CRITICAL REVIEW OF THE USE OF ELECTROTHERAPY

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The study of a treatment involving physical energy goes hand in hand with the study of medicine itself. This statement may seem exaggerated, but when faced with pain or functional impairment, the doctor has the intrinsic need to find the best possible remedy, in addition to that something extra that makes it possible to relieve the suffering of others.
Looking back to the earliest forms of self-treatment, individuals suffering from a headache or stomachache would place their hand over the painful zone in order to obtain a brief respite from the painful symptoms. When this proved insufficient, they would then have to resort to the first homemade remedies such as hot water, cold water, and simple tisanes. Our medical history evolves from here, with physical energy becoming more sophisticated over time, until reaching our current level of knowledge and the protocols adopted today.
In the awareness that we are still at the beginning of our therapeutic journey, we believe that electrical therapy has always been a very important form of treatment throughout history, from the rudimentary applications involving electric rays in Egyptian, Greek, and Roman times, to modern microwaves controlled by powerful software with small sources.
The history of electrical therapy is very closely related to the discoveries of modern physics. From the patterns of magnetic fields studied by Faraday, which produce electrical currents, to the electrical currents themselves, which Maxwell believed to produce particular magnetic fields, we have progressively arrived at their use in the field of medicine. Naturally, pain was the first symptom to be treated with electric currents, improving the patient’s painful symptoms with the use of the galvanic current.
This led to the observance of improvements in the tissues around the injured part and the improved tone of the treated subsystem, causing many thermal spas to use this new therapy at the beginning of the last century in order to prevent morbigenous forms and also to improve patients’ moods. These were all positive developments, but not all patients responded to the treatments in the hoped for fashion, and there were many side effects (burns, cardiac arrests, convulsions, increased depression). Lastly, we should not forget those who saw this therapy as a possible remedy for mental problems.
However, this gave rise to other questions related to the physics of the infinitely or extremely small, with regard to what effects it had on the cells of the various tissues, why the responses to the same currents were so different, and why all subjects experienced pain relief.
The response was provided, not very long ago, by Melzak and Wall, who developed the “gate control" theory (illustrated below) in 1965. This theory highlighted the difference in response between small and large nerve fibers (the small ones open the gate and the large ones close it), thus clarifying the decisive factors in pain reduction.
The above means that we are now able to analyze the various waveforms and their effects in combined formulations in great depth.

Modern Electrotherapy

There are currently 100 different forms of electric currents. We should understand electric current to mean positive + and negative – charges, which move with an intensity directly proportional to the velocity of movement of the charges themselves and inversely proportional to the time employed in electrotherapy. It is therefore essential to choose the most suitable form of electrotherapy, which responds to fundamental requirements such as therapeutic success, tolerability, and lack of side effects.

Using electrotherapy correctly means having studied the various forms of electric currents used for therapeutic purposes, and the bioelectrical and biochemical effects that they generated in the body. The responses to electrical stimuli are rapid in tissues such as nerves and muscles, since they are comprised of excitable cells, with electrical impulses (action potentials) being produced for nerve stimulation.

Let us define the concept of "currents suitable for stimulation". Stimulatory currents are electric currents that are introduced into the human body in a suitable (tolerable) fashion, so as to produce action potentials in excitable tissues (nerves and muscles). Clinical pictures and, sometimes, known therapeutic effects are attributed to the various technical forms of the currents.

Here are some examples of currents in use today:

1) Faradic current: direct current with adjustable impulse trains, resembling voluntary contraction
2) Diadynamic current: direct and semi-sinusoidal at low *f*

a. single-phase *f*
b. diaphase fix
c. short period current
   long period current
   syncopated current
d. with the use of an electrode in the most painful point; to prevent addiction

Frequency (f): No. waves that pass through 1 point/second
Period (T): time between successive wave crests. T=1/f
Velocity (c): at which a wave crest travels
Length (λ): distance between wave crests
Amplitude (A): max. value of the movement
A charge produces an E.C. that exercises its F on another charge in its turn

e. at least two types of current per session
f. treatment <10'
g. hyperpolarization of the membrane
h. Inhibition-R pain
i. trophic effect through vasodilatation
j. tissue nutrition through analgesia H

3) Exponential current for the treatment of flaccid paralysis
4) Milliampere current for pain treatment
5) Tens
6) Rectangular current at *f*

Analgesic action Gate control
Endorphin release
Impulses:

of short duration and *f*: rapid and short-term analgesia.
of long duration and *f*: slow and long-term analgesia.
Afferent activity of fibers with a large diameter to close the Gate.
To reduce pain and stop the activity of the reverberating neuronal circuits.
7) Interferential currents
Hyperpolarization of the membrane.
Inhibition of the pain receptors.
Trophic effect linked to vasodilatation, thus improving perfusion locally and in the treated segments. Excitomotor effect on innervated muscles and increase in basal tone. The application of the four electrodes creates two crossed biochemical fields:
A 1st distributor generates an AC at an *f*K of 4000 Hz.
A 2nd makes it oscillate around 4000 Hz with a Δf of 1100 Hz.
There is a low *f* current in the meeting (crossing) point that generates bioelectrical effects.
8) The galvanic or direct current, which, we should remember, was one of the first used in therapy, is suitable for introducing drugs into the body on the basis of the drug polarity.
9) Kotz
In terms of strengthening muscles, it generally leads to recruitment and a reduction in painful symptoms.
10) The high voltage current primarily has an analgesic and decontracting effect, using very high intensities for a very short period of time (microseconds). In this context, the expected success of a treatment is judged based on experience and clinical studies.

Subdivision by Frequency Area

The various forms of currents are adapted to the frequencies used in medicine, such as low frequencies (Nf,>0-1,000 Hz), medium frequencies (Mf,>1,000-300,000 Hz), and high frequencies (Hf,>300,000 Hz). Due to the different electrophysiological properties of these frequency areas, it is easier to associate potential groups of effects with these areas.
Within the individual areas, it should be observed that the information currently in our possession is still based on our experience and clinical studies. In fact, even here, there is a shortage of clinical parameters that can be used to choose the most suitable forms of current for a certain clinical picture.
Classic stimulators usually use the following frequencies:

Direct current:	0 Hz
Low frequencies:	>0 - 200 Hz
Medium frequencies:	2,000 Hz and 3,800 – 4,200 Hz

We are not going to discuss high frequencies any further here, although they are an important part of electrotherapy, since they are primarily used for heat production (short waves and microwaves) and in nerve inhibition for pain therapy (ultra high frequencies).
With regard to the stimulation threshold, we can consider the perception threshold, the motor threshold, and the pain threshold.
In the first place, it should be observed how, when using low frequencies, a lower current intensity is needed to reach the threshold than in the case of high frequencies. In the second place, we should mention that, as in the case of all stimulation currents, the intensity is always vertically modulated so as to exceed and then return below the threshold. The implementation of this movement, in keeping with the rhythm of the low frequencies, produces synchronous action potentials that are then sent into the nerve and can be used to produce therapeutic effects.
In medicine, we can identify two groups of therapeutic effects in relation to treatment with electrical currents:
1) Stimulatory effects (bioelectric). Synchronous responses (action potentials) of excitable cells to our electric stimulus, induced by the rhythm of the low frequencies;

2) Non-stimulatory effects (biochemical). Reactions on an electrobiochemical and electrophysiological level, created by medium frequencies with constant intensity. Only Horizontal Therapy currently makes it possible to obtain both types of the above effects in the same tissue simultaneously.
HT works with an alternating current at medium frequencies [2, 5], keeping the intensity constant at all times and simply modulating the frequency between 4,400 Hz and 12,300 Hz. This stimulation is able to boost the metabolism and influences the achievement of the following therapeutic results [8, 9, 10]: greater efficiency in cellular diffusion processes, produced by the so-called biochemical “shaking effect”, which takes place in the extracellular matrix between the capillary vessels and the tissues stocked with metabolic products;
3) Biostimulation effects on the enzymes and substrata, which entail a greater probability of meeting between substrata and enzymes in the correct position and orientation. This encourages a biochemical reaction between them, which activates the metabolism.
4) A reduction in pain in the tissue thanks to the dispersion and reduced concentration of local pain and inflammation transmitters, resulting from the biochemical action of the shaking effect.
5) Stimulation of the receptors in the cellular membrane, made apparent by the direct effect on adenylate cyclase and thus on the formation of one of the main intracellular mediators, cyclic adenosine (cAMP).
6) Activation of intracellular communication through bioelectrical and biochemical processes, with selective activation of the "cell-cell" channel (gap junctions - intracellular synapsis that enables communication between cells) during the passage of the current through the tissues.
7) Actions that modulate the flow of information between cells that participate in the shaking mechanism as a whole, thus activating the exchange of intracellular metabolic products.
8) As a result of HT, substances such as calcium ions, 3’, 5’ -cAMP, 3’, 5’ cGMP, and 1,4,5-inositol triphosphate, which transfer information from one cell to another, act as current carriers, passing through cells and using the “cell-cell” channels to an even greater extent.
9) Activation of resonance phenomena in the so-called "active centers" of the enzymes. With the use of a suitable frequency range, this leads to stimulation of the metabolic processes.
10) Effect on the cellular field between the stimulation threshold and the depolarization threshold (conduction threshold - nerve conduction block), which consists of activating transitory excitability action ("TEA") with a depolarization/repolarization action that does not really differ from the natural processes that take place within the cellular membrane. Unlike that which occurs with traditional therapy, when HT is used, the cells themselves regulate the action potential periods, which are not imposed in a synchronous fashion, in keeping with the stimulation frequency.
The reversible depolarizing effects on the structures excited through the application of HT, are evident through:
- the reversible nerve conduction block.
- the physiological effect of muscular fiber contraction. In HT, the actions designed to soothe pain are characterized by:
- an immediate therapeutic effect in the form of: peripheral nerve conduction block, produced by the permanent reversible depolarization;
- persistence of the central analgesic effect, as a reaction to the irritant stimulus or as a result of the analyzer action, which leads to the transitory excitement action of the cell "TEA".
- delayed persistence of the therapeutic effect, which is permanent for a longer period, with a consequent reduction in edemas, and peripheral and central analgesic activity, through the stimulation of endorphin release in the central nervous system.
In the treatment of geriatric patients with involuted pathological states affecting a

locomotive apparatus, HT works on the metabolism and improves the efficiency of enzymatic processes within the cell, thanks to the precise positioning of molecules in an alternating electric field. This increases the probability that the substratum molecule and the enzymatic molecule meet in the correct position and with the correct orientation. Reactions of this type take place in chrondrocytes and cells that play a reconstructive role in inflammatory and degenerative processes.

Meanwhile, in synovial fluid and the matrix of the water-rich cartilage tissue, the variable HT electrical field only compensates for the differences in terms of organic and inorganic concentration levels, which therefore remain in constant movement and constitute the vehicle for the passage of the current through the tissues. Substances that do not occur in ionic form, such as glucose, are only moved indirectly, through the modification of intracellular diffusion. This is particularly important in the case of patients with degenerative joint problems, in which pain restricts movement on the level of the joints.

The medium frequency currents are characterized by analgesic activity, inasmuch as they work on the nociceptive receptors of the tissues and block the conduction of nociceptive stimuli. It is therefore possible to obtain a noticeable reduction or the complete elimination of painful peripheral reactions coming from the muscular fibers, which have been altered by arthrosis. Thanks to this fact, it is easier for the patient to make a complete movement with the joint both during the operation and afterwards, and thus improve the alimentation of the joint cartilage, mechanically forcing the translocation of the synovial fluid inside the joint in question [1, 2, 8]. HT does not just force striated muscles, but also the smooth muscles around the vessels. At the same time, it also supports the draining function of the capillary and lymphatic vessels.

After surgery, reactive congestion becomes apparent in the treated tissues, and repeated treatment with medium frequency currents represents a type of training for blood vessels. It is also believed [2, 5] that the metabolism of the vessel endothelial tissue, and the cells within the zone of current passage, is stimulated as a result of the action exercised by the current on the cellular wall. Literature describes significant variations in adenosine monophosphate following HT procedures [11, 12].

The systematic use of electrotherapy with HT in the treatment of degenerative joint diseases in geriatric patients, whether during the initial or acute phase, makes it possible to relieve or completely eliminate pain. There is also a high probability that the joint functions will be reconstructed and kept unaltered, and the progression of internal alterations will be controlled or delayed.

How to Use Electrotherapy

After an analysis of the instruments used to produce electrotherapy, their current availability, and the methods for using the various forms of wave, we can draw some significant conclusions that provide us with new information about using electrical currents in the aforementioned way.

Until 2003, TENS was the most commonly used form of electrotherapy in the western world - firstly, because of the possibility to find low price appliances, secondly, because of its ease of use (the treatment was administered in the home), and thirdly, because of the possibility of applying it to any disease.

The aforementioned biochemical and bioelectrical effects led to new ways of considering electrotherapy through association of a form and use of electrotherapy with the various diseases and anatomical/pathological pictures, specifically targeting pain and the "restoration" of the damaged tissue (in our case, traumas caused by sport). Moreover, it made it possible to study specific frequencies and intensities for all types of chronic and acute diseases.

In the case of chronic diseases such as gonarthrosis (Saggini R et al., University of Chieti), a recent multicenter study observed improved knee articularity in patients, with a considerable and significant reduction in the use of corticosteroids and NSAID type drugs.

Also, with regard to chronic pain (Janiszewski, Kluszczylska, Blaszczyk – Adult Rehabilitation Department, University of Lódz, Poland), it has been demonstrated that the use of this new form of electric current, defined HT, helps restore the biochemical and bioelectrical balance, improving the quality of life for elderly patients, boosting their moods, relieving pain, and demonstrating effective action against osteoporosis by improving the bone mass. This work was confirmed by the multicenter study carried out on female patients suffering from lower back pain caused by a recent vertebral fracture, performed by Saggini, of the University of Chieti, and Zambito, of the University of Verona. It concluded that treatment with Horizontal Therapy should be recommended for managing the pain caused by a recent lower back fracture, inasmuch as Horizontal Therapy has shown itself to be suitable for reducing pain and increasing functional capacity in the medium term, that is to say, in the three months after treatment, and was also found to improve bone tissue structure.

Also in the field of chronic pain, Felicetti (IRCCS Maugeri Foundation, Pavia) studied lumbar arthrosis, with results comparable to those obtained by the University of Chieti with regard to improvements in articularity and the general conditions of the patients.

With regard to acute post-traumatic pain, a study was carried out on the treatment of foot pain in athletes by Marchini, Graziano, and Marchetti at the University of Pisa, and another study was carried out by Saggini et al. at the University of Chieti, to assess the effect of Horizontal® Therapy and, in particular, the two different current emission methods, on shoulder disease with post-traumatic arthrosynovitis in comparison with a treatment using interferential currents accompanied by pharmacological treatment.

An examination of the results obtained in this study demonstrates that treatment with Horizontal Therapy, using the specific program, is effective in a statistically significant fashion in the short term and, after treatment, there is a significant reduction in pain. The stabilization, expressed in terms of the objective VAS and the reduction in anti-inflammatory drugs, is statistically significant up to thirty days for Group A compared to the other groups studied. In particular, in the brief period following treatment with Horizontal Therapy, using the specific program, the assumption of non-steroidal anti-inflammatory drugs and painkillers ceased completely, while this was not the case in the other two groups. Throughout the subsequent period too, the assumption of non-steroidal anti-inflammatory drugs and painkillers remained at the same level as the end of the treatment cycle, with a statistically significant value ($p \leq 0.001$) at one month. Moreover, in the brief period following treatment with Horizontal Therapy, using the specific program, the VAS underwent a statistically significant reduction, which continued right through to the end of the assessment period of one month ($p \leq 0.001$), while the other two methods demonstrated a lower significance.

With regard to the ultrasonography assessment, it revealed a complete disappearance in 80% of the 20 Group A patients, while there was a 60% disappearance in Group B and a 50% disappearance in Group C.

Our study of patients suffering from knee injuries demonstrated a rapid reduction in pain, edemas, and the consequent functional restrictions in the majority of cases we treated - to be precise, 18 out of 20 from the very first applications. In particular, while the intensity of the painful symptoms could clearly be quantified with a VAS before therapy, at a level of 4.0, associated with functional impotency of 3.8, after the ten therapy sessions, these values fell to 0.8 and 1.0 respectively. The application of this protocol for sports-related injuries can therefore lead to a significant reduction in recovery times, with consequent earlier resumption of training, further reducing the use of drugs and making a decisive contribution to the restoration of the athlete's health. All distortion injuries respond well to this method, especially in the world of sports, because it makes it possible to improve the athlete's condition very quickly, halving recovery times. It should be observed that its association with kinesitherapy makes it possible to focus treatment of pathologies, such as shoulder injuries (frozen shoulder, capsulitis, tendonitis, and rotator cuff lesions), firstly on pain, then on

movement, as already defined in the study entitled “Treatment of Non-Traumatic Shoulder Pain with Analgesic Electrotherapy Followed by Kinesis, with Resistance Modes Adapted According to the B.B. Method” (Saggini R, Carmel R, Fraccaro S).

Conclusions

The above shows how we are facing a major change in the use of electrotherapy to treat acute, chronic, and post-op pathologies. In fact, thanks to the new technology that is now available and the introduction of new geometric parameters, applied to the electric current, we are able to make use of increasingly sophisticated systems and able to emit more and more complex waves, which are also more intelligible to those tissues and cells that need therapeutic treatment designed to recreate a state of “eutrophism”.

It noted that there is no longer a single system, which is the same for all, a machine that, after pushing a button, can be used to treat any phlogistic and post-traumatic disease.

For some, the new approach may seem complex and difficult, but this should be welcomed, so that those in the field of rehabilitation who have developed these therapeutic processes can be rightly rewarded for the significant results being produced, thanks to the possibility to discriminate between tissues by using different programs. In fact, this would have been impossible to achieve in the past.

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