Hz) The other protocol started with Table I, #16 (7.613 PT @2.13 Hz) targeting cytokines and NGF as it worked its way down incrementally to #4. [3,17]

It is suggested that magnetic domain walls within the telomeric chain may be responsible for correlation of critical mass targets, i.e. energy domains.

It is interesting to note the example of H-ras and V-src whose expression profiles in PC-12 cells is seen to result in mitotic arrest and neuronal differentiation. This may be compared to induction by nerve growth factor. Peptide hormone trophic factors do indeed share a common mechanism of interaction with oncogene protein of viruses [40]. Rita Levi Montalcini [41] noted that whenever cellular death of specific populations of neurons is connected to growth factor availability such as NGF, (the exogenous supply or endogenously

produced) this observation may offer a glimpse into new approaches to presently incurable diseases.

Conclusion

While magnetic resonance therapy utilizing picoTesla range fields is still in its infancy, the diversity of positive experimental outcomes thus far possibly indicates a new path of study. This path includes a potentially holistic, non-invasive and safe methodology. It is hoped that researchers will examine the literature and take up this clarion call for continuing research utilizing non-ionizing radiation.

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