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Magnetism in Medicine:
ONDAMED - A New Diagnostic and Therapeutic Modality

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ABSTRACT

We review magnetism´s influence on human beings as well as its physical properties, mechanisms of action and physiological effects on the organism. We present a new structural cellular model, forming conducting microcircuits through which electrons flow; these are assumed to be responsible for cellular and organ interactions and for biochemical processes and nerve conduction. We comment on the electromagnetic diagnostic and therapeutic devices which are used in medicine and the potential for growth in this area. We introduce ONDAMED, a diagnostic and therapeutic equipment that relies on pulsed electromagnetic fields, which has proven to be effective and safe after being in use in Europe for 20 years.

Key words: *Magnetism, electromagnetic fields, living matrix, ONDAMED.*

BACKGROUND AND EVOLUTION

Much of the progress in medicine has relied on contributions from scientists and researchers in other natural science fields. One example of this is the discovery of a type of electromagnetic radiation, X-rays, by Wilhelm Conrad Röntgen in 1895. Development in this field has been fast and the joint work of physicists, engineers and physicians have enabled the creation of sophisticated technologies such as electron beam computed tomography (EBCT), nuclear magnetic resonance (NMR), functional magnetic resonance (FMR) and magnetic source imaging techniques such as magnet-oencephalography (MEG).[1]

However, it is interesting that the medical community accepts these diagnostic devices with astonishment and at the same time, when used for therapeutical purposes, questions and rejects the biological effects of the same physical principles on which these technologies are based. It is possible that thisis due to the aura of mystery that has surrounded magnetism since its discovery, among other reasons.

Knowledge of magnetism began to appear around 1200 B.C. with iron smelting and the identification of what would later be referred to as lodestone or magnetite. The first treaty on magnetized needles and their properties was published by Petrus Peregrinus in 1289. It established the basic principles of magnetic forces:

1) they act at a distance;

2) they only attract magnetic materials; 3) like poles repeal each other and opposite poles attract each other and 4) northern poles point towards the north and southern poles to the south. His contributions include the astrolabe with which European navigators travelled the world discovering and conquering territories.[1]

References associating magnetism to medicine date back to Thales de Miletus (624-547 B.C.) and Hippocrates (460-360 B.C.). Unfortunately, wonderful cures to medical, psychiatric and surgical problems were attributed to magnetic

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activity. Still today, the pretension of various magnet therapy modalities without solid scientific support contrast with the enormous progress of physics in understanding these natural phenomena and the development of diagnostic and therapeutic uses in the field of medicine. The latter was possible thanks to the miniaturization of electromagnets, the development of superconducting electromagnets at the Bell Laboratories in 1961, and the introduction of powerful permanent magnets (initially made of samarium and cobalt, and more recently made of neodymium, iron and boron). Nowadays, electromagnetic springs are used in vascular catheters and other devices to monitor intracranial electroencephalography, the electro-thrombosis of inoperable aortic aneurysms, the development of pacemakers, etc. [1]

The electromagnetic fields most often used for diagnostics and treatments in medicine are known as pulsed electromagnetic fields (PEMF). They were initially used in Japan in the 40's, but the Food and Drug Administration (FDA) did not approve their use in the United States to stimulate bone repair in unconsolidated fractures until 1979. A decade later, the FDA authorized their use to treat pain and edema in soft surface tissues.[2]

BASIC PRINCIPLES AND DEFINITIONS

The following physical and biological principles govern the effects of magnetism in the human being.

Magnetism is a property of matter that results from electrons orbiting around the nucleus. This effectproduces an orientation (or intrinsic angular momentum) known as spin and the generation of magnetic fields. It is measured in Gauss (G) or Tesla (T) units. (One T equals 10,000 G). The magnetic field of the Earth is approximately 0.5 Gauss, whereas that of nuclear magnetic resonance (NMR) equipment is 1.5 to 2.1 T.[3]

The term radiation simply means energy transmitted by waves. An electromagnetic wave is a movement of energy on an axis; it is formed by a combination of oscillating electric and magnetic forces that propagate self-sustained in one direction in space. Moving electric charges are the underlying cause of all magnetism; any change in the electric field is accompanied by a change in the magnetic field and vice versa.[4,5]

All modalities of energy in our known universe are arranged in the electromagnetic spectrum. This is divided into ionizing radiation capable of breaking molecular links and non-ionizing does not break molecular links (this includes optic and electromagnetic radiation)

The spectrum covers everything from low energy electrons and slower electric current movement to high energy photons and the speed of visible light and other waves. Humans perceive most of these frequencies through their effects light, color, heat, sound and not directly in visual form.[5,6]

Frequency is defined as the number of complete cycles in which a wave vibrates or moves in a second.

It is expressed in hertz (Hz). Wavelength is the distance between two consecutive crests or two consecutive troughs of a wave. Amplitude is the maximum point of intensity of the signal.[5,6]

The speed of an electromagnetic wave in space is equal to the speed of light, but the speed in matter depends on its electrical properties; or rather, its permissiveness and permeability. Magnetic fields have the unique capacity to penetrate many substances without dissipating.[5]

Magnetic resonance involves synchronization with natural frequencies of the magnetic system. This refers to an alignment of the atoms in response to the stimulus generated by magnetic forces. The frequencies of magnetic resonance are non-ionizing and typically located in the radio spectrum (for nuclear spin) or in that of microwaves (for electron spin). The advantage of the resonance method is that it makes it possible to select a particular frequency out of the total magnetic susceptibility and provides information on atomic processes.[7]

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Magnet therapy includes at least six groups of electromagnetic fields that are used therapeutically for a number of diverse ailments:[2]

1. *Permanent/static magnetic fields:* Created by permanent magnets or the simple passage of direct current through a spiral.
2. *Low frequency sinusoidal electromagnetic wave fields:* Present in distribution lines with frequencies of 60 Hz in the United States and Canada and 50 Hz in Europe and Asia.
3. *Pulsed electromagnetic fields (PEMF):* From very low frequency to 30 kHz, they always maintain the same polarity and have specific shapes and amplitudes. They are the most often used for diagnostic and therapeutic purposes.
4. *Pulsed radiofrequency fields (PRF):* They use radiofrequency in the 13.56, 27.12 and 40.68 MHz ranges.
5. *Transcranial magnetic/electric stimulation:* A therapeutic method that uses short, but intense pulses.
6. *Millimetric waves:* A high frequency range between 30 and 100 GHz.

The use of electromagnetic radiation for medical purposes is supported by the classical laws of electromagnetism:[8]

- *André-Marie Ampère's Law:* The flow of electrical currents must produce magnetic fields in the surrounding space.

- *Michael Faraday's Induction Law:* Oscillating magnetic fields generate oscillating electric currents in nearby conductors, including live tissues.

MECHANISMS OF ACTION

The effects of electromagnetism in the human being should not be assessed considering only the source of energy that emits the stimulants. It is essential to acknowledge the biological environment with which said energy interacts. Hence, the results of in vitro experiments cannot necessarily be extrapolated in vivo.

It has been complicated to define the effect of magnetic fields on live tissue given the difficulty in identifying if the biological response is the product of the magnetic field, the electric field or electromagnetic radiation. The difference between the first two lies in the alignment of the electrons, whereas electromagnetic radiation is characterized by the release of photons at a distance in space.9 The conclusion is based on various theoretical models that prove that magnetism is responsible for the organic efect.[10]

Energy is generated from colliding molecules which involves a series of physical and chemical interactions, the result of which depends on the specific characteristics of the reactants involved in each reaction.

The *cell membrane ion effect* model assumes that the cell membrane is composed of biopolymers that are oriented in such manner that the two sides are electrically charged. Na+ ions accumulate on the extracellular side and A-protein ions on the intracellular side. A- ions are plentiful on the cytoplasm and are balanced out by K+ ions to maintain a neutral and stable balance. The A-K+ complex breaks due to the collision with water molecules which separates both ions and generates an electromagnetic response. The K+ ion moves through the membrane through tunnels or canals through selective pumping.[10] The resulting depolarization modifies the electric power of the cell and thus, its physiological behavior.[9]

The *ion cyclotron* model is based on the movement of a specific ion (charged particle) in a magnetic field. Ions move in a circular path in a static and uniform field. The spin cycle and radius are independent meaning resonance is

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defined when the frequency of the field applied coincides with that of the cell where the phenomenon is produced.10 This technology is used for detailed molecule analysis in clinical and industrial laboratories to design medications, for radiotherapy cancer treatments, radiological diagnosis (PET scan), etc.

Both theories converge in the *ion paramagnetic resonance (IPR)* model which explains the effect of alternate fields. Given that each ion features its own magnetic momentum and resonates with the electromagnetic field, a continuous field is required to direct the momentums of the atoms as well as an alternate field of frequency tuned with a certain type of atoms that force them to enter into resonance.[10] This basic physiological principle is similar to nuclear magnetic resonance with the difference that the latter involves the excitation of atomic nuclei whereas the effect is generated in ion paramagnetic resonance (IPR) by the stimulation of electrons.

In an area that is more familiar to physicians, X rays are a type of ionizing electromagnetic radiation generated in a device containing a source of power, an anode and a cathode. The latter is a tungsten filament that heats until the energy of the electrons rises to release the atom. The free electrons accelerate towards the anode producing kinetic energy which is dissipated upon colliding with a tungsten plate which produces photons creating what is known as an X-ray.[11]

PHYSIOLOGICAL FUNDAMENTALS

All human beings are comprised of atoms of different elements surrounded by water molecules. These atoms generate magnetic forces and electric fields which in turn are influenced by magnetic fields that occur naturally such as the geomagnetic field of the Earth and solar radiation.[12]

Albert Szent-Györgi (Nobel Prize for Medicine in 1937 for the synthesis of vitamin C) observed that the processes in human organisms are too fast and subtle to be simply explained by chemical reactions or nerve impulses and postulated that the dual links in protein molecule structures release electrons capable of travelling at high speed through the organism. He inferred that protein fibers act like proton and electron conductor circuits which was later proven upon verifying that proteins actually work like semiconductors.[13]

Significant similarity has been acknowledged between modern microelectronic circuits and live tissues, which suggests that electron conduction mechanisms in amorphous solids are reproduced in biomolecules like proteins. This is expressed as a quick vectorial electron transfer through biopolymer structural pathways or like an electron jumping between molecules.[14]

Based on these concepts, Oschman[13] suggested the existence of a conductor system he called a living matrix. It is comprised of a cytoskeleton that connects the cytoplasm, cell membrane and extracellular space to the nucleus and spreads throughout the organism like a system of canals through which electrons freely flow communicating all of the cells together and with the genome.

After this hypothesis was launched, glycoproteins were identified called integrins which cross the cell membrane as a link between the inside and outside of the cell. Stimulants are transferred from the extracellular space through the production of a kinase that is indirectly and temporarily bound to intracellular end of the integrin, triggering a series of processes such as cell growth, division, differentiation and survival.

The rest of this system seems to be comprised of extracellular structural elements such as collagen, intracellular elements such as microtubules, intermediate filaments and microfilaments, and a nuclear matrix comprised of histones and DNA. The system support tissue is comprised of glycosaminoglycans, the end portions of which with sulphate and carboxyl groups feature significant negative charge.[14]

Each cell in the body works like a transmitter and a receptor of electromagnetic information and these are precisely the frequencies that precede or correspond to biochemical

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functions. Normal cells oscillate with different frequencies than sick cells; therefore, biological activity is a product of the interaction of energy. Cell response to electromagnetic radiation is known as inductive coupling. Electromagnetic forces act intracellularly producing biochemical responses characterized by electrolyte movements through the cell membrane, the excretion of toxic products, protein synthesis, cell metabolism stimulation, the generation of high energy links, etc.[6] There is speculation that the mechanisms of action responsible for triggering these effects include the modification of the receptor-ligand complex in the membrane.[15]

The effects on tissues and organs are diverse: muscular relaxation, vasodilation, increased partial pressure of oxygen (which fosters a trophic effect), cell proliferation, analgesia (through the production of endogenous opioids), etc. Studies backed by the National Research Council in 1997 confirm prior findings that electromagnetic fields induce changes in the electroencephalographic activity in the brain, produce measurable changes in the synthesis of polypeptides in salivary glands and influence the concentrations of calcium and melatonin in cells exposed to high frequency fields.[1]

CLINICAL APPLICATIONS

It is surprising that despite the fact that man found a way to control and generate electric 120 years ago and that it has been used for all other diagnostic purposes in a successful manner, there is still so much disbelief in the medical community with respect to its therapeutical potential. Without a doubt, this is due to the enormous influence of the pharmaceutical industry which has exclusively favored the biochemical alteration care model, thereby limiting our treatment options.

The different radiology, electroencephalographic, electrocardiographic, electromyographic and other studies stand out among the diagnostic applications of electromagnetic energy. Moreover, there are a huge number of technologies that are barely used in medical practice including microwave resonance.[15]

The first reports of the use of electricity for therapeutical purposes in medicine date back to 1841 and 1850. Hawthorne and Lente, respectively, used it to treat pseudoarthrosis and supernumerary articulations and for unconsolidated fractures. Almost 100 years later, Fukada and Yasuda described the piezoelectric effect of bone in 1957, laying the grounds for Bassett's subsequent studies. He demonstrated that mechanical efforts generate electric power and that electric current stimulates the formation of bone tissue. He later concluded that endogenous electric stimulants are responsible for bone remodelling.[10]

The United States National Institutes for Health (NIH) accept treatment with electromagnetic fields for at least the following symptoms: bone and chronic tendon injury repair, nerve stimulation, wound and varicose ulcer healing, osteoarthritis, electro puncture, tissue regeneration, immune system stimulation and neuroendocrine modulations.[15] Other authors have expanded this list adding: pain, trauma and injury control, reducing swelling and improving blood circulation, fibromyalgia, infectious processes (antimicrobial effects), specific malaria treatment, stress reduction, the correction of neurological disturbances, increasing physical energy and athletic performance, etc.[9, 16, 17]

In addition, electromagnetism is being used or is being researched to develop remote guided surgical instruments, radiofrequency and laser surgery, diathermy, to design medications, etc.[15, 18]

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ONDAMED®

The ONDAMED was developed in 1993 by German engineer Rolf Binder. It is a pulsed electromagnetic field (PEMF) system listed as a class II medical device under the FDA neurology category and also considered a "safe tool for research and clinical studies on pain, discomfort and general discomfort". It has been used in Europe for almost 20 years with excellent clinical results. The apparatus emits a series of electromagnetic frequencies which the organism responds to.

ONDAMED is a comprehensive therapeutic system that combines the emission of magnetic fields with biofeedback techniques. The device produces very low intensity pulsed electromagnetic fields ranging from 0.1 to 32,000 Hz (imperceptible to the human being) with the capability of bio-augmentation of living systems through propagation of electronic energy in tissue. The individual response depends on the functional integrity of body organs and tissues which perform as oscillators that vibrate in total harmony unlike what occurs when illness is present and the harmony is disrupted and weakened.16,17 ONDAMED augments the healing process by supplying the appropriate resonant frequencies weakened through illness and damage and thus "jump starts" the body's own repair process.

The practitioner's diagnosis is assisted through a pulse biofeedback loop which is dependent on the autonomous nervous system and manifest through changes in the radial pulse. Upon perceiving the specific electromagnetic frequency, the organism responds with variations in the amplitude and intensity of the vascular autonomic signal (VAS), also known as peripheral artery tonometry. This consists of variations detected in the radial pulse that represent rapid systemic changes in the arterial smooth muscle tone mediated by sympathetic and nonsympathetic neurons. It is a reproducible phenomenon that is manifested one to three cardiac cycles after the stimulant begins and persists for eight to 15 cycles. This effect has been verified in response to stimulants as different as magnetic currents, sound frequencies, colors, luminous waves, emotions, tactile perception, diverse substances, etc. In this context, ONDAMED can identify already existing pathologies or ones in the process of appearing where there is an alteration in resonance capacity although clinical symptoms still have not appeared.[8]

Just to cite some examples of the specific resonance frequencies of some organs and tissues: the repair of peripheral nerves - 2.0 Hz, bone - 7.0 Hz, blood pressure - 15 Hz, blood flow and circulation - 17 Hz, chemical sensitivity - 443 Hz, hypophysiary function - 635 Hz, colon - 635 Hz, heart - 696 Hz, thyroids - 763 Hz, immune system - 835 Hz, endocrine system - 1537 Hz, etc. Depending on the circumstances and specific interactions, there can be more than one resonance frequency for the same organ or system.[19]

The procedure is simple: first, a transducer is hung around the neck. This is what emits the electromagnetic waves. At the same time, the operator perceives the vascular autonomic signal (VAS) in the radial artery. The 173 frequencies of the preset programs are applied. Each time a change in the autonomic response is identified, this is directly documented in the device's memory. The frequencies at which there was a greater response are selected and these are induced through the neck transducer while the operator crawls the body with another transducer. The place where there is a more intense response to the body crawling is again identified using the VAS and energy is directly applied to this area. The equipment features another two applicators that are used depending on the regions requiring treatment.

The specific dependence of biofeedback is that it makes this instrument completely personalized and suitable to the circumstances prevailing at any given moment. The process is repeated at each visit and changes are typically observed in some of the predominant frequencies with respect to those previously detected. The specific mechanism through

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which the ONDAMED exercises its effects is still unknown. Experience has shown that cell repair and regeneration are stimulated and changes in the hematoencephalic barrier are fostered, thereby favoring the assimilation of hormones, drugs and nutraceutics. However, it is clear that the effects are mediated by a combination of biological, physiological, energy and emotional responses.[16]

CONCLUSIONS

Magnetism is a physical phenomenon that exercises its influence on the entire universe, including living beings. The biological manifestations of electromagnetism range from the potential of action produced by cellular depolarization in response to ionic flow through its membrane to organic representations that are in fact used for diagnostic purposes such as cardiac, cerebral or muscular electric activity.

There is ever more scientific evidence that questions the physiological model currently accepted which exclusively considers bio-chemical processes and nervous conduction as responsible for cell and organic interactions. It is necessary to consider electromagnetic phenomena as cell behavior elements that precede the other processes. Although the mechanisms of action for these phenomena have still not been completely clarified, it is clear that they at least exercise their effects on the calcium canals in the cell membrane, initiating depolarization events. The structural model of a cytoskeleton that connects the cell nucleus to the cytoplasm and extracellular space and all of the body's cells to each other and the genome comprising microcircuits through which electrons flow, it is worth a thorough analysis and much research.

It would seem that these proposals are similar to what has occurred throughout the history of medicine where a purely descriptive first stage dominated by anatomists gave rise to the physiologist era, the emphasis of which lies in attempting to understand the way in which the organism works. Modern science has taken us to the molecular stage that goes further still into physiological mechanisms. However, this awareness must not be researchers' exclusive domain, but rather it must permeate into the clinical domain to direct patient care. This is already occurring in the diagnostic area, more so than in the therapeutic area where treatment modalities based on electro-magnetism are still viewed with much skepticism and unbelief. Doctors must be scientists, with constant questions and open to research. We must reject dogmas and influences with purely commercial interests to search for better options for optimizing the care of our patients.

Understanding these phenomena will make it possible to expand the horizons of conventional medicine, increasing our knowledge of the intricate physiopathological mechanisms of disease.

Medicine must work with scientists from other disciplines to improve existing technologies for health care and develop new ones. It is precisely this joint work between healthcare professionals and physicists that have culminated with the creation of diagnostic equipment that nowadays offers us capacities that until recently were suspicious. According the International Organization of Medical Physicians (IOMP), until 2009 there were more than 18,000 professionals in this area working on healthcare.[20]

Finally, ONDAMED is a technology that in-corporates diagnostic and therapeutic modalities and that has proven its effectiveness and safety for the diagnosis and treatment of many ailments including some whose etiology is unknown and for which only palliative care is possible, generally with poor results. It is a very useful tool that, in combination with other conventional evaluations and treatments, significantly helps improve patients' quality of life.

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