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Masterclass

The role of electrotherapy in contemporary physiotherapy practice

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SUMMARY. **Although electrotherapy has a well established role within physiotherapy practice, the current concepts that influence its application vary considerably from those proposed historically. It is argued that there is a place for electrophysical modalities in contemporary practice, and several basic principles are considered together with more specific information regarding two modalities namely, ultrasound and interferential therapy.**

Electrophysical agents are utilised to bring about physiological effects, and it is these changes which bring about the therapeutic benefit rather than the modality itself. Clinical decision protocols employing the available evidence should enable the most appropriate modality to be employed for a particular patient. Indiscriminate use of electrotherapy is unlikely to yield significant benefit, however used at the right time, it has the potential to achieve beneficial effect. The patient management programme which combines manual therapy, exercise therapy and electrotherapy, based on current evidence, should enable the most efficacious management of a patients' dysfunction. This paper aims to consider some of the current concepts in electrotherapy and to relate this to both general and specific treatments. © 2000 Harcourt Publishers Ltd

INTRODUCTION

Electrotherapy is one of the fundamental elements of physiotherapy practice, yet despite its widespread use from the early professional times, it is often poorly understood, sometimes inappropriately used and the topic of substantial debate.

This article attempts to ground modern electrotherapy practice into some form of contextual framework. It is not suggested that the practice of electrotherapy is central to the management of musculoskeletal conditions, in general it is most appropriately used as an adjunct to other therapies. Used appropriately, it has significant potential to benefit. Used inappropriately, it may have no effect, or worse still, have a detrimental effect on the patients' wellbeing. One of the major skills in electrotherapy relates to the decision making process – which modality to use, and with which treatment parameters. Whilst not attempting to provide a series of recipes, this article will attempt to review modern electrotherapy principles and illustrate its potential usefulness.

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CURRENT CONCEPTS IN ELECTROTHERAPY

Modern electrotherapy applications tend to employ lower treatment 'doses' than in the past, and yet the claimed treatment effects are supposedly more significant (Watson 1995). The rationale for this philosophical shift relates to a number of research trends, largely outside the direct realm of physiotherapy, but which, nonetheless, have a major impact on electrotherapy treatments.

One of the more nebulous of these, is that of minimal intervention. It is difficult to determine quite where this started, but there is little doubt that current treatment doses with ultrasound, for example, are significantly lower than those employed several years ago. Therapists tend to use the lowest effective dose rather than using a high dose, as the latter may in fact be too 'strong' for the required response. By employing a 'low dose', sufficient to pass the threshold of minimal effect, it is hoped that the desired physiological changes can be initiated without causing detrimental or unwanted 'side effects' (Kitchen & Bazin 1996; Low & Reed 2000).

A second area of changed philosophy relates to the internal energy systems of the body. There are numerous natural electrical activities in the body, and these relate to many tissues, not just the nervous system and muscle (Watson 1995). Musculoskeletal tissues are generally electrically active in their own right, and this electrical energy is an essential component of normal physiological function. The endogenous bioelectric activity is quite normal, and not a phenomenon associated with 'alternative' therapies alone. Much of the fundamental research in this area has been conducted by physiologists, biochemists and electrical engineers e.g. (Athenstaedt 1974; Harrington et al. 1974; Frohlich 1982; Betz & Caldwell 1984; Binderman et al. 1984; Konikiewicz & Griff 1984; Nordenstrom 1984; Offner 1984; Cooper & Schliwa 1985; Choy et al. 1986; Wolf 1986; Karu 1987; McLeod et al. 1987; Blank 1988; Marino 1988; Zon & Ti Tien 1988; Borgens et al. 1989; Robinson 1989; Bistolfi 1990; Wang et al. 1993) Many of the findings do help to explain some of the effects associated with alternative or complementary therapies, but the fundamental science belongs to all aspects of medicine, including physiotherapy in general, and electrotherapy in particular.

The tissues in which these electrical phenomena have been demonstrated is broad, covering skin (Foulds & Barker 1983; Vanable 1989), bone (Friedenberg et al. 1973; Borgens et al. 1985; McGinnis 1989), ligament (Frank et al. 1985; Akai et al. 1988) and tendon (Stanish et al. 1985). Bioelectric activity has been demonstrated at subcellular, cellular tissue and whole organism levels (Becker 1990; Borgens et al. 1989). The mechanisms for the generation of the electrical energy varies from tissue to tissue, but with common themes as would be expected in any biological system. There is no doubt that this electrical activity is fundamental to physiological processes. Researchers have demonstrated that changes in electrical activity are strongly associated with physiological events, and it has also been demonstrated that blocking or reversing the electrical activity can result in diminution or loss of the expected reaction (Becker 1974a; Becker 1974b). Whilst there is inevitably some doubt in the wider scientific community, the growing acceptance within the medical professions that these internal electrical activities are significant has influenced practice in several fields including orthopaedics (Brighton et al. 1981; Chakkalakal et al. 1988), psychology (Edelberg 1972) and physiotherapy (Charman 1990a).

The full range of bioelectric phenomena are too extensive to review here, but the interested reader is referred to other papers by the author for a more detailed description of their relevance (Watson 1995; Watson 1996a; Watson 1996b).

BASIC MODEL OF ELECTROTHERAPY

The method by which most therapists learn about the various electrotherapy modalities is firstly with the physics, and then through the physical and physiological effects, eventually being able to determine (by default if by no other means) the therapeutic uses for which it can be employed.

In the clinical situation, the decision making process appropriately commences with a discussion of the patient's problems. Having identified the therapeutic aims and priorities for treatment, it is possible to establish the physiological mechanisms which will need to be activated or enhanced in order to achieve resolution of the problem. Once the physiological effects are known, then the modality that is best able to achieve these effects can be determined. The final selection of dosage and treatment method should be based on the evidence (in its broadest sense), thus the resulting treatment application should be appropriate, logical and supported by whatever evidence is available.

This two way learning and decision making model is illustrated in Fig. 1.

By selecting treatment modalities and doses based purely on past learning, the therapist risks applying a less than fully appropriate treatment, and although the patient may well improve, the maximum efficiency may not have been achieved. Keeping up to date with the evidence is a daunting task, especially if the topic area is seen as being 'peripheral' to the main activity of the practitioner.

EVIDENCE BASED THERAPY

There is rarely a single answer when it comes to clinical decisions. There are usually several options, some of which have a better probability of achieving the required effect. Evidence based practice is a relatively modern term for a process which has been applied in therapy for many years. There have been problems with the volume and appropriateness of the evidence, but in recent times, both of these aspects have been steadily improving. Historically, the evidence has been based on undergraduate learning, which is supplemented by experience and peer evidence, both formal and informal. More recently, there have been widespread calls for quality evidence

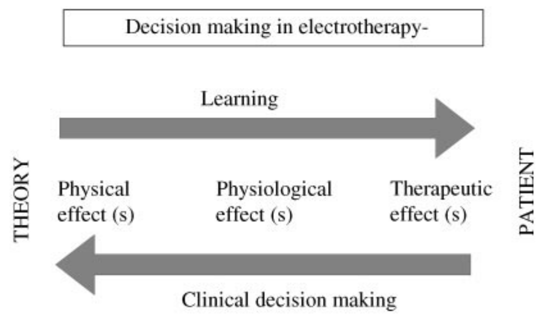

Fig. 1—A simple bidirectional model of electrotherapy.

which can be evaluated and implemented if deemed appropriate. This should lead to improvements in quality treatments but it is important not to dismiss existing treatments which appear to work (based on experience), but for which there are no specific published papers. There is a danger of rejecting therapeutic approaches which are in fact valid but which lack double blind controlled trials. If one looks critically at the full range of physiotherapy treatments from cold therapy to hydrotherapy and many in between, there is simply insufficient evidence to support or reject them in all known circumstances. Absence of evidence does not always mean that there is evidence of absence (of effect). This does not excuse the lack of published evidence related to electrotherapy, but points to the reality that there are many treatments used which appear to have contextual validity, but lack direct evidence.

The database of electrotherapy related research is growing steadily with the most readily identifiable gaps related to quality clinical studies and those comparing the efficacy of various therapeutic combinations. The laboratory and physiological based studies tend to dominate. There are several active electrotherapy research groups in the UK and overseas who publish in a range of therapy, medicine and physiology related journals.

In the ideal situation, everyone would know all there is to know about every modality. The treatment selection could therefore be rationalised to the point where a single flowchart would suffice in terms of electrotherapy decision making. This is not the case however. There is a wealth of information pertaining to the various modalities, including laboratory based studies, fundamental physics, clinical studies and larger scale trials. This combined with empirical and anecdotal/peer evidence of efficacy provides a substantive database from which such decisions can be made. The major problem is in keeping up to date with the research literature and incorporating it into the professional framework which is used to make clinical decisions.

In electrotherapy, the last series of update articles appearing in a mainstream publication were those by Partridge and Kitchen in 1990 (e.g. ultrasound reviews in Partridge & Kitchen 1990a; Partridge & Kitchen 1990b). These provide a sound evidence-based foundation for many recent developments, but they must now be, in part at least, out of date. Other publications have carried review articles on various aspects of electrotherapy, and where these are known, they have been included in the modality references.

One of the other significant problems with electrotherapy is that each modality is based to some extent or another on physics. It appears to be unfortunate that physiotherapists and physics are often poorly matched companions, and physiotherapists interpretation of the laws of physics has at times been rather unique. This is not deliberate, but if the basic science on which we base our explanations is flawed, then acceptance of our explanations is difficult to achieve outside the portals of the profession. With the updated versions of texts, this is becoming less of a problem, and recent authors are to be congratulated on demystifying some of these historical misconceptions. There remain, however, several widely held beliefs which are essentially incorrect, and it will take time for the 'real' explanations to permeate the professional mass.

THE ELECTRICAL POTENTIAL OF THE CELL

At a basic level, all cells are electrically active. The cell membrane exhibits a potential across its structure. This averages some 70 mV (70 thousandths of a volt), though can be up to 90 or 100 mV in nerves, with the internal aspect of the cell being maintained in a more negative state compared with the extracellular environment. The cell membrane potential is inherently related to the cell transport mechanisms. These are the processes by which material is moved into and out of the cell. Many of the materials which are routinely moved across the membrane are ions – charged particles – and their transportation is effected by a variety of pumps and gated channels. Charman (1990b) has reviewed the relationship between a variety of these mechanisms.

Although the membrane potential is small (in absolute terms), it is substantial relative to the thickness of the membrane. The average membrane thickness is some 7–10 nm (Alberts et al. 1989) (a nanometre is 10^{-9} of a metre – or a thousandth of a millionth of a metre). The equivalent voltage is in the order of 10–14 million volts across a metre. This is the voltage gradient (volts per metre) across the membrane rather than an actual potential difference. As each living cell in the body has this voltage gradient, it must be there for a purpose as it costs energy to maintain. The gradient is an essential component of the cell transport (as above), and the two phenomena are closely related. Changes in the voltage will influence transport mechanisms, and conversely, changes in transport mechanisms will influence the voltage gradient (Adey 1988, Charman, 1990b).

The cell membrane is a key player in influencing cellular activity levels (Alberts et al. 1989). The nucleus is critical for genetic control and reproductive functions, but activity changes in the membrane exert a strong influence on cell processes.

HIGH AND LOW ENERGY APPROACHES

There are many ways of considering the range of electrotherapy modalities – some authors have divided them into thermal, electrical, electromagnetic and sonic – a classification which on the surface at least appears to encompass most of the basic approaches (Kitchen & Bazin 1996; Low & Reed 2000). Rather than argue the benefits or otherwise of such a classification, it is proposed that there is another method of considering electrotherapy, which is based on the magnitude of the energy being applied.

Two approaches within electrotherapy influence this close relationship between cell electricity and cell chemistry. One option is to deliver sufficient energy across the membrane to force a change in behaviour by depolarising (or hyperpolarising) the membrane. Electrical stimulation therapies (such as interferential, TENS) are good examples of this approach. The electrical current passed through the tissues forces nerves to depolarise, and thereby causes the nerves to 'fire'. The type of nerve influenced in this way, and the rate at which the fibre is depolarised will determine the physiological and therefore the therapeutic effect achieved (Scott 1996; Low & Reed 2000).

The alternative approach is to deliver much smaller energy levels, and instead of forcing the membrane to change activity, the membrane can be excited (or stimulated). The excitement of the membrane (in general terms) results in an excitement of cellular activity (usually by means of a second messenger e.g. calcium ions activating cAMP). Modalities which adopt this approach are those which employ small energy levels, often not producing any direct sensation of activity. Patients frequently ask whether the machine is working as nothing appears to be happening. Ultrasound, laser and possibly pulsed shortwave therapies appear to fall into this category. Each modality initiates a tissue response which is a result of cellular excitement rather than a direct effect. The effects listed for ultrasound include, for example, stimulation of the healing process. It is in fact not the ultrasound which induces such changes, but rather the ultrasound produces a cellular excitement, the consequence of which includes the activation of a range of physiological processes which are related to tissue healing. The ultrasound in this context acts as a trigger, and the effects which are commonly ascribed to the modality are the result of cellular excitement.

FREQUENCY AND AMPLITUDE WINDOWS

It has been suggested, though possibly not in an integrated fashion, that there are windows of opportunity with regards electrotherapy modalities. In principle, such a window of opportunity exists when particular parameters (in terms of treatment dose) have a positive effect on the outcome, whilst other settings of the same variable may have less of an effect, or possibly no effect at all.

One such window relates to the amplitude of the delivered energy. In broad terms, if the intensity set on the treatment machine is too low, then the energy input will be insufficient to achieve an effect. If however, the amplitude is set too high, then the energy input may be excessive, and no positive response occurs. The amplitude window therefore is a theoretical range of amplitudes or intensities at which the benefit is derived (Litovitz et al. 1990, Goldman & Pollack 1996). Deviation outside the boundaries of this window may lead to a zero net effect, or possibly, to an inhibitory outcome. This concept is not unique to electrotherapy, and parallels can be seen in other forms of therapy (e.g. manual therapy and exercise therapy) in addition to a range of pharmacotherapies.

The amplitude window is unlikely to be a static phenomenon. Its dynamic qualities relate to both the sensitivity and/or irritability of the tissue, and the tissue type itself. The more acute the tissue state, the more energy-sensitive it is. Some acutely injured or traumatised tissues appear to respond to very low energy doses, whilst a normal (i.e. non injured) tissue, exposed to the same energy dose, will fail to demonstrate a significant physiological response (e.g. Karu 1987). Similarly, tissue in a chronic state will require a greater energy input than that required to activate the acute lesion. There appears to be a sliding scale of intensities which are effective. It is almost impossible to know, given our current understanding, exactly which lesions require a particular amplitude input to achieve activation. For some modalities, overview data is available, whilst for others, the information in this respect seems rather scant.

In addition to the amplitude window, there appears to be a frequency window which in essence, behaves in the same way. Some frequencies appear to be excitatory whilst others have little or no effect. The frequency window also appears to vary with the tissue state, such that the frequencies which are optimally effective in the acute, irritable stage have less effect in the chronic or non irritable states. It remains distinctly possible, that the optimal frequency will be related to the target tissue type in a similar way to the amplitude window (Cleary 1987).

The combination of a simultaneously existing amplitude and frequency window would suggest that there are many ways of failing to achieve the optimal dose. It is possible that the windows are interdependent (though there is no direct evidence to suggest that this is the case). If the combined effect of the optimal amplitude and frequency windows is to achieve maximal tissue activation, then this is considered desirable. Given the number of permutations, even for a relatively straightforward treatment modality, such as TENS, it is possible to get both amplitude and frequency almost correct, yet miss the optimal combination.

Furthermore, it is suggested that there may be an additional 'window' in terms of energy (Low 1995) (which will be related to both the frequency and amplitude windows). Although it may well complicate the issue, the three way interaction of amplitude, frequency and energy windows may serve as a useful tool in future clinical decision making frameworks.

It would be rash to suggest that there is a full understanding of how to manipulate these parameters, but given the increasing research evidence in the field of electrotherapy, more examples of effective (and of course, ineffective) parameters are becoming known. The fundamental problem with research in this area is that many investigations only manipulate the effects of a single variable – classical reductionist research. For this concept to be fully realised, it is essential to manipulate the interaction of two or more variables simultaneously – something which is very difficult in experimental research.

The concept of the variable amplitude and frequency windows is illustrated in Fig. 2. One or more variables may need to move on their own scale in order to maximise effect. The permutations are finite, but too numerous to try all of them. One of the skills of the therapist is to be able to make a judgement regarding the starting point from which the treatment dose can be fine tuned.

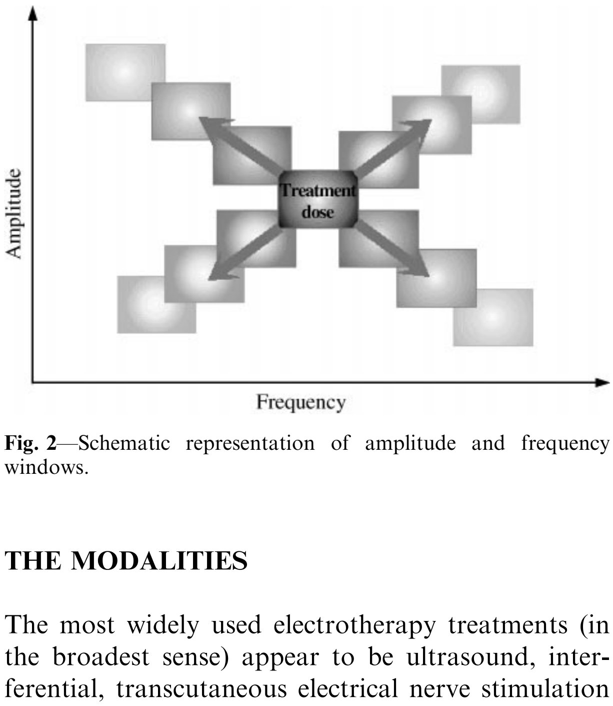

Fig. 2—Schematic representation of amplitude and frequency windows.

THE MODALITIES

The most widely used electrotherapy treatments (in the broadest sense) appear to be ultrasound, interferential, transcutaneous electrical nerve stimulation (TENS) and pulsed shortwave (often inappropriately referred to as pulsed electromagnetic energy or PEME) (Pope 1995). Other modalities and applications vary in their popularity. Laser therapy is frequently used, and combination therapy (simultaneous application of interferential and ultrasound therapies) has gained popularity. More recently, there has been a shift in the use of electrical stimulation, and a wide range of 'new' stimulations have been introduced into clinical practice. These include 'eutrophic' stimulation, neuromuscular electrical stimulation (NMES), functional electrical stimulation (FES) and chronic electrical stimulation.

Only two modalities will be specifically considered in this masterclass (ultrasound and interferential therapy) in the light of their popularity and usage in the musculoskeletal field. Ultrasound is an example of a 'low energy' intervention producing cellular excitement, and interferential is used as an example of a form of electrotherapy which is based on 'forcing' nerves into a particular behaviour pattern, thereby causing specific effects.

ULTRASOUND

Ultrasound (Fig. 3) should not strictly be included in electrotherapy in that sound energy is a mechanical wave rather than an electromagnetic wave or an electric current. It is usually grouped with the other

Fig. 3—Therapeutic ultrasound machine.

electrotherapies, possibly explaining the recent name change to the 'electrophysical modalities'.

Essentially, the ultrasound machine generates a sound wave beyond human sensory range, commonly at either 1 or 3 MHz (millions of cycles per second) (Fig. 4). This wave travels through the tissues and is preferentially absorbed in dense collagenous tissues (e.g. ligament, tendon, fascia and joint capsule). The absorption of the wave energy brings about several physical effects, most notably stable cavitation and acoustic streaming (Maxwell 1992). The consequences of these effects is that the cell membrane potential is altered and the cell membrane transport mechanisms change – in particular, the membrane becomes more permeable than usual to various ions (e.g. calcium and sodium) (Mortimer & Dyson 1988). The result of this intervention is that the membrane, and hence the cell itself becomes more excited – carrying out its usual role but in an enhanced or activated fashion. Fig. 5 represents the mechanism by which therapeutic ultrasound is able to achieve physiological stimulation.

Ultrasound effectively produces cellular excitation, enhancing cellular activity rather than dampening or inhibiting it (Nussbaum et al. 1994).

When applied to the tissues during the inflammatory stage following injury or pathology, its overall

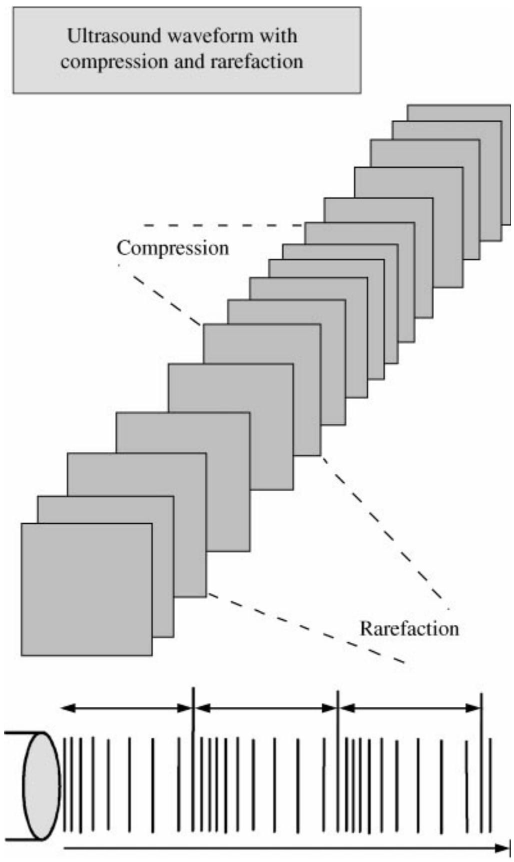

Fig. 4—Essential arrangement of the ultrasound wave.

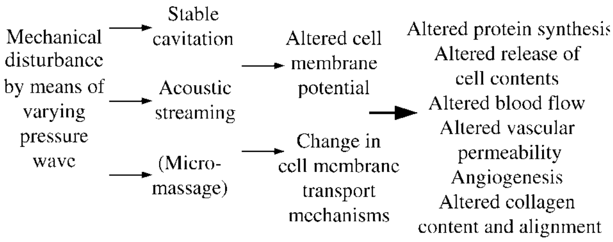

Fig. 5—Schematic representation of ultrasound physiological effects.

effect is to stimulate or enhance the inflammatory cascade, thereby acting as a pro-inflammatory mediator rather than an anti-inflammatory treatment. The therapeutic benefit of this is that the inflammatory process runs its course rather more efficiently, enhancing the tissues to move into their next phase (proliferation) (Dyson & Luke 1986; Dyson 1987; Young & Dyson 1990a; Maxwell 1992; Nussbaum & Gabison 1996; Nussbaum 1997).

When applied during the proliferative (repair) phase, it stimulates the active cells and maximises the scar production activity and quality. Both fibroblastic and endothelial cell activity are enhanced (Dyson & Niinikoski 1982; Young & Dyson 1990a; Young & Dyson 1990b; Maxwell 1992) The intention at both of these phases is not to make the inflammation or the proliferation 'bigger' events, but rather to enhance their activity and efficacy.

In the later stages of repair, soft tissues will remodel, making the scar as functional as possible within the confines of the parent tissue. Ultrasound appears to enhance this remodelling phase (Dyson & Suckling 1978; Dyson & Niinikoski 1982; Maxwell 1992), making it a useful tool from the early inflammatory stages to the later scar refinement processes.

Given the evidence for the effects of ultrasound, it is possible to determine a framework for treatment parameter selection. The basic principle is that the more acute and irritable the tissue in question, the lower the required dose to achieve a stimulating effect. The frequency selection (1 or 3 MHz) will influence the effective treatment depth (3 MHz is more superficial – to a depth of approximately 2 cm, 1 MHz effective to a depth of to 4 or 5 cm). The pulse ratio needs to be higher for the more acute lesions (1 : 4) and lower for the more chronic (1 : 1 or continuous). Intensities vary from 0.1–0.3 W/cm^2 for the acute lesions to 0.4–0.7 or 0.8 W/cm^2 for the chronic lesions (this is the intensity at the lesion rather than at the surface). Treatment times are based on the principle of 1 minute of ultrasound per treatment head area, though account must be taken of the pulse ratio employed. If the machine is pulsed 1 : 1, it is only delivering ultrasound for 50% of the time, hence the treatment time needs to be adjusted accordingly.

The contraindications (CSP Guidance – in press) include:

- Avoid exposure to foetus
- Malignancy
- Vascular abnormalities including DVT, emboli and
- Severe atherosclerosis
- Anaesthetic areas
- Acute infections
- Haemophilic patients not covered by factor replacement

Application of some specific areas including:

- The eye
- The stellate ganglion
- The cardiac area in advanced heart disease
- The spinal cord after multiple level laminectomy
- The gonads
- Active epiphyseal regions in children

INTERFERENTIAL

Interferential Therapy (Fig. 6) appears to be one of the more difficult modalities to explain, though in principle, it is just another form of electrical stimulation. The difference is that it uses 'medium frequency' currents to bring about the effects normally attributed to a low frequency stimulation. This is achieved by applying two 'medium frequency' currents (at several thousand hertz AC) to the tissues, so that an interference current is generated (Fig. 7). The pattern (which is an amplitude modulation) mimics the effect of a low frequency current (typically up to 250 Hz), and the tissues respond accordingly. One therefore achieves the benefits of low frequency stimulation without the associated unpleasant side effects (pain, discomfort, skin irritation etc) (Martin 1996).

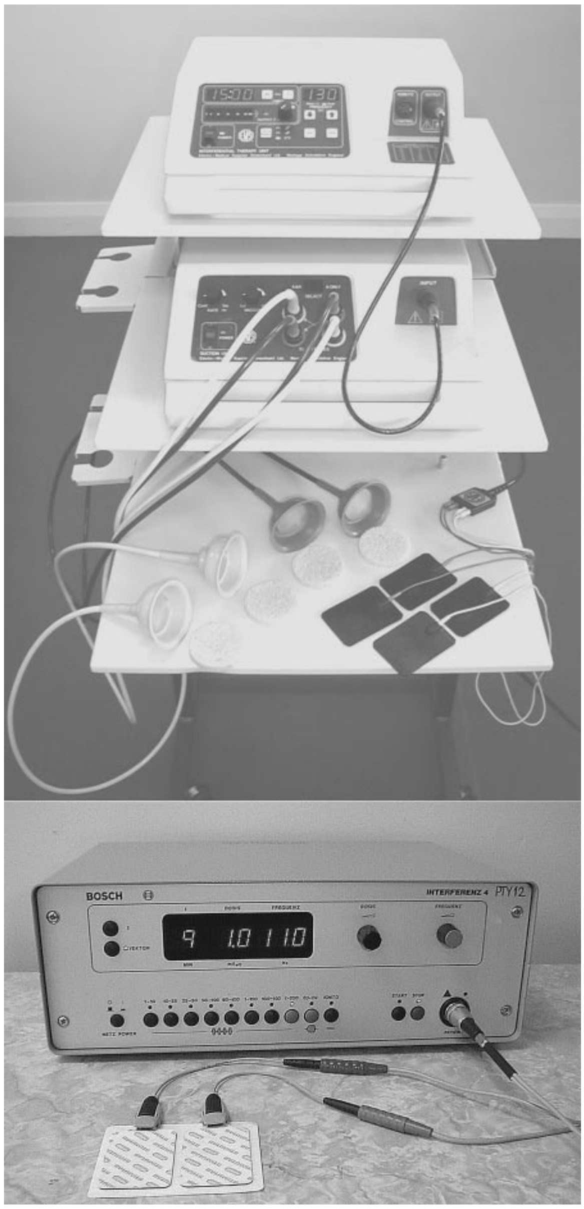

Fig. 6—Interferential therapy machines and accessories.

It is suggested that by adjusting the frequency produced in the interference zone, it is possible to influence a range of different nerves. By changing the type of nerve which is primarily stimulated, the physiological outcome of the stimulation is modified, and hence, so is the therapeutic outcome. This view has however been recently challenged by both Johnson (1999) and Palmer et al. (1999).

Frequencies can be utilised which primarily activate motor nerves, resulting in a muscle stimulation ranging from low frequency twitching (<15 Hz) through to a tetanic, sustained contraction (>40 Hz) – each of which have their therapeutic uses. There is at present, no evidence to suggest that muscle stimulation with electrical stimulation is any more (or less) effective than by active exercise, but it can be utilised as a means of ensuring the muscle activity level is raised (McMeeken 1994). This in turn will influence the local blood flow as a normal physiological response to an adjusted metabolic rate. Frequency ranges from 1 to 150 Hz or more can be employed in this respect, though it is suggested that clinically, the most appropriate ranges are between 10 and 20 or 25 Hz (Noble et al. 2000). At the lower end of this scale, a rapid muscular twitching will be produced, whilst at the upper end, a partial tetany will result. There is currently some concern regarding electrically induced sustained full tetanic contraction in skeletal muscle, and given this concern, it may be best avoided.

Using appropriate frequencies, sensory nerve stimulation can be achieved, thereby producing a mechanism to activate the pain gate (e.g. between 80–130 Hz) and opioid (<10 Hz) mechanisms which are associated with physiological pain relief

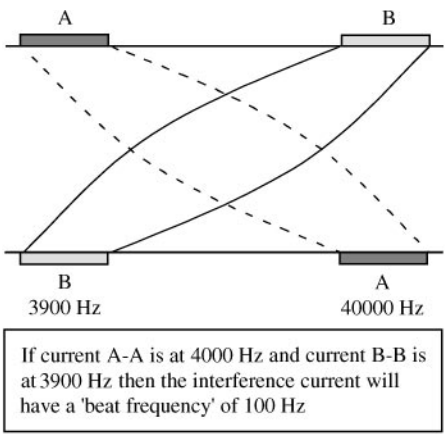

Fig. 7—Principle of Interferential Therapy treatment.

Fig. 8—Bipolar interferential therapy treatment for lateral elbow pain.

mechanisms (in the same way that TENS is believed to operate). Although there is less published evidence for the effectiveness of interferential therapy compared with TENS, there have been several recent studies which have demonstrated statistically significant pain threshold changes with interferential treatments compared with control or placebo treatments (Johnson & Wilson 1997; Stephenson & Johnson 1995; Tabasam & Johnson 1999).

Several other claims are made for interferential therapy, but with rather less evidential basis. There appears to be little or no evidence for direct effects in the stimulation of healing (though this could of course be brought about by modifying muscle activity, blood flow and oedema reabsorption). Clinical trials have been reported concerning the effects on oedema (e.g. Christie & Willoughby 1990) which have failed to demonstrate a significant outcome effect. Given our current understanding of the modality, it is possible that the zero effect results relate to the treatment parameters employed rather than the actual ineffectiveness of the modality.

The use of interferential therapy as a means to stimulate bone healing has also been reasonably well investigated, with some encouraging results e.g. (Ganne 1988; Fourie & Bowerbank 1997).

Selection of appropriate frequency ranges (as above) to stimulate the right type of nerve fibre, which in turn will bring about the most relevant therapeutic effect is the key to treatment. It appears from the published work, that the use of wide frequency sweep ranges is one of the least efficient methods of applying interferential therapy (Quirk et al. 1985; Christie & Willoughby 1990). The research which has utilised smaller frequency ranges has shown more consistent results (Stephenson & Johnson 1995; Johnson & Wilson 1997; Ganne, 1988; Tabasam & Johnson 1999; Noble, 2000) and it is suggested therefore that this is most likely to be the most significant variable for the modality.

Effective treatment times appear to vary between 10 and 30 minutes (shorter applications for the more acute lesions). The use of suction (vacuum) electrodes does not appear to provide any additional therapeutic benefit beyond that of the modality itself, though they are easier to apply, especially to large areas (e.g. low back, hip, shoulder). There is currently an increase in the use of pre-gelled, self adhesive electrodes (similar to those employed in TENS). They are cost effective, and being patient specific, reduce the potential for cross infection (Lambert et al. 2000).

Electrode placement is important in that the target nerves must be exposed to the delivered current Fig. 8. Most therapists apply the electrodes in the immediate vicinity of the lesion, though in the case of pain management, they can be alternatively applied over the nerve trunk, the spinal nerve root, within appropriate dermatomes or at acupuncture/trigger points in the same way that TENS applications can be varied.

Current intensity needs to be a definite but generally a non painful sensation. This will diminish with time, and therefore needs to be maintained to achieve the required effect (in the same way as all electrical stimulation modalities).
The contraindications (CSP Guidance – in press) include:

- Patients who do not comprehend the physiotherapists' instructions or who are unable to co-operate
- Danger of haemorrhage (e.g. recent soft tissue injury)
- Patients with pacemakers
- Dermatological conditions (e.g. eczema, dermatitis)

Application of electrodes over:

- Trunk/pelvis during the first 12 weeks of pregnancy
- The pregnant uterus at any stage of pregnancy
- Malignant tissue (except in terminal/palliative care)
- The eyes
- Anterior aspect of the neck & carotid sinus.

CONCLUSION

Without attempting to explain every modality, treatment doses and related physics, an attempt has been made to illustrate that modern electrotherapy does have a place in physiotherapy practice. Much as there is a significant volume of research, it is not possible to explain all the effects of all the modalities. There are elements where the anecdotal evidence is not supported by controlled trials. There are instances where there is reasonable laboratory research evidence which is not reflected in clinical application.

There is however a rationale for the continued application of various modalities as a component of care. The relationship between the energy input, the physiological effect and the therapeutic benefit derived from the treatment is important. The modalities are not magical any more than massage, manipulation or exercises. The energy, applied from outside the body acts as a stimulus for one or more physiological responses, and it is the physiological activation which helps to bring about the perceived therapeutic effects.

The selection of the most appropriate modality depends therefore on the knowledge of the relationship between the energy, the physiology and the therapeutic. Selecting the most appropriate modality is not a matter of learning a series of recipes, but of clinical decision making based on physics, physiology, pathology, assessment and patient treatment skills. Continued research in this field is essential in order to achieve the maximum benefit from the intervention. Research which considers the combined effects of manual, exercise and electrotherapy rather than the current reductionist approach is logically the next investigation phase.

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