Method of Determining Optimal Stimulation Sites for Transcutaneous Electrical Nerve Stimulation

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This article describes a technique that allows therapists to use a transcutaneous electrical nervè stimulation unit and a finger to probe for the superficial points of nerves. The therapist holds one electrode of the stimulator channel in his hand and places the other electrode of the channel on the patient. The therapist then places his index finger as near as possible to the superficial point of the nerve innervating the patient's area of pain. The amplitude is then slowly increased until the patient reports a paresthesia radiating along the course of the nerve stimulated and into the area of pain. The rationale underlying this technique and its advantages and limitations are discussed. Because many of the points detected with this technique correspond to effective acupuncture points, the technique may also be a method of detecting those acupuncture points that are associated with nerves.

Key Words: *Acupuncture, Electric stimulation, Paresthesia, Physical therapy.*

The use of electrical stimulation to produce pain relief developed from the finding that electrical stimulation of large myelinated fibers in a peripheral nerve could reduce the output of cells in the dorsal horns of the spinal cord normally responding to noxious stimuli.[1] Wall and Sweet successfully relieved long-standing pain in six out of eight patients with as little as two minutes of stimulation of the primary afferent fibers supplying the painful area.[2] Their results suggested that electrodes might be permanently implanted on peripheral nerves or on the dorsal columns of the spinal cord. The induction of analgesia with implants has been explicitly coupled to the production of tingling or buzzing sensations radiating into and covering the area of pain. Such sensations can be obtained from the orthodromic and antidromic depolarization of large nerve fibers in the major nerve supplying the painful areas.[3,4] In addition, a particularly high degree of pain relief can be achieved with stimulation of peripheral nerves in cases where pain transmission can be specifically ascribed to a particular nerve (eg, peripheral nerve injuries).[5,6] Thus, these findings give strong support to the belief that the effects of transcutaneous electrical nerve stimulation (TENS) can be maximized if the nerve(s) involved in the transmission of the "pain signal" can be identified and stimulated.

The belief that identification and stimulation of the specific nerve(s) involved in the pain signal would enhance the effects of TENS was further supported in a report of a 55-year-old woman who suffered from severe stabbing pain in the toes and medial arch of the foot secondary to diabetes.[2] Stimulation of the saphenous nerve produced tingling only in the calf and had no effect on the pain syndrome; however, stimulation of the superficial peroneal nerve produced what was described by the patient as an "electric feeling" in the toes and effectively relieved the pain in the toes. Peroneal nerve stimulation, however, had no effect on pain in the medial arch, which is supplied by the plantar nerve. Only subsequent stimulation of the plantar nerve alleviated the arch pain.[2]

Although the physical therapist is often able to identify the nerves involved in a given pain syndrome, the surgical implantation of electrodes is, of course, not within the therapist's expertise. On the other hand, placing electrodes on the most superficial points of nerves may very closely approximate the implantation of electrodes. Indeed, the finding that TENS could produce the same sensations as those produced by implants in a patient and could afford considerable pain relief to the patient led to the initial use of TENS as a screening device before physicians implanted electrodes on nerves.

The purpose of this paper is to describe a technique that allows the therapist to probe electrically for the superficial points of nerves with a TENS unit and a finger. I will address the advantages and limitations of this technique and the method for direct stimulation of nerves. Many of the points detected by this technique appear to correspond to acupuncture points, and this technique will be briefly compared with other methods of detecting acupuncture points.

METHOD

The following procedure to locate the superficial points of nerves involves electrically coupling the therapist to the patient. The therapist, using karaya or any other self-adhering electrode material, places one electrode of the stimulator channel in the palm of his hand and the other electrode of the same channel in the palm of the patient's hand. (Fig. 1). Then, placing his index finger of the hand containing the electrode as near as possible to where the nerve is believed to be superficial and without touching the patient in any other place, the therapist slowly increases the intensity of the stimulation

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PRACTICE

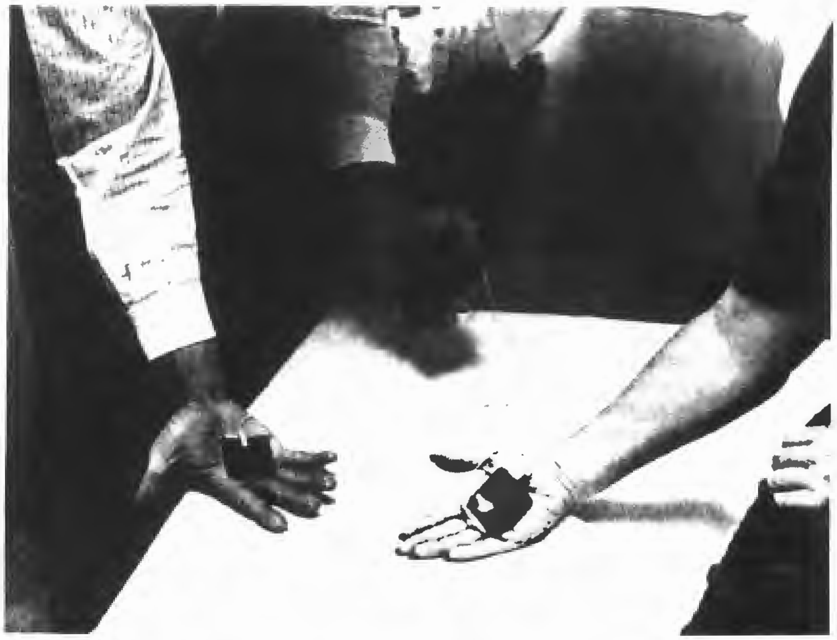

Fig. 1. One electrode of the stimulator channel is placed in the hand of the patient and the other electrode of the channel is held in the hand of the therapist. A self-adhering electrode coupling agent is used to hold the electrode.

until the patient reports a radiating sensation along the course of the nerve being stimulated (Fig. 2). If the patient's sensation of stimulation is limited solely to the area under the therapist's finger, then only a small receptive field at that point in the dermatome, rather than the nerve itself, is being stimulated. To correct this inappropriate stimulation, the amplitude is reduced and the procedure repeated at a slightly different point until the desired radiation is produced. A good anatomy text aids in identifying the nerve to be stimulated, the points at which it is superficial, and the expected course of radiation.

Because this technique is designed for locating optimal stimulation sites on nerves and is not necessarily predictive of the outcome of TENS, both the width and rate control of the unit may be set so that the sensation produced at the therapist's fingertip is comfortable to the therapist. For example, when I use the Dynex II TENS unit* (rate adjustable from 2–110 Hz, width adjustable from 40–200 μsec, and amplitude adjustable from 0–60 mA), the most comfortable rates capable of eliciting a tingling sensation appear to be between 30 to 50 Hz. All pulse durations are equally acceptable for the treatment, but pulses of short duration and high amplitude are probably better for selectively stimulating large myelinated fibers than pulses of longer duration and lower amplitude.[7] Additionally, use of a unit that does not shut off automatically every time skin contact is interrupted eliminates the necessity of turning the unit off and on again every time the position of the finger is changed.

Therapists should certainly experiment with this technique on each other to become familiar with all aspects of the sensations produced and the points on nerves at which they are produced before attempting to use this technique on patients. For example, by probing just lateral to the tendon of the biceps brachii in the antecubital crease, you can locate the lateral antebrachial cutaneous nerve that produces paresthesia extending along the radial aspect of the forearm (Fig. 2). Moving the finger medially along the crease and halfway between its end and the medial epicondyle, you can find the superficial point of the medial antebrachial cutaneous nerve. Stimulation here produces paresthesia extending down the ulnar aspect of the forearm. In the lower retropopliteal space just medial to the tendon of the biceps femoris muscle, a superficial point of the common peroneal nerve may be found (Fig. 3). Because this nerve communicates with the medial sural cutaneous nerve to form the sural nerve, stimulation at this point will elicit, in the posterolateral leg, paresthesia extending behind the lateral malleolus and onto the dorsum of the foot. This nerve is sometimes involved in a form of sciatica and may be activated

Fig. 2. Using the index finger of the hand holding the electrode, the therapist probes for the lateral antebrachial cutaneous nerve in the antecubital fossa.

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Fig. 3. With one electrode still in the patient's hand, the common peroneal nerve is stimulated in the lateral retropopliteal fossa producing paresthesia in the dorsolateral leg and foot.

electrically to alleviate pain in such cases.

Once you locate the optimum stimulation site for the first electrode, the procedure may be repeated using the second electrode of the same channel on the same or on a different nerve. The second electrode may also be conventionally placed over the dermatome of the involved nerve or on the pain site itself if such placement appears to provide maximal relief.

To introduce the technique, I place the electrode held by the patient arbitrarily in the patient's hand. The placement of the patient's electrode does not affect the ability to generate paresthesia into a given area or nerve distribution. For example, stimulation of a point on the common peroneal nerve is still capable of eliciting a paresthesia that radiates distally to points on the foot. Producing this distribution of paresthesia under these circumstances provides convincing evidence that the direction of current flow may not necessarily be the same as the distribution of sensation; that is, while current flows up the leg into the body and down the arm into the hand, the tingling sensation appears to travel down the leg. Sensation is seen here to result from the depolarization of particular nerve fibers and is referred along the course of that nerve into its receptive field. Thus, the direction of current flow is not what is sensed by the patient. The path through which the current traverses and the relative current densities along that path, however, will determine the effectiveness with which a particular group of nerve fibers is stimulated and thus, indirectly, the distribution of sensation. When the amplitude of the stimulating current is increased, the recruitment of more fibers leads to an increase in the strength of sensation and, possibly, a broadening of sensation distribution as fibers innervating new areas are recruited.

Another noteworthy phenomenon is that you may also stimulate with the hand contralateral to the one holding the electrode. By probing with the contralateral hand, you would actually be passing current across your own body. Therapists should remember that TENS has never been reported to produce adverse effects on vital organs. Indeed, the amount of transcutaneously-applied current necessary to produce ventricular fibrillation has been calculated to be substantially greater than that produced by any battery-operated TENS unit.[5] Because all parts of the therapist's body are now extensions of the TENS electrode, care should be taken to avoid contacting the patient at places other than the ones to be stimulated.

Patient response to this technique will vary, as does the response to TENS in general, along a continuum from those who report immediate pain relief to those who report increased discomfort. Alternative stimulation characteristics or electrode placement sites should be attempted on patients who do not perceive relief with direct stimulation of the nerve before they are rejected as candidates for TENS.

DISCUSSION

Advantages

Stimulating the nerve directly at superficial points on the nerve trunk has several advantages compared with choosing other electrode sites for nerve stimulation. I will review the most important positive effects of this treatment technique.

Bypass of peripheral receptors to reach deep nerve. Shealy and Maurer have argued that the excitation of peripheral nerve trunks should be maximal with TENS.[5] The degree of excitation of these trunks appears subjectively to the patient as a sensation of "stimulus penetration" and as an increase in the apparent distance over which the sensation spreads from the electrodes themselves.[5] Producing this deep penetrating radiation should be a goal and viewed in contrast to the superficial tingling (often burning) sensation felt on the skin surrounding the electrode. The latter sensation results from stimulation of only superficial axons and receptors in the dermatome at the electrode site and is often caused by poor skin contact.[8] Unfortunately, therapists may be prone to accept reports of this sensation as an indication that electrodes are properly placed and TENS is being effectively administered when, in fact, it is not. Because selective block of superficial axons and receptors does not effectively block the sensations and effects of TENS delivered to nerves, these axons and receptors may not be necessary for electrical stimulation to be effective in producing analgesia.[7] Superficial receptors also rapidly adapt to stimuli, which further discourages their being relied on as prime targets of stimulation.[9] The tendency of peripheral receptors to adapt to stimuli is experienced by a person who, after first entering cold water, soon does not feel the cold. Direct stimulation of the nerve itself will bypass this adaptive tendency and allow lower current levels to be maintained for longer periods while producing effective paresthesia.

Remote but more effective stimulation of deep nerves. Direct stimulation of a nerve supplying a painful area may also be particularly indicated in pain of myotomal or sclerotomal origin. Because the innervations of these deep tissues may differ from the overlying dermatome (eg, in the outer buttock where the dermatome corresponds to L2-L3, the myotome to L4-L5-S1, and the sclerotome to L4-L5[10]), stimulation of a dermatome may not result in stimulation of the nerves innervating the pain-producing structure.[11] Dermatomal stimulation may be quite adequate for treating pain of, for example, an incision postoperatively, but nerves supplying deep tissues may be stimulated more effectively at some distance from the actual site of pathology and before they branch to innervate these deep receptive fields. Selecting TENS to treat pain may then be predicated on the accessibility of the nerve supplying the painful area (for proper electrode placement) rather than on any inherent inability of electrical stimulation to act on such pain.

Remote stimulation for sensitive dermatological conditions. Stimulating a nerve at a distance from the site of pathology may be desirable in cases of dermatomally-derived pain as well (eg, burn cases) because adequate stimulation of a painful area can be achieved without placing electrodes or coupling agents on an already hyperesthetic or irritated area.

Increased number of nerve fibers stimulated with less current. More nerve fibers are contained within a smaller area in a nerve trunk than after the nerve branches to innervate its receptive field. Therefore, less current can be used to stimulate more nerve fibers when the electrode stimulates the nerve trunk than if the electrodes are placed over the dermatome alone.

Increased effectiveness of smaller electrodes. Because the volume of neural tissue needed to yield maximal beneficial effects from stimulation is actually quite small with respect to the standard 2 × 2 carbon silicone electrode, electrodes can be reduced in size and current density can be increased. Smaller electrodes are more easily placed in creases where nerves are superficial. Placement of electrodes in creases may be particularly indicated in cases where increased resistance from obesity exists because deep paresthesia cannot often be produced with electrodes placed on dermatomes in these cases.

Extended battery life. Because smaller electrodes also manifest less resistance to current flow than larger ones and less resistance occurs from overlying tissue at points where nerves are superficial, less power can be used to stimulate nerves more efficiently at superficial points on the nerve trunk than if electrodes are placed elsewhere. All of these factors combine to extend the battery life of the system.

Reduction of burning sensation. Patients often refer to a superficial burning sensation produced by TENS at the electrode site. This sensation is caused by passing too much current into relatively nonconductive tissue; the current produces heat rather than effective nerve stimulation. Delivery of current to nerves at superficial points reduces the incidence of burning sensation and improves the production of paresthesia.

Less current and greater muscle contraction. For transcutaneous electroacupuncture (2–3 Hz stimulation at intensities producing strong muscle contractions),[12] stimulating the nerve that innervates a muscle requires less current to produce contractions than does stimulating the muscle fibers directly.[13] Also, stimulation of the nerve in this case produces contraction of the entire muscle innervated by that nerve rather than just the part innervated by a specific motor point.[13]

Positive psychological effect. The psychological effect of touching patients during therapy cannot be overemphasized. Delivering stimulation to patients through one's own body may provide a technique that is capable of alleviating patients' anxiety about electrical stimulation and ultimately can serve to gain the trust of the patients. When the therapist uses this technique, the patients may feel that if the therapist can tolerate stimulation so easily, they can, too. Indeed, therapists who are themselves anxious about electrical stimulation may want to overcome their own anxiety about using TENS by becoming more comfortable with this technique and the sensations produced by TENS.

Relationship to acupuncture. Because over 50 percent of acupuncture points, especially the newer, more effective points, lie precisely over or in very close proximity to points where nerves are superficial,[14] the probing technique I have described may also be a method of detecting such acupuncture points. Indeed, the points detected in the Method section were acupuncture points lung 5, heart 3, and bladder 39, respectively.[15]

Electronic probes have been used to detect acupuncture points because acupuncture points are highly conductive with respect to surrounding tissue.[15] Because many of these points exhibiting high electrical conductivity are also located at points where nerves are superficial,[16] many of the points detected by electronic probes could also be detected by the procedure described by me.

Some acupuncture points are also pressure-sensitive and have consequently been detected by palpation.[17] In fact, a 71 percent correlation between acupuncture points and trigger points has been reported.[18] Because some of these pressure-sensitive points also have been found at places where nerves are superficial,[15] some of the points detected by palpation also would correspond to points detected by the procedure described by me.

Limitations

Accessibility of nerves. Because the nerves supplying the limbs are more accessible to TENS than the nerves supplying the torso, this technique may be more appropriate for use on the limbs than on the torso. In fact, the realization that patients who are treated with TENS delivered through paraspinally placed electrodes never report paresthesias that radiate along the course of any of the underlying dorsal roots indicates that the contention that electrodes may be placed paraspinally to stimulate the roots of nerves innervating painful peripheral structures[11] or organs[19] is without foundation.

Restricted use. Wall and Sweet reported that as little as two minutes of stimulation was required to determine the effects of nerve stimulation on a patient's pain.[2] Therapists may find, however, that any need to hold the stimulating finger in place for periods of even two minutes may prohibit them from using their finger for evaluating the effect of TENS on a patient's pain. This technique should, therefore, be used primarily to locate the superficial points of nerves before treatment with TENS.

Lack of specificity. As defined by electrical conductivity, acupuncture points measure about 1 mm in diameter.[20] A finger cannot detect or treat the acupuncture point as precisely as can the smaller probe tips of electronic point detection-stimulation devices. The latter also allows the therapist to quantify precisely the conductivity of points and the amount of current that is ultimately used to stimulate each point through meter or LED readouts.

Patient discomfort. When the therapist probes with a finger and a TENS unit, the patient will experience sensations ranging from tingling paresthesia to burning. Because electronic probes use much smaller currents to detect points of high conductivity, the patient need not experience any disagreeable sensation when electronic probes are used to detect points.

Therapist discomfort. Finally, becoming comfortable with the sensation produced at the therapist's fingertip may take time. Electronic probes may be indicated for the therapist who finds the electrical sensation produced while probing with a TENS unit and a finger too uncomfortable.

SUMMARY

I described a technique to probe for the superficial points of nerves with a TENS unit and a finger. When these points were stimulated, deep, radiating paresthesia was produced in the distribution of the underlying nerve using a modest amount of current. I discussed the advantages and limitations of this technique and of the direct stimulation of nerves.

Additionally, I noted that the points producing the greatest degree of radiating paresthesia from this technique were also major acupuncture points. This finding appears to support the belief that acupuncture points can sometimes serve as optimal stimulation sites for TENS.[11]

Therapists are encouraged to experiment with this technique on each other to become familiar with the points at which major nerves are superficial. The degree and distribution of the hypalgesia resulting from stimulation of various nerves can be tested by pricking or pinching areas that are covered by the resultant paresthesia as well as those not covered. By using self-experimentation with TENS, therapists may be able to relate better to the experiences their patients undergo during this treatment.

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