SOME RESULTS ON CLINICAL APPLICATION OF LOW FREQUENCY MAGNETIC FIELD CREATED BY APPARATUS FOR MAGNETOTHERAPY

Hristo Damianov, Matei Gavrilov, Borislav Tonev

Medical University of Sofia, G. Sofiisky str. 30, 1000 Sofia,Bulgaria

Abstract

The experimental and clinical data demonstrate that exogenous magnetic field (MF) and electromagnetic field (EMF) of surprisingly low amplitudes can have a profound effect in healing of a wide variety of pain, injuries, and pathologies. Perhaps the greatest challenge for what it may term electromagnetic biology and medicine is to establish the proper dosimetry for modulation of the desired biochemical cascade.

The final results of magneto-therapy depends to the space-temporal configuration of applied magnetic field. Therefore the basic requirements in the process of design of apparatus for magneto-therapy is connected with optimization of parameters of applied low frequency magnetic field.

1. INTRODUCTION

Usually the low frequency magnetic field in physiotherapy is provided by apparatus for magneto-therapy. This apparatus can provide low frequency magnetic pulses with different parameters.

There is a large body of experimental and clinical data that suggest that various exogenous low frequency magnetic field (MF) at surprisingly low levels can affect a large variety of tissues and processes, most of which are of critical importance for diagnostics and therapy. The longest clinical applications of magnetic fields are related to bone unification and the reduction of pain and edema in soft tissues.

During the past 25 years more than 2 million patients have been treated worldwide for a large variety of injuries, pathologies and diseases. This large number of patients exhibited a success rate of approximately 80%, with virtually no reported complications .

Low-frequency sine waves and low-frequency pulsed electromagnetic fields were used for treatment of pain associated with rotator cuff tendinitis, multiple sclerosis, carpal tunnel syndrome, and periathritis. With the exception of pcriathritis, which reported no difference between treatment and control groups, all other targeted sources of pain received a reduction in visual analog scale (VAS) pain scores. More importantly, the improvement was observed in 93% of patents suffering carpal tunnel pain, and 83% in rotator cuff tendinitis. It was also reported that 65% of the patient who received daily treatment over 8 weeks for rotator cuff tendinitis were pain free at the end of the study, as well as 70% of the multiple sclerosis patients who received 15 treatments with low-frequency sine wave MF reported a reduction in spasticity, improvement of bladder control, and improvement in endurance.

A number of clinical studies, in vivo animal experiments and in vitro cellular and membrane research suggest that magnetic and electromagnetic field stimulation may accelerate the healing processes .It is now clear that endogenous electromagnetic and magnetic interactions are associated with many basic physiological processes ranging from ion binding and molecular conformation in the cell membrane to macroscopic 'terations in tissues. The investigations of the mechanisms of action of MF on biological ystems that are in a state different than their normal physiological one represent the next ontier in electromagnetic biology and medicine. Space does not permit more than a superficial presentation of evidence here to support the statement that "different MF reduces different effects in different biotargets under differing conditions of exposure."

Basic science studies suggest that nearly all participants in the healing process (such as brinogen, leukocytes, fibrin, platelets, cytokines, growth factors, fibroblasts, collagen, lastin, keratinocytes, osteoblasts, and free radicals) exhibit alterations in their functions as a results of exposure to MF. Magnetic fields were also shown to affect vasoconstriction and vasodilation, phagocytosis, cell proliferation, formation of the cellular network, epithelization, and scar formation. Alteration of the basic cellular activities that occur at any one of the distinct stages of tissue repair. The interactions of MF with any structure in the human organism could initiate biophysical and biochemical changes that in turn modify the physiological pathways *u:i* accelerate the healing process.

A question arises: how can this "heating" signal are applied for reduction of pain and edema. The answer is that the pulsed version of this signal (65-us pulse bursts, 100-600 pulses/s, peak magnetic field of 2G) allows the target tissue to be exposed to MF and to elicit a non thermal biological effect.

Therapeutic efficacy depends on the status of the patient (age, general health, and gender) as well as on the stage of pathology and/or disease. It has also been found that there is a distinct relationship between specific diseases and MF parameters that initiate optimal response for these particular pathologies.

2. TIME-VARYING MAGNETIC FIELD FOR PAIN CONTROL

Low-frequency sine waves and low-frequency pulsed magnetic fields were used for treatment of pain associated with rotator cuff tendinitis, multiple sclerosis, carpal tunnel 1 syndrome, and periathritis. For example, an improvement was observed in 93% of I patients suffering carpal tunnel pain and 83% in rotator cuff tendinitis. It was also reported that 65% of the patients who received daily treatment over 8 weeks for rotator cuff tendinitis were pain free at the end of the study, as well as 70% of the multiple sclerosis patients who received 15 treatments with low frequency sine wave MF reported a reduction in spasticity, improvement of bladder control, and improvement in endurance.

Pulsed radio frequency (PRF) modality was used for treatment of migraine, chronic pelvic pain, neck pain, and whiplash injuries. In parallel with improvement after the injury a reduction in the pain of 35% for patients having migraine, accompanied by a significant reduction in occurrence off headaches was reported.Pulsed signal therapy (PST) has been used for relief of pain and other ostheoai thrilis symptoms mainly. The system includes a bed, a circular coil of either 11 or 22 in. in diameter that delivers pulses of variable frequencies (in the range of 0,5-2 pulses/s), and magnetic fields of up to 2 mT. Several double-blind studies report a 88% decrease in pain from knee osteoarthritis after 18 sessions 30 min daily and the pain relief was present during the next month of follow-up.

3. PERMANENT MAGNETS FOR PAIN CONTROL

Since the middle of the 1990s, permanent magnets have become widely used for pain relief. Several recent studies report reduction of pain in postpolio patients (up to 76%). Fibromyalgia (up to 32%), peripheral neuropathy (up to 33%), and postsurgical Bunds (37-65%).

I these recent studies reported pain management for different etiologies and sites of pain. They demonstrate the potential of a static magnetic field to provide significant pain relief in different disorders. In a double-blind study it was shown that a static magnetic field of 300500 G significantly decreases the pain score in postpolio pain syndrome patients when compared with a placebo group. Another double-blind study demonstrated that sleeping on mattresses in which ceramic permanent magnets are embedded (with magnetic field at the target in the range 200-600 G) provided significant benefits to pain, fatigue, and sleep in patients suffering from fibromyalgia .The status of the patients in the real treatment group was improved by more than 30%. In a pilot study a significant improvement in 75% of patients with diabetic neuropathy who used permanent magnetic field stimulation on the soles of their feet was found.It appears that the proper choice of magnetic field strength, application site, duration, and frequency of application are of importance for the success of the therapy.

It should be noted that several studies failed to obtain any effects when so-called bipolar magnets were used. Reviewing the diverse effects reported recently, we conclude that the failure to find any effect is an obvious result of inaccurate dosimetry and poor planning of the studies.

4. MECHANISMS OF ACTION

The main reasons that MF and EMF are still not widely accepted as treatment modalities could be the absence of agreement about a common mechanism of action for EMF bioeffects and insufficient number of publications in medical journals. MF are recognized as capable of inducing selective changes in the microenvironment around and within the cell, as well as in the cell membrane which in turn may correct selected pathological states. However, the biophysical mechanism(s) of interaction of weak electric and magnetic fields with biological tissues as well as the biological transductive mechanism) remain to be elucidated. The analysis of reported specific reactions to MF and EMF indifferent biological systems suggests that most of the observed bioeffects strongly depend on the parameters of the applied electromagnetic fields.

To study the biophysical mechanisms of MF interactions one should begin with identification of the desired target to MF action. Then the nature of the initial physico-chemical interaction of EMF with biological systems and the expression of these phys-icochemical changes as a biological response should be investigated. The cell memhrane is most often considered the main target for EMF signals. Due to the fact that most of the cellular structures are electrically charged and that the biochemical reactions involve ion transfers, it is easy to assume that MF and EMF possess the potential to influence both the structure and function of the most important biochemical-biophysical processes. Starting from cell size and shape, going through the composition and architecture of the cellular membrane, one can also take into account the different sensitivity of cells based on the above described characteristics. Any change in the electrochemical microenvironment of the cell can cause modifications in the structure of its electrified surface regions by changing the concentration of a specifically bound ion or dipole, which may be accompanied by alterations in the conformation of moiecular entities (such as lipids, proteins, and enzymes) in the membrane structure. The role ofions as transducers of information in the regulation of cell structure and function is widely accepted. When cells are organized in a tissue, thel expected response should include cell-cell communications. In addition for in vivo experiments the complexity of the animal and human organism and theexislence of compensatory mechanisms that work on the organism level must be considered.

From a clinical point of view it is also difficult to believe that each of these mechanisms might be useful in explaining the beneficial effects of magnetotherapy, especially the significant and rapid pain relief observed in several different studies such as postpolio patients, diabetic neuropathy, postsurgical wounds, and fibromyalgia.

A series of studies of EMF influence on various biological systems demonstrated the appearance of windows effects. The windows represent combinations of amplitude and frequency within which the optimal response is observed; outside this range the response is significantly smaller. In other words, this demonstrates the principle "more does not necessarily mean better."

CONCLUSION

The correct choice of effective electromagnetic stimulation to accelerate healing requires measurement and computation of a variety of parameters, such as amplitude, field frequency and shape, duration of exposure, and site of application. Not only the precise characteristics of the applied or driving field and/or current but also the exact diagnosis and all other clinical data should be considered. Further research in the area of magnetic stimulation should clarify and optimize the choice of the appropriate magnetic field that are optimal for modulation of defined structures and processes that are involved in tissue healing and pain relief. A precise evaluation of electromagnetic field initiated bioeffects becomes increasingly important since the number of electromagnetic technologies and j devices used in clinical practice continues to grow.

References

[1] Abraham SE. Reynolds AC, Cusick JF. Failure to naloxonee to reverse analgesia from I transcutaneous electrical stimulation in patients with chronic pain. Anesth Analg 1981; 60:81-

[2] Anderson SA, Holmgren E. Pain threshold effects of peripheral conditioning stimulation. In Bonica JJ. Albe-Fesard DG, eds. Advances in Pain Research and Therapy. Proc. First World CongrPain. Vol 1. New York: Raven Press, 1976:761-768. :

[3] Arendt-Nielsen L, Bjerring P. Long-term effect of low and high frequency TNS on pain related cortical responses. Pain 1987; 4(suppl):S366.

[4] Augustinsson L-E, Bohlin P, Bundscn P, Carlsson CA, Forssman I. Pain relief during delivery by transcutaneous electrical nerve stimulation. Pain 1977; 4:59-65.

[5] Callaghan M. Siernback R A, Nyquist J. K, Timmermans G. Changes in somatic sensitivity during transcutaneous electrical analgesia. Pain 1978; 5:115-128.