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On the Possibility of Treating Oncological Diseases by Exposing the Diseased Cells of the Body to the Variables of Electromagnetic and Acoustic Fields of Low Frequency

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ABSTRACT

It has been strictly analytically proved that there is a possibility of an external low- frequency EM field and resonant acoustic field influence on oncological diseases so that to destroy the diseased cells of the body. A numerical estimate of the frequency range in which this is carried out is given.

Keywords: Low-Frequency EM Field; Acoustic Influence; Frequency Range

Introduction

In previous author's works (see [1-3]) we investigated some individual cases of the manifestation of the body's reaction to the influence of external variables of electromagnetic (abbreviated – EM) fields. In this paper we will continue our research in this direction and try to answer the question of finding the frequency range in which the destruction of the affected cells is possible. In this message we will expand the search a bit and consider acoustic fields along with an alternating electric field. As we will see later there is a certain frequency range in reality when such a possibility is realizable. It is also worth noting that when any magnetic additives for example iron or manganese are artificially introduced into the body cell structure affected by oncology the reaction of these cells to the alternating magnetic field becomes much more effective. At the same time the same natural question arises: is it possible to find such a frequency range of the external alternating magnetic field so that the affected cells begin to collapse as well as in the result of exposure of the body to alternating electric and acoustic fields? It would be biased on our part not to say that work was carried out in this direction but in the vast majority it was purely experimental research. However, although a number of works are theoretical in nature (see for example [4-11]) the approach discussed below allows to find specific values of "therapeutic" frequencies. Further on we will focus on the study of the effects on the body of electric and acoustic fields only and we will not consider the magnetic field yet.

Interaction of Cells with an Electric Field.

Consider this situation. Let a constant electric field E_0 affect the body for a certain period of time Δt . Time Δt is defined as the time of occurrence of a polarizing moment p induced in each affected cell by a constant and uniform field E_0 . This means that if the body is additional exposed to the alternating field.

$$\mathbf{E}'(t) = \mathbf{E}_0' \, coswt \, , \quad (1)$$

where $\mathbf{E}_0'$ – is its amplitude and w – is the frequency the induced dipole moments dc will begin to oscillate. The lower index c indicates that we are talking about a diseased cell. The connection of the dipole moment vector with polarization as it is known [12] is determined in our case by the dependence.

$$\mathbf{d}c = \mathbf{p}Vc, \quad (2)$$

where Vc – is the volume of one cell. Based on the motion equation $m\mathbf{a} = \mathbf{F}$ where m – is the mass of the cellular matter exposed to the electric field and the force acting on it is determined by the expression

$$\mathbf{F} = q\mathbf{E}'(t), \quad (3)$$

where q – is the charge induced by the field E_0 in accordance with the dependence (1) we have

$$m\ddot{r} = qE'_0 \cos wt$$

Integrating this equation twice over the time we find

$$r(t) = r_0 - \frac{qE'(t)}{mw^2}, \quad (4)$$

where r_0 – is one integration constant. The second constant is set to zero. It follows from (4) that the dipole moment according to the definition of [13] but in relation to our problem is

$$\mathbf{d}_c = q(\mathbf{r}(t) - \mathbf{r}_0) \, .$$

That is

$$\mathbf{d}_c = \frac{q^2 E'(t)}{mw^2}, \quad (5)$$

Hence the internal energy of the cell resulting from the superposition of both electric fields based on the general definition of [12] namely $E_1 = -\mathbf{d} \cdot \mathbf{E}$ according to (1) and (5) will be

$$H_1 = -\mathbf{d} \cdot \mathbf{E} = \frac{q^2 E'^2(t)}{mw^2}. \quad (6)$$

Taking also into account the energy of the cell surface tension α_c which should keep it from disintegrating the total energy taking into account (6) may be represented as

$$\varepsilon = \frac{q^2 E'^2(t)}{mw^2} + \alpha_c S_c \quad (7)$$

where S_c – is the total cell surface area. We will introduce the average density of the diseased cell ρ_c into consideration and we will consider it a sphere with radius R_c for simplicity. As a result, the total energy (7) may then be rewritten as follows:

$$\varepsilon(t) = \frac{3q^2 E'^2(t)}{4\pi\rho_c R_c^3 w^2} + 4\pi\alpha_c R_c^2 \quad (8)$$

Where it was taken into account that the sphere area is $S_c = 4\pi R_c^2$ and its volume is

$$V_c = \frac{4\pi R_c^3}{3}.$$

Further averaging the energy (8) over the oscillation period $T = \frac{2\pi}{W}$ which in accordance with (1) allows to simply replace the cosine squared with a multiplier $\frac{1}{2}$ we find for its average value:

$$\varepsilon = \frac{3q^2 E_0'^2}{8\pi\rho_c R_c^3 w^2} + 4\pi\alpha_c R_c^2. \quad (9)$$

To find the full force acting inside the cell expression (9) should be differentiated by radius R_c. As a result, we

$$\overline{F} = -\frac{\partial\overline{\varepsilon}}{\partial R_c} = \frac{9q^2 E_0'^2}{8\pi\rho_c R_c^4} + -8\pi\rho_c R_c. \quad (10)$$

Based on the condition $\overline{F} \geq 0$ we find the threshold value of the frequency at which the cell destruction process should occur

$$w_0 \leq \frac{3qE_0'}{8\pi\sqrt{\rho_c\alpha_c R_c^5}} \quad (11)$$

Formula (11) answers the first question about the theoretical possibility of the external electric field influence on oncological diseases. Upper frequency threshold (right side in (11))

$$w_{th} \leq \frac{3qE_0'}{8\pi\sqrt{\rho_c\alpha_c R_c^5}} \quad (12)$$

may be estimated based on the following numerical values of the parameters. The cell density may be set equal to the water density that is $\rho_c = 1\frac{g}{cm^3}$ we will take the surface tension the same as for water $\alpha_c = 74\frac{erg}{cm^2}$ the cell radius $R_c = 100nm = 10^{-3}cm$ the induced charge $q = Ze \sim 4,48.10^{-9}SGS, Z = 10$ and we will set the value of the alternating external electric field amplitude to $E_0' = 10^3 SGS$. Substituting all these values into the formula (12), we come to the following estimate for the threshold frequency

$$w_{th} = \frac{3ZeE_0'}{8\pi\sqrt{\rho_c\alpha_c R_c^5}} = \frac{3.10.4,48.10^{-9}.10^3}{8\pi\sqrt{1.74.10^{-15}}} \approx 20s^{-1}. \quad (13)$$

Such a frequency in the case of EM oscillations corresponds to approximately a kilometer wavelength range.

It is worth emphasizing that since both healthy and diseased cells are quite close in physical parameters great caution should be exercised here and it is necessary previously purely experimentally determine all the physical indicators of oncological and healthy cells. After that it will be possible to say quite definitely which specific frequency not affecting healthy cells should lead to the death of the diseased cells.

Acoustic Influence

In order to assess the influence of an acoustic wave on the cell we will proceed as follows. Let $\xi = \xi(x, y) -$ be the deviation of the cell surface points associated with an external acoustic influence from some of its average value R_c. As a simple approximation we will consider the cells to be ideal spheres of radius R_c. If the cell surface tension is denoted as α_s (in dimension this is the energy attributed to the unit of its surface) and the surface density as ρ_s which is defined in the usual way in the form $\rho_s = \frac{dm}{ds}$ where $dm -$ is the mass of cellular matter in the surface layer dS. Then the total internal energy of the cell may be represented as the following additive expression:

$$\varepsilon = \frac{1}{2}\int_{S_c} \rho_s \dot{\xi}^2 ds - \int_{S_c} \alpha_s ds, \quad (14)$$

where $\dot{\xi} = \frac{\partial \xi}{\partial t}$, $S_c -$ is the cell surface. Since we have the right to represent the surface element in the form

$$ds\sqrt{1+\xi_x^2+\xi_y^2 dxdy}, \quad (15)$$

Where $\xi_x = \frac{\partial \xi}{\partial x}, \xi_y = \frac{\partial \xi}{\partial y}$. Then provided that the surface deviation is slight compared to the radius that is

$\xi << R_c$ we have the right to represent expression (15) as a decomposition

$$dS = \sqrt{1+\xi_x^2+\xi_y^2}dxdy \approx \left(1+\frac{\xi_x^2+\xi_y^2}{2}\right)dxdy. \quad (16)$$

Omitting an insignificant constant, we write expression (14) taking into account (16) in a more general form assuming that the shift ξ is a vector ξ

$$\varepsilon = \frac{1}{2}\int_{s_c}\left[\rho_s\left(\frac{\partial \xi}{\partial t}\right)^2 - \alpha_s\left(\left(\frac{\partial \xi}{\partial x}\right)^2 + \left(\frac{\partial \xi}{\partial y}\right)^2\right)\right]dxdy. \quad (17)$$

Finding the variation of functional (17) by ξ and setting it to zero we come to the equation

$$\rho_s\ddot{\xi} - \alpha_s\Delta_2\xi = 0. \quad (18)$$

where $\ddot{\xi} = \frac{\partial^2 \xi}{\partial t^2}$ and $\Delta_2 -$ is the two-dimensional Laplace operator that is $\Delta_2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ In equation (18) it is also necessary to take into account the external force which should appear in its right part. In the hydrodynamic approximation given that a human body is eighty percent water the role of this force should be reduced to a pressure gradient (see [9]) which eventually leads to the acoustic influence we are interested in.

That is instead of (18) the equation should be written

$$\rho_s\ddot{\xi} - \alpha_s\Delta_2\xi = -\frac{\rho_s}{\rho_c}\nabla P, \quad (19)$$

where $\rho_c -$ is the cell density.

Since $\nabla P = \left(\frac{\partial P}{\partial \rho}\right)_\sigma \nabla \rho'$, where $\sigma -$ is the entropy, $\rho' -$ is the density deviation in the sound wave. Then assuming that

$$\rho' = \rho_0' \cos t\left(\omega t - k.r\right), \quad (20)$$

where $\omega -$ is the frequency, $k -$ is the wave vector, and $\rho_0' -$ is the amplitude of the sound wave we get from eq. (19)

$$\ddot{\xi} - \frac{\alpha_s}{\rho_s}\Delta_2\xi = -k\left(\frac{\partial P}{\partial \rho}\right)_\sigma \frac{\rho_0'}{\rho_c}\sin\left(\omega t - k.r\right). \quad (21)$$

Choosing vector ξ in the radial direction and assuming that the wave inside the cell is homogeneous that is its length λ significantly exceeds the linear size of the cell R_c and this in turn allows to assume that the length of the wave vector may be represented in the form $k = |k| = \frac{2\pi}{\lambda} = \frac{2\pi}{L}$ where the length parameter L is the degree of uniformity of the sound field. As a result, according to the above equation (21) reduces to the form specified below for radial displacements:

$$\ddot{\xi} - \frac{\alpha_s}{\rho_s}\Delta_2\xi = -\frac{2\pi}{L}\left(\frac{\partial P}{\partial \rho}\right)_\sigma \frac{\rho_0'}{\rho_c}\sin \omega t. \quad (22)$$

The partial derivative appearing here may be transformed as follows. We will proceed from the state equation of an ideal gas [8] according to which $PV_c = k_s NT_c$, where $k_B -$ is the Boltzmann constant, $N -$ is the number of particles, and $T_c -$ is the temperature of the cell. Modifying the Clapeyron-Mendeleev equation for our case we may write that

$$P = k_B T_c \frac{\rho_c}{m_c} \quad (23)$$

where $m_c -$ is the effective mass of the inner part of the cell. Based on the formula

$$\left(\frac{\partial P}{\partial \rho}\right)_\sigma = \frac{\left(\frac{\partial P}{\partial \rho}\right)_T}{1 - \frac{T}{C_p}\frac{\rho}{V}\left(\frac{\partial P}{\partial \rho}\right)_T \left(\frac{\partial V}{\partial T}\right)_P^2} \quad (24)$$

where C_p − is isobaric heat capacity taking into account the dependence (23) we obtain

$$\left(\frac{\partial P}{\partial \rho}\right) = \frac{k_B T_c}{m_c\left[1 - \frac{T_c}{C_p}\frac{\rho_c}{V_c}\frac{P}{\rho_c}\frac{V_c^2}{T_c^2}\right]} = \frac{k_B T_c}{m_c\left(1 - \frac{N}{C_p}\right)} = \frac{k_B T_c C_p}{m_c C_v} = \frac{P}{\rho_c}\frac{C_p}{C_v}, \quad (25)$$

where C_V − is the isobaric heat capacity. For the cell we may assume that

$$C_V = C_p \quad (26)$$

Thus, according to (25) and condition (26) equation (22) may be rewritten as

$$\ddot{\xi} - \frac{\alpha_s}{\rho_s}\Delta_2 \xi = -\frac{2\pi}{L}\frac{P}{\rho_c}\frac{\rho_0'}{\rho_c}\sin \omega t. \quad (27)$$

Further using the approximation $\Delta_2 \xi \approx -\frac{\xi}{R_c^2}$ which "works" well for a spherical surface when it comes to the matter surface oscillation, we come to the equation below instead of (27)

$$\ddot{\xi} + \omega_0^2 \xi = -A \sin \omega t, \quad (28)$$

where the amplitude is

$$A = \frac{2\pi}{L}\frac{P}{\rho_c}\frac{\rho_0'}{\rho_c}. \quad (29)$$

And the natural frequency of the cell surface oscillations

$$\omega_0 = \frac{1}{R_c}\sqrt{\frac{\alpha_s}{\rho_s}}. \quad (30)$$

The resonant solution of equation (29) is found trivially and as a result we find

$$\xi = \frac{2A\gamma\omega_0}{(\omega_0^2 - \omega^2)^2 + 4\gamma^2\omega^2}\cos \omega t, \quad (31)$$

where we have formally introduced attenuation γ which must satisfy the condition

$$\omega >> \gamma. \quad (32)$$

At resonance the wave amplitude appearing in solution (31) takes the value

$$B = \lim_{\omega \to \omega_0} \frac{2A\gamma\omega_0}{(\omega_0^2 - \omega^2)^2 + 4\gamma^2\omega^2} = \frac{A}{2\gamma\omega_0}. \quad (33)$$

Let's estimate the values of frequency ω_0 and amplitude B. According to (30) we have

$$\omega_0 = \frac{1}{R_c}\sqrt{\frac{\alpha_s}{\rho_s}} \approx \frac{1}{10^{-3}}\sqrt{\frac{74}{1}} \approx 8.6.10^3 s^{-1}. \quad (34)$$

And according to (29) and (33) we get

$$B = \frac{A}{2\gamma\omega_0} = \frac{\pi}{L}\frac{P}{\gamma\omega_0\rho_c}\frac{\rho_0'}{\rho_c} \quad (35)$$

In the CGS system the pressure may be set equal to $P = 10^4 SGS$. The attenuation based on the inequality (32) and the estimate (34) let be equal to $\gamma = 10 s^{-1}$. The length of the inhomogeneity may be set equal to the linear size of the cell that is $L = 2R_c$.

Thus, we will have from (35)

$$B = \frac{\pi}{L}\frac{P}{\gamma\omega_0\rho_c}\frac{\rho_0'}{\rho_c} \approx \frac{\pi}{2.10^{-3}}\frac{10^4}{10.8,6.10^3.1}\frac{\rho_0'}{\rho_c} \sim 10^2 \frac{\rho_0'}{\rho_c}(cm).$$

It may be seen that for a real ratio $\frac{\rho_0'}{\rho_c} \sim 10^{-3}$ the amplitude will be about one tenth of a centimeter which significantly exceeds the cell size that is leads to its rupture.

Conclusion

Concluding this message, we note.

1. It is shown that at a frequency close to the ultrasonic threshold (formula (30)) acoustic oscillations may well lead to the destruction of the diseased cells.

For the alternating electric field, the frequency must be extremely low, that is the EM wavelength is very large and that practically allows us to deem the applied electric field to be simply homogeneous.

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