Transcutaneous Neural Stimulation, Needle Acupuncture & 'Teh Ch'i' Phenomenon

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Abstract: Greatest relief of pain is reported to occur following the subjective appreciation of the "Teh Ch'i" phenomenon. This phenomenon is associated with the stimulation of muscle or nerve trunks where large diameter afferent fibers are present. According to the gate theory, the stimulation of large diameter afferent fibers relieves pain. Almost all large diameter afferent fibers are derived from muscle proprioceptors which are mostly mechanoreceptors and respond specifically to a manipulated needle. Muscle stimulation is maximal at a fairly narrow transverse band, the zone of innervation, near the neurovascular hilus of the muscle and approximating the skin motor point. Many acupuncture points are now seen to coincide with motor points. For best results, therefore, it would seem logical that stimulation should be at the motor point. Many methods of stimulation are available today in acupuncture. Two popular methods are transcutaneous neural stimulation using surface electrodes and needle acupuncture with or without electricity. The relative merits of these methods of stimulation and their relationship to Teh Ch'i are discussed.

IT IS AN ancient and well-known observation that, with needle acupuncture, greatest relief of pain follows the subjective appreciation of "Teh Ch'i"— a combined deep feeling of soreness, heaviness or pressure, numbness, fullness or distention. Objectively, the needle is seen to be grasped by locally contracting muscle[1]—frequently bending the needle. This phenomenon poses many unanswered questions. What is its neurological basis? Does it occur following all methods of acupuncture, or does it occur only with needling? If, as it is commonly believed, Teh Ch'i is followed by successful therapy, then should not the aim of the acupuncturist be to evoke Teh Ch'i at each point of stimulation?

The Teh Ch'i phenomenon or "needle sensation"[2] occurs within seconds following needle acupuncture at most acupuncture points when mechanical or electrical stimulation is applied. Local anesthetic, injected around the nerve supply of the muscle pierced, blocks the phenomenon as well as the effect of acupuncture, but cutaneous local anesthetic introduced at the skin site of acupuncture or vascular occlusion[3] does not. Although the Teh Ch'i phenomenon has not been mentioned in the literature following transcutaneous neural stimulation, in our experience patients who derived benefit from transcutaneous neural stimulation have reported that their muscles felt "tired," "numb," or "achy," especially when muscle contractions were observed during stimulation.

Of the many methods available for the stimulation of acupuncture points, the two most favored in North America are needle acupuncture and transcutaneous stimulation. Transcutaneous neural stimulation, or the electrical stimulation of the peripheral nervous system via surface electrodes, achieved its popularity because it is a relatively safe and non-invasive procedure (no surgical implantation of electrodes as in dorsal column stimulation and no needle insertion).

Acupuncturists familiar with both techniques adamantly believe that needle acupuncture is vastly superior to transcutaneous neural stimulation, but advocates of either method are agreed that the stimulation of superficial cutaneous nerves is less satisfactory than the stimulation of deeper tissues or of nerve trunks. Shealy,[4] who as early as 1968 had tried a wide variety of pulse parameters including square waves, sine waves, saw tooth and spikes, concluded the latter two to be more effective for delivering a greater amount of electrical charge to underlying structures[5] and for deep tissue penetration. Long and Carolan[6] obtained good results using a modified square wave pulse applied over major nerve trunks. Fields *et al*[7] dramatically relieved the pain of causalgia by stimulating a normal section of the appropriate nerve central to the lesion, but discovered that stimulation of the skin adjacent to the nerve was not rewarding. In our own experience for low back pain, transcutaneous neural stimulation yielded best results when electrodes were placed over muscles at their motor points (using muscles belonging to both the anterior and posterior rami) or over major nerve trunks.[8] Many acupuncture points are now known to coincide with muscle motor points.[9/10/11/12]

The motor point, a known anatomical entity, is identified clinically as the skin site where a twitch may be evoked in response to minimal electrical stimulation. Myoneural junctions are not spread all over the muscle, but are usually concentrated in a confined zone—the zone of innervation which lies near the motor point. It is the terminal branches of the nerve nearer the skin surface which are accessible for stimulation and correspond to the motor point.[13]

The gate control theory of Melzack and Wall for the perception of pain relies on the supposition of mutual, pre-synaptic inhibition between receptors that do not register pain (mechanoreceptors) and those that do (nociceptors). Large diameter afferent-fiber activity "closes" and small diameter fiber activity "opens" a gate which permits the input of information about noxious stimuli. If this gate control theory—now modified to allow for gates at several levels in the nervous system—remains valid (and recent opinion still supports it)[14] then the contribution of large diameter afferent-fiber activity from superficial cutaneous nerves (the stimulation of which appears less effective) would be less significant than that from the deep (muscle) nerve supply.

An analysis of the afferent-fiber diameter content in the dorsal nerve root may explain this.

Afferent fibers from skin and deeper structures, joined by those coming from the gut, enter the spinal cord through the dorsal nerve root to relay in the posterior grey column in which the cell bodies of the second sensory neurons are arranged in several laminae. Laminae 2 and 3 (the substantia gelatinosa) form an immense network of neurons which relates to the cells of other laminae including laminae 5 which are the cells responding to noxious stimuli.

A comparison of the afferent fibre diameter distributions in cutaneous and muscle nerves (Fig. 1A, B and C) with that of the dorsal root reveals that the fibers of largest diameter in the dorsal root are almost all non-cutaneous fibers.[15] Furthermore, the more important groups of large diameter afferent fibers are derived from muscle and tendon organs. A large number of the nerve fibers of muscles are sensory in function; Sherrington estimated that at least 40% of nerve fibers innervating a given muscle subserve sensory rather than motor end organs. The flower-spray endings (Group II) and annulospiral endings (Group Ia) are situated in muscle spindle and the Golgi tendon endings (Group Ib) at the muscle-tendon junction. These are proprioceptors and convey to the CNS information about muscle length, tension and velocity of muscle stretch. The smaller diameter afferent fibers (Groups III and IV) have not as yet been clearly defined, but are probably derived from muscle fascia and other deep tissue and probably include nocireceptors similar to those in skin.[16]

The relative afferent innervation ratio of different skeletal muscles should also be

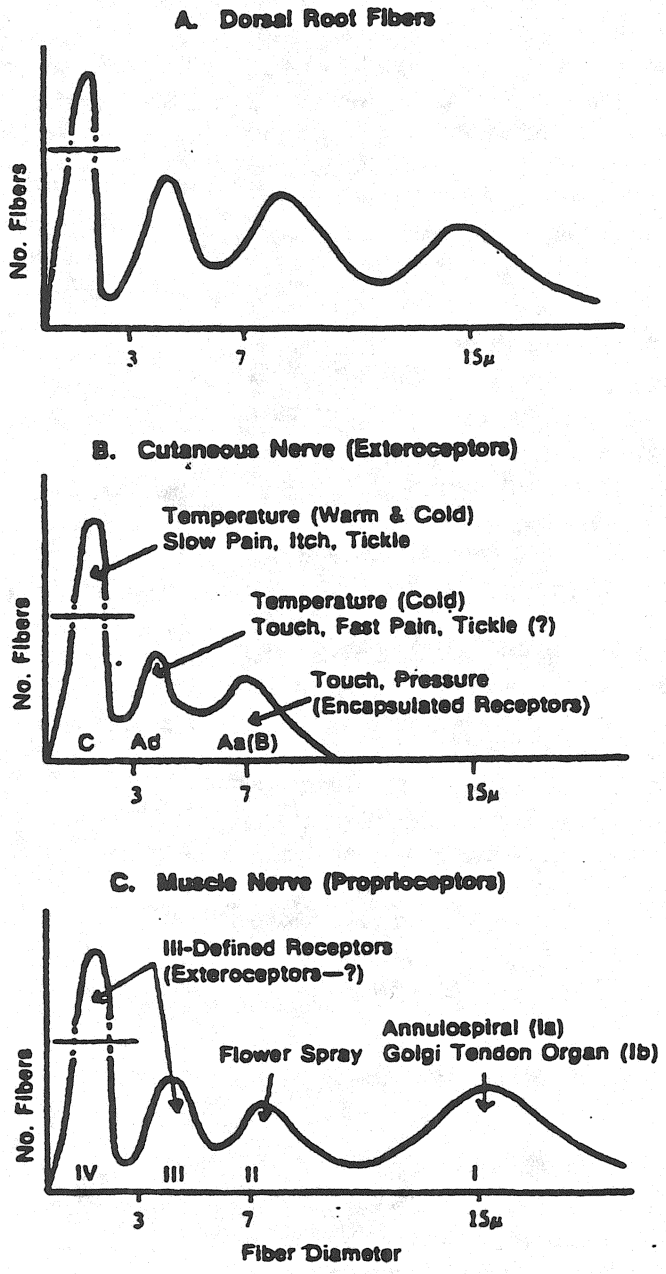

Fig. 1.
Large Fibers of Dorsal Root (A) are from Muscle Proprioceptors (C).

examined. Some muscles have higher innervation ratios than others. For example, the small interosseous muscles of the hand have approximately 120 muscle spindles per gram of tissue as compared to 5-20 in the gastrocnemius or soleus muscles. Therefore, whilst this rich sensory innervation provides greater feedback to the CNS for fine movement, it also provides, when stimulated, a greater afferent barrage to the dorsal horn. The reported efficacy of the Ho-ku point (first dorsal interosseous) is probably related to its high afferent innervation ratio.

Discussion

It is now some ten years since Melzack and Wall predicted that the stimulation of large diameter fibers would relieve pain. This prediction has proven both correct and useful.[14] Workers in this field have reported that stimulation of large diameter afferent fibers at the peripheral nerve trunks or at the muscle is more effective than stimulation of superficial cutaneous nerves. An analysis of the fibers at the dorsal root shows that practically all of the large afferent fibers originate from muscle. These large fibers are from proprioceptors and probably explain the subjective "deep" sensation of Teh Ch'i which contrasts with the superficial sharp, prickly or "burning" sensation from cutaneous exteroceptors. As muscle proprioceptors are almost exclusively mechanoreceptors, muscle stimulation mechanically by needle is specific and effective.

In theory, therefore, the relative merits of various forms of stimulation may be summarized as follows:

A) Cutaneous Stimulation

This is the most inefficient method using an electrical current of low intensity sufficient only to stimulate superficial cutaneous nerves with their low content of large diameter afferent fibers.

B) Transcutaneous Neural Stimulation (with electrodes)

This method is more efficient and uses a phasic current of sufficient intensity and efficient wave form to reach deeper tissues (including muscle). Since the zone of innervation of muscle is situated near the skin at the motor point, the greatest effect is obtained when electrodes are placed at the motor point or over the peripheral nerve trunk (which will also contain large diameter afferent fibers). Effective muscle stimulation is usually confirmed by visible contractions.

C) Needle Insertion

Needle insertion, accurately placed in the zone of innervation and manipulated, specifically stimulates mechanoreceptors and their large diameter fibers. Furthermore, needling produces a focus of injury and microtrauma; its current of injury persisting for several days until the microwound heals. The end result of repeated needling and multiple microtraumata leads to scar tissue formation which eventually displaces the number of functioning nociceptors and may explain the permanent relief of chronic pain. Mechanical stimulation of the needle also produces the triple response of Lewis with local production of autocoids (histamin-like substances) and this may be a factor in the relief of pain.

D) Needle Acupuncture with Electricity

Electricity is often used to augment the effect of the needle since large fibers have a lower threshold to electric stimuli, but electricity non-specifically and non-selectively stimulates all fibers including small diameter fibers as well as autonomic fibers. Although the role of the autonomic system has yet to be resolved, needling is often accompanied by autonomic manifestations: profuse sweating (sudomotor effect, skin temperature changes (peripheral vasodilatation), "goose pimples" or cutis anserina (pilomotor effect) and increased peristalsis.

Gross[17] and others have described sensory disorders which do not fall into the known order of peripheral nerves, but into a different topography—a vasal topography. Pain has a close correlation with both the sympathetic periphery and the entire autonomic system. Thus visceral regions may be incorporated

into a somatic or cutaneous irritation, and vice versa.

When the stimulating needle is not exactly situated at the fairly narrow transverse band of innervation (motor point), the relative afferent barrage will be smaller, but not entirely "zero;"[18] an electrical current can increase the stimulation by "jumping the gap."

Moxibustion, sometimes also employed to enhance needle acupuncture, selectively stimulates thermoreceptors, but these are commonly associated with unmyelinated fibers or small myelinated fibers (Figure 1B). Moxibustion may, therefore, be counterproductive.

Teh Ch'i does not occur in cutaneous stimulation. It occurs best in transcutaneous neural stimulation when accompanied by visible muscle contractions and in needle insertion only when the mechanical stimulation of the needle is at a site where there are sufficient mechanoreceptors, i.e., at the muscle zone of innervation. Teh Ch'i may be induced in needle acupuncture with electricity even though the needle is some distance away from the zone of innervation if the electrical current is increased sufficiently to "jump the gap."

Summary

Greatest relief of pain is reported to occur following the subjective appreciation of the "Teh Ch'i" phenomenon. This phenomenon is associated with the stimulation of muscle or nerve trunks where large diameter fibers are present. According to the gate theory, the stimulation of large diameter fibers relieves pain. Almost all large diameter fibers are derived from muscle proprioceptors which are mostly mechanoreceptors and respond specifically to a manipulated needle. Muscle stimulation is maximal at a fairly narrow transverse band, the zone of innervation, near the neurovascular hilus of the muscle and approximating the skin motor point. Many acupuncture points are now seen to coincide with motor points. For best results, therefore, it would seem logical that stimulation should be at the motor point.

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