

Current Concepts in Electrotherapy

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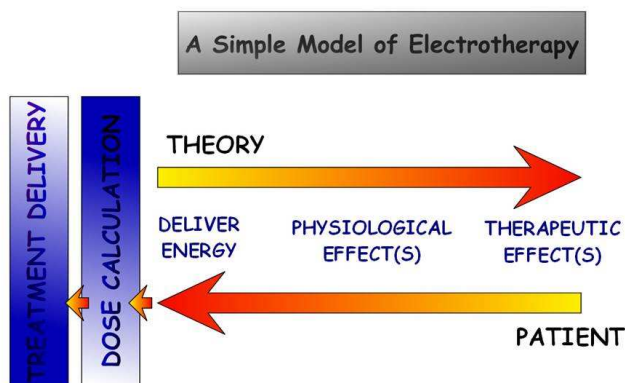
Web Pages : www.electrotherapy.org

The Changing Nature of Electrotherapy

Much as electrotherapy has been a component of physiotherapy practice since the early days, its delivery has changed remarkably and continues to do so. The most popular modalities used these days are in many respects quite dissimilar to those of 60 or more years ago.

Modern electrotherapy practice needs to be evidence based and used appropriately. Used at the right place, at the right time for the right reason, it has phenomenal capacity to do good. Used unwisely, it will either do no good at all, or worse still, make matters worse. The skill of electrotherapy is to make the appropriate clinical decision as to which modality to use and when.

The term "Electrotherapy" in this context is used in the widest sense. Strictly speaking some modalities (Ultrasound for example) do not strictly fall into an electrotherapy grouping, which is why some authorities prefer the term 'Electrophysical Agents' which would encompass a wider range. For the sake of ease, Electrotherapy will be used throughout this documentation, but acknowledged that it could be challenged as a term.



A simple, but effective clinical decision making model (represented in the adjacent diagram) can be utilised. All electrotherapy modalities (with the exception of biofeedback) involve the introduction of some physical energy into a biologic system. This energy brings about one or more physiological changes, which are used for therapeutic benefit. Clinically, it is probably more useful to work the model in reverse - determine first the nature of the problem to be addressed. Then

establish the physiological changes that need to take place in order to achieve these effects. Lastly, the modality which is most able to bring about the changes in the tissue(s) concerned should be a relatively straightforward decision.

In the clinical environment, there are two additional 'jobs' to do : firstly to select the most appropriate 'dose' of the therapy and then lastly to apply the treatment. Generally speaking, the delivery of the therapy is relatively straightforward. The dose selection however is critical in that

not only are the effects of the treatment **modality dependent**, but they appear to be **dose dependent** as well. In other words, it is important to select the most appropriate modality based on the available evidence, but also to deliver it at the most effective known dose. There are many research publications that have identified a lack of effect of intervention X, yet other researchers have shown it to work. This appears strange at face value, but when dose and treatment parameters are taken into consideration, it becomes clear that there is a dose dependency, and the evidence for this is getting stronger the more that gets published. This issue is considered further in the section on Electrotherapeutic Windows (below).

Electrotherapeutic Windows

Windows of opportunity are topical in many areas of medical practice and are not a new phenomenon at all. It has long been recognised that the 'amount' of a treatment is a critical parameter. This is no less true for electrotherapy than for other interventions. There are literally hundreds of research papers that illustrate that the same modality applied in the same circumstances, but at a different 'dose' will produce a different outcome. The illustrations used here are deliberately taken from a range of studies with various modalities to illustrate the breadth of the principle. Furthermore, the examples used are not intended to criticise the researchers reporting these results. Knowing where the window 'is not' is possibly as important as knowing where it is (Watson, 2007).

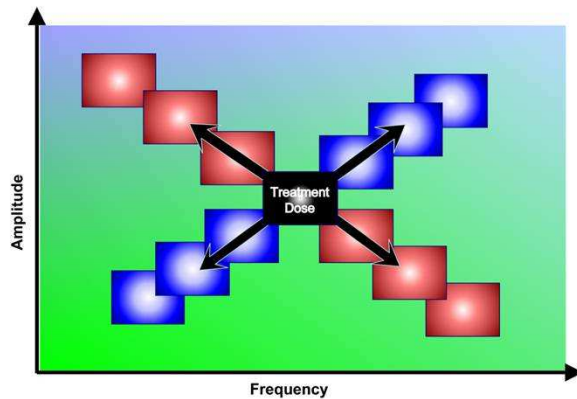
Given the research evidence, there appear to be several aspects to this issue. Using a very straightforward model, there is substantial evidence for example that there is an '**amplitude**' or '**strength**' window. An energy delivered at a particular amplitude has a beneficial effect whilst the same energy at a lower amplitude may have no demonstrable effect. Laser therapy provides a good example – one level will produce a distinct cellular response whilst a higher dose can be considered to be destructive. Karu (1987) demonstrated and reported these principles and research produced since has served to reinforce the concept (Vinck et al 2003).

There are many examples of amplitude windows in the electrotherapy related literature, and in some instances, the researchers have not set out to evaluate window effects, but have none the less demonstrated their existence. Papers by Larsen et al (2005) measuring ultrasound parameter manipulation in tendon healing, Aaron et al (1999) investigating electromagnetic field strengths, Goldman et al (1996) considering the effects of electrical stimulation in chronic wound healing, Rubin et al (1989) investigating electromagnetic field strength and osteoporosis and Cramp et al (2002) comparing different forms of TENS and its influence on local blood flow all provide evidence in this field.

Along similar lines, '**frequency windows**' are also apparent. A modality applied at a specific frequency (pulsing regime) might have a measurable benefit, whilst the same modality applied using a different pulsing profile may not appear to achieve equivalent results.

Electrical stimulation frequency windows have been proposed and there is clinical and laboratory evidence to suggest that there are frequency dependent responses in clinical practice. TENS applied at frequency X appears to have a different outcome to TENS applied at frequency Y in an equivalent patient population. Studies by Sluka et al (2005), Kararmaz et al (2004) and Han et al (1991) are amongst numerous studies that have demonstrated frequency dependent effects of TENS. There are also several authors who appear to have demonstrated that frequency parameters are possibly less critical, especially in clinical practice, and examples

can be found in the literature on TENS and Interferential Therapy. Frequency windows are not confined to TENS treatments, and there are examples from other areas including electromagnetic fields (Blackman et al 1988), ultrasound (Schafer et al 2005) and interferential (Noble et al 2000).

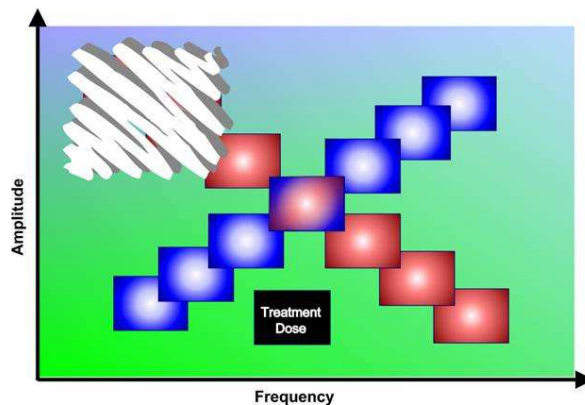


A simple therapeutic windows model is illustrated in the figure alongside, using amplitude and frequency as the critical parameters.

The 'ideal' treatment dose would be that combination of modality amplitude and frequency that focuses on the central effective zone. It can be suggested (from the evidence) that if the right amplitude and the right frequency are applied at the same time, then the maximally beneficial effect will be achieved.

Unfortunately, there are clearly more ways to get this combination 'wrong' than 'right'. A modality applied at a less than ideal dose will not achieve best results. Again, this does not mean that the modality is ineffective, but more likely, that the ideal window has been missed. The same principle can be applied across many, if not all areas of therapy.

In figure to the right, the most effective treatment window (black box, lower central) has been clearly missed by the delivered treatment (upper left) and hence whatever the effect of the therapy, it will fail to be maximally effective.



The situation is complicated by the apparent capacity of the windows to 'move' with the patient condition. The position of the therapeutic window in the acute scenario appears to be different from the window position for the patient with a chronic version of the same problem. A treatment dose that might be very effective for an acute problem may fail to be beneficial with a chronic presentation

Given the rapidly increasing complexity simply by using a two parameter model (amplitude and frequency) with two levels of condition (acute and chronic), it is easy to see how difficult the clinical reality might be. As the volume of published work continues to increase, new results can be included into the existing framework, and this helps to identify where the windows are (positive research outcomes) and where they are not (negative outcomes). If this methodology is pursued, it is interesting to note how the effective treatments cluster when plotted, adding weight to the therapeutic windows theory.

Assuming that there are likely to be more than two variables to the real world model, some complex further work needs to be invoked. There is almost certainly an energy or time based

window (e.g. Hill et al 2002) and then another factor based on treatment frequency (number of sessions a week or treatment intervals). Work continues in our and other research units to identify the more and less critical parameters for each modality across a range of clinical presentations.

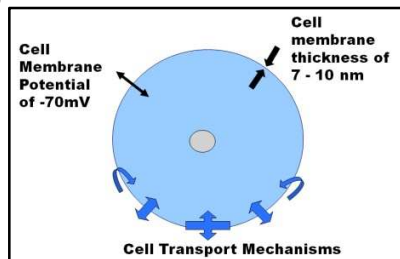
The Body Bioelectric

The electrical activity of the body has been used for a long time for both diagnostic and monitoring purposes in medicine, largely in connection with the 'excitable' tissues. Examples include ECG, EMG, EEG. More recent developments have begun to look at the tissues which were not regarded as excitable, but in which, endogenous electrical activity has been demonstrated. The endogenous electrical activity of the body arises from a variety of sources, some of which are well documented whilst others remain more obscure in their origins & control mechanisms. The relationship between endogenous electrical activity (not exclusively potentials), injury & healing have been researched in several areas of clinical practice and has been well documented in several publications, including Watson (2002, 2008).

The subject of endogenous bioelectricity is somewhat larger than can be detailed here, though there is one important link between regular electrotherapy and endogenous bioelectrics identified below.

The Bioelectric Cell

Every living cell has a membrane potential (of about -70mV), with the inside of the cell being negative relative to its external surface. The cell membrane potential is strongly linked to the cell membrane transport mechanisms in that much of the material that passes across the membrane is ionic (charged particles), thus if the movement of charged particles changes, then it will influence the membrane potential. Conversely, if the membrane potential changes, it will influence the movement of ions.



Relative to the size of the cell, the membrane potential is massive. The membrane is, on average 7-10 nm thick (a nanometre is a thousandth of a millionth of a metre). The equivalent voltage is somewhere in the order of 10 million volts per metre (which is reasonably impressive!). The energy in the membrane (and other organelles of course) offers the potential (no pun intended) to change the behaviour of the cell – one of the fundamental tenets of electrotherapy – and therefore make a difference to the behaviour of cells and tissues. That different cells and tissues respond preferentially to different types of energy and at different 'doses' should be no surprise.

Approaches to Electrotherapy

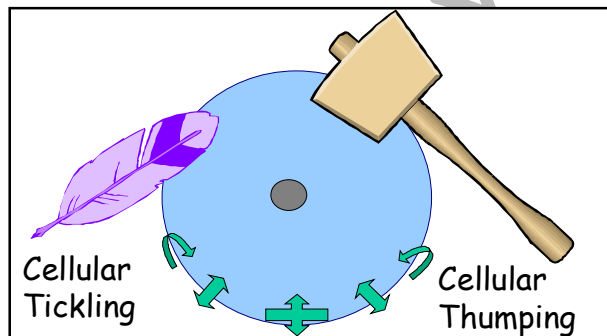
Given the natural energy systems of the living cell, there are two approaches to the application of electrotherapy modalities. Firstly, one can deliver sufficient energy to overcome the energy of the membrane and thereby force it to change behaviour. Secondly, one can deliver much smaller energy levels, and instead of forcing the membrane to change behaviour, it can be 'tickled'. Low energy membrane tickling produces membrane excitement, and membrane excitement in turn produces cellular excitement. Excited cells do the same job as bored cells, but they do so at a rather harder and faster rate. It is the excited cells which do the work rather than the modality itself.

In addition to considering the endogenous potentials, there are several exciting aspects of this work which are of more direct relevance to physiotherapists and others working in the rehabilitation field. Most obviously is the possible relationship between the endogenous bioelectric activity and the energy inputs (in a variety of forms) by means of electrotherapy treatments.

There has been a general trend over the last few years, for the energy levels applied in electrotherapy to be reduced. Ultrasound treatment doses are significantly lower (in terms of US intensity & pulse ratios) than previously thought to be effective. Pulsed Shortwave employs power levels which are several orders of magnitude lower than those applied during continuous shortwave therapy. Laser therapy is another such example of the clinical application of low energy levels to damaged, irritated or traumatised tissues.

The over-riding principle of these interventions, is that the application of a low power/energy modality can enhance the natural ability of the body to stimulate, direct and control the healing & reparative processes. Instead of 'hitting the cells' with high energy levels, and thereby forcing them to respond, the low energy applications are aiming to tickle the cells, to stimulate them into some higher activity level and thus use the natural resources of the body to do the work.

This philosophy can be applied to many areas of therapy, not exclusively to electrotherapy - though it does marry well with the subject. Several areas are currently being investigated in this respect, including the possibility of using the endogenous bioelectric activity as a feedback mechanism to enable the patient to take (natural) control of their healing, measurement of the physiological effects of a variety of electrotherapy modalities (including Pulsed Shortwave, Interferential Therapy). One final area of interest is to potentially take the applied energy to really low levels (microcurrent type therapies) and deliver a current to the tissues that is remarkably similar to the endogenous currents that appear to be physiologically effective. Several machines are already available that work on this basis, and the research is picking up rapidly in this field.



Summary

Electrotherapy has a place within clinical practice. When used appropriately, the evidence supports its effectiveness. When used in other ways, it is not surprising that it has little or no beneficial effect. Modality and dose selection appear to be key, and critical clinical decision making issues.

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Chapters :

- (1) Current Concepts and Clinical Decision Making in Electrotherapy
- (3) Electrical Properties of Tissues
- (10) Pulsed and Continuous Shortwave Therapy (with Maryam AlMandeel)
- (12) Therapeutic Ultrasound (with Steve Young)
- (19) Electrical Stimulation for Enhanced Wound Healing

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