PAIN RELIEF WITH INTERFERENTIAL THERAPY

This paper considers some of the developments in knowledge and understanding of the phenomenon of pain. The 'pain-gate' theory and the descending pain suppression mechanisms are mentioned briefly. A number of mechanisms are suggested whereby interferential therapy may relieve pain. A brief description of the interferential stimulus and its potential for utilizing the mechanisms described in earlier sections is given. Suggestions are made concerning the frequencies used for gaining this pain relieving effect.

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The problem of pain has occupied physicians and researchers for many decades in an attempt to understand and treat this common occurrence, but it is the last 20 years that have seen the most significant advances in this direction. The proposal of a 'pain-gating' mechanism, suggested by Melzak and Wall in 1965, is one of the more important advances. This theory has led to a new understanding of ways in which the phenomenon of pain can be treated and has led, for example, to the development of a completely new technology, namely that of the dorsal column stimulator and transcutaneous electrical nerve stimulation (Shealy and Mortimer 1970, Long and Hagfors 1975). More recent modifications and understanding of the basic theory, together with the emergence of another pain modulating mechanism, ie the descending pain suppression system, have made it possible to suggest a number of ways in which conventional treatment modalities may relieve pain.

The Concept of Pain

The concept of pain is essentially a series of chemical processes, which eventually give rise to a psychological and behavioural response within the affected person. In the acute situation arising from trauma or pathology, it is the direct stimulation of the pain nerve endings themselves, by chemical substances liberated within the damaged tissue, which is responsible for activating the pain pathway. Once the pain pathway has been activated, impulses arrive at the central nervous system, where integration and interpretation occurs at a spinal cord, brain stem, thalamic and cortical level. The eventual interpretation of this information is a psychological and behavioural recognition of the damaged state of the body (Liebeskind and Paul 1977, Mountcastle 1980, Bishop 1980, Watson 1981a). In chronic pain syndromes, however, it is possible that part of the stimulation of the central nervous system could come from 'reverberating neural pathways', these being activated from within the system (Melzack 1977). In this manner, the patient could perceive considerable pain in the presence of minimal peripheral activation. Thus there may be considerable differences in the nature and mechanisms involved with 'chronic' as opposed to 'acute' pain syndromes.

'Pain-Gating' Mechanisms

The original 'pain-gate' theory of Melzack and Wall has undergone extensive criticism and revision since its first proposal in 1965 (Handwerker, Iggo and Zimmermann 1975, Kenton, Crue and Carregat 1976, Nathan 1976, Strassburg, Kainich and Thoden 1977). However, it remains the most important theory of this type today and, at its simplest level, it describes the possible effects of stimulation of large diameter afferent fibres on the transmission of nociceptive stimuli.

In the dorsal horn of the spinal cord, there is a 'gate' which may be 'closed' and this 'closure' impedes the transmission of nociceptive impulses in the second order neuronal pathway for pain. The principal mechanism proposed for 'closing' the spinal gate was postulated to be stimulation of related large diameter fibres on the transmission of nociceptive stimuli.

Descending Pain Suppression Mechanisms

In more recent years, an additional pain relieving pathway has been described and this is the so-called 'descending pain suppression' system (Mayer et al 1971, Liebeskind et al 1973, Mayer and Liebeskind 1974, Hosobuchi, Adams and Lynch 1977, Basbaum and Fields 1978, Watson 1982). It basically involves a direct stimulation from the pain nerve. 
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endings themselves (A delta and C fibres), the actual nociceptive impulses being responsible for generating a 'long-loop' descending pain inhibition. Nociceptive impulses travelling through the spinal cord, in the anterolateral spinthalamic tracts and others, eventually reach the thalamus in mid-brain regions, branching co-lateral axons synapse with a number of centres, in particular the periaqueductal grey matter and raphe nuclei. Cells from the raphe nuclei send their axons back down the spinal cord to the original levels of involvement. At this point there is thought to be an inhibition of the second order nociceptive neuron, via an inhibitory interneuron.

The descending pain suppression system is also thought to be closely linked to the endogenous opiate mechanisms of the body. These consist of a group of neurotransmitter substances known as enkephalins and a hormone like substance called beta endorphin. These substances are intimately involved with the transmission of impulses within many parts of the descending pain suppression system. Specific receptor sites for these compounds have been located in many regions of the system (Bishop 1980, Watson 1982). In this manner, nociceptive stimuli may produce an auto-inhibition via a complex negative feedback system, operating within the central nervous system. The concept of a descending pain suppression system is depicted in Figure 2 and in Figure 3, together with the spinal gating systems.

Interferential Currents

The concept of an interferential current is by no means a new idea. It was originally proposed in the mid 1950's by Dr Hans Nemeck, working in Austria. In spite of the fact that interferential therapy has been available for some 25 years, it is only comparatively recently that it has begun to generate very much international interest.

The term interferential therapy stems from the idea of two currents 'interfering' with each other and this gives rise to the term 'interference therapy'. The 'interference' effect is produced in the tissues by the superimposition of two medium frequency, alternating currents of approximately 4,000 cycles per second (c.p.s.). The current which flows from one circuit, is driven by a fixed frequency oscillator and cannot be changed by the operator. However, the current in the second circuit is driven by a variable frequency oscillator and its range is commonly variable from approximately 4,000 to 4,100 c.p.s. The phase difference between the two circuits produces an interesting effect in the patient's tissues. The two currents 'beat' together in such a way that at some points they will join together and produce an increased amplitude, whilst at other times they will completely negate each other and produce no effect at all. This effect is known as amplitude or 'envelope' modulation.

The number of these 'envelopes' per second is known as the beat frequency. It is important to remember that it is the 'beat' frequency which is in the biological frequency range and that the 4,000 c.p.s., medium frequency current is used as a 'carrier wave' in order to overcome the electrical resistance of the skin. Thus the current produced underneath the electrodes is in the region of 4,000 c.p.s., whilst the interference effect is produced within the patient's tissues. There is no interference effect underneath the four electrodes. Figure 4 illustrates the concept of an interferential current (for a more complete description see De Domenico 1981 and Ward 1980).

Possible Pain Relieving Mechanisms

From the remarks made in previous paragraphs, it is now possible to propose a number of different mechanisms which may be implicated in the relief of pain, using an interferential current. These are:

(a) Activation of 'pain-gating' mechanisms

(b) Stimulation of the descending pain suppression system and endogenous opiate mechanisms.

(c) A physiological 'block' of nociceptive input.

(d) Removal of the substances which stimulate pain nerve endings from within the damaged area

(e) A placebo effect.

Figure 1: A diagramatic representation of the concept of a 'pain gate'
The first two methods are contingent upon the ability of a treatment modality to selectively activate both the large diameter sensory fibres and the small diameter nociceptive neurons respectively. The third method may be achieved by an "over stimulation" of the nociceptive fibres themselves. This physiological "block" may contribute to a subjective relief of pain for the patient, since the degree of input to the cortex may be considerably reduced. The fourth method involves an increase in the blood flow through the damaged part, since this will tend to hasten the removal of the substances which stimulate the pain nerve endings in the acute situation. Consideration will now be given to the means by which interferential therapy may relieve pain.

Interferential Currents and Pain Relief

In order to utilise the mechanisms described for modulating pain impulses, the interferential current must comply with certain stimulus parameters. To selectively stimulate large diameter afferent fibres, for example, the stimulus should ideally have a pulse duration of less than 10 microseconds and a frequency of approximately 100 Hz. A stimulus with these characteristics is able to selectively activate the large diameter afferent fibres and in this way utilise the "pain-gating" mechanisms for pain relief.

Activation of the descending pain suppression system relies on the selective stimulation of small diameter nociceptive fibres. In order to activate these neurons, a potential stimulus would require a pulse duration of approximately 100 to 200 microseconds with a pulse frequency of approximately 15 Hz. It should be noted that a pulse width of 100 to 200 microseconds will still activate the large diameter fibres, since their threshold remains considerably lower than that of the small A delta and C fibres. However, the somewhat reduced frequency of stimulation may tend to favour the activation of the descending pain suppression mechanism (Howson 1978).

In the case of interferential currents, the 4,000 cycle carrier has a pulse duration of approximately 125 microseconds the 4,000 cycle alternating current thus produces 8,000 stimuli per second. Although the carrier frequency is very high, the effective stimulus has a frequency of up to 100 Hz. This corresponds to the point of maximal amplitude during each interferential "envelope". If the interferential beat frequency is operating in a rhythmical mode, then the frequency of the effective stimulus may be changing, for example, from 80 to 100 Hz. Thus the stimulation characteristics of an interferential current are well within the range of those required to produce pain relief. Figure 5 depicts the stimulus characteristics of an interferential current for the activation of "pain-gating".
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Figure 4: Amplitude modulated, medium frequency, alternating current (interferential current). The two circuits at the top of the diagram (1 & 2) are of slightly differing frequencies. At certain points, the two phases will match identically (A & B) and in such situations the resultant summation will produce an overall increase in amplitude. At other points (C) the currents are equal and opposite, thus cancelling each other out. The envelope effect (dotted line) shows the shape of the beat frequency cycle. The number of these 'envelopes' per second represents the 'beat' frequency of the current. Interferential current is amplitude modulated, medium frequency alternating current.

Figure 5: The probable 'effective' stimulus characteristics of an interferential current. The rectangular area represents the 'effective' stimulus in the sense that the amplitude of the signal on either side of this area is likely to be insufficient to produce effective stimulation of the tissues. At a frequency of approximately 4,000 Hz, the pulse duration of each phase is about 125 microseconds. The first half cycle is probably the effective stimulus, since the second phase occurs at a time when the neurons are refractory and they cannot respond.

Nociceptive fibres mainly belong to the A delta and C groupings, the A delta population being finely myelinated, while the C group are unmyelinated (Mountcastle 1980, Vallbo et al 1979). The C group fibres are capable of synchronous firing with an electrical stimulus that has a frequency which does not exceed approximately 15 Hz. Frequencies in excess of 15 Hz will usually lead to a 'dropout' phenomenon and they will cease conducting. With frequencies greater than 50 Hz, the C group fibres may not conduct at all and thus produce a physiological 'block'. In the case of the A delta group fibres, the maximal frequency of stimulation may be somewhat higher at about 40 Hz. However, frequencies greatly in excess of this figure may also lead to a 'functional block' of their activity. In this manner, a stimulus frequency of 100 Hz, effectively applied to nociceptive neurons, may lead to a physiological block, following an initial short burst of activity: the decrease of nociceptive activity within these fibres may lead to a subjective relief of pain for the patient. The concept of a 'physiological block' is theoretically possible with interferential currents, but it remains to be adequately demonstrated.

Another way in which interferential currents may relieve pain is concerned with their ability to stimulate the circulation and aid in the removal of pain producing substances. Interferential beat frequencies in excess of 80 Hz are claimed to produce a marked depression of A delta and C fibre activity, along the lines mentioned in previous paragraphs. Since the muscular coat of the small arterioles of the body is innervated by sympathetic fibres, a depressive effect on this system is calculated to produce an increased blood flow.
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flow through the part. Vasodilation could be produced in the damaged area by inhibiting the sympathetic stimulation of the muscular coat of the small artenole wall. This leads to a relaxation of the vessel walls and subsequent increase in their diameter. This in turn leads to an increased blood flow through the part and eventually to a removal of the pain producing substances from the area. This effect may be utilized in the treatment of peripheral vascular disease (Niklova-Troeva 1968).

A final way in which interferential currents may relieve pain is concerned with the placebo effect of the treatment. The fact that interferential currents relieve pain is empirically indisputable, since physiotherapists from many parts of the world have witnessed some apparently amazing results with this modality. As with all treatments, there is a possibility that the results obtained would have occurred without the treatment being administered. There can be little doubt that the high technology involved with interferential treatment is both impressive, and in some cases bewildering, for the patient. The great array of coloured leads, flashing lights and curious noises is likely to induce a certain amount of awe in the patient. In these circumstances it would not be surprising for most patients to feel that they were receiving an 'effective' treatment for their pain. In this way the patient may report an improvement in their condition, which is not due to the treatment being administered, but to some other factor.

Conclusion

The developing concept of pain has led to the proposition of a number of ways in which it can be relieved, in particular by the activation of 'pain-gating' and descending pain suppression systems and the utilization of physiological 'blocking' methods. Effective treatment using these systems is contingent upon the stimulation of large and small diameter afferent fibres. The stimulus characteristics of interferential currents are well within the required parameters for such activation and they are therefore capable of acting through these systems. Pain-gating and physiological 'blocking' are most likely to occur at the higher frequencies and are probably more effective when delivered in a rhythmic manner. A frequency sweep of 80 to 100 Hz is satisfactory for this purpose. The activation of the descending pain suppression systems is most likely to occur at the lower frequency range probably around the 10 to 25 Hz region. Again, a rhythmic sweep through these frequencies is likely to produce the best results. Pain relief may also be produced with interferential currents by a stimulation of the blood flow through the affected area, with the consequent removal of some of the pain producing substances. A placebo effect may also play a part in the subjective relief of pain, as reported by the patient. Interferential currents are by no means a panacea and undoubtedly have a number of limitations; however, when the technique is applied correctly and administered properly, excellent results can be expected.

References

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