

ELECTROMEDICINE

The Textbook of the American Academy of Pain Management

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TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

Our understanding of pain mechanisms and how pain is perceived has undergone significant changes. Initially, pain was viewed as an emotion rather than a sensation. It was said to be the opposite of pleasure. This theory dated back to the time of Aristotle. The traditional theory, described as the specificity theory by Descartes in 1664, conceived of a pain system as a direct channel from the skin to the brain (Melzack & Wall, 1982). This concept was supported and expanded on by Von Frey, who argued that there were specific pain receptors (Sinclair, 1953). As scientific experimentation grew towards the later part of the last century, Goldscheider developed the pattern theory, which stated that sensation was based on spatial and temporal patterns of a number of impulses (Nafe, 1929; Geldard, 1953). Zotterman (1936) discerned A-Delta and C afferent nerve fibers. Later research stated that A-delta fibers carried fast, but short-lived, well-defined pain impulses while C fibers carried slow, diffuse, long-duration pain.

The modern basis for the widespread use of transcutaneous electrical nerve stimulation (TENS) for pain control is the gate control theory proposed by Dr. Ronald Melzack and Dr. Patrick Wall (1965). This theory suggests that hypothetical "gates" in lamina V of the substantia gelatinosa could be "closed" to block pain stimuli traveling from A-delta and C fibers in the peripheral nervous system where they synapse into the central nervous system. Although this theory was later modified, it created much notoriety at the time and revolutionized the way most practitioners viewed and treated chronic pain.

In 1967, C. Norman Shealy, M.D., a neurosurgeon who had been implanting dorsal column stimulators (DCS), discovered that devices that transmitted electricity transcutaneously were just as effective without the risks associated with surgery (Shealy, Mortimer, & Reswich, 1967). With the Melzack-Wall theory behind him, Shealy's work renewed interest in electromedicine and resulted in the beginning of the modern day TENS devices.

Transcutaneous electrical nerve stimulation is an established modality with over 250,000 TENS units prescribed annually in the United States alone. Accordingly, much information is available on standard TENS applications, precautions, contraindications, side effects and results (Mannheimer & Lampe, 1984; Tapio & Hymes, 1987). Mixed results have occurred due to several factors, such as waveform, frequency, pulse repetition rate, intensity, alternating vs. direct current, electrode placement and treatment time. Perhaps the single largest variable is the education, or lack thereof, provided to

health care practitioners recommending these devices and instructing patients in their use. Many professionals simply give the unit to a patient with the factory settings and never alter them, leaving each device as a hit or miss item. TENS devices must be tried at a variety of settings to achieve optimal pain relief for a given patient. In principle, TENS applies an electrical force that stimulates pain-suppressing A-beta afferent nerve fibers which compete against pain-carrying afferent nerve fibers. The same stimulation would occur if one lightly tapped the painful body part repeatedly with a pen, spoon, or other blunt object. Ice, massage, heat, manipulation and other long-standing therapy techniques have relieved pain this way for centuries.

Energy Source

Most TENS units work with currents in the milliamperere range delivered for about 250 microseconds. The most common output is biphasic to avoid the side effects of polarization. They are powered either by alkaline or nickel cadmium batteries. In general, alkaline batteries are preferred for constant stimulation because they have a relatively slow, linear power decay. Rechargeable batteries have a series of peaks or near-peaks in their discharge rate because each cell discharges in series. Accordingly, rechargeable batteries should be avoided, especially in the cheaply made Taiwanese devices.

Electrodes

Initially, dry pads were provided that required the use of a gel. This was messy, provided uneven conductivity and caused minor skin burns at a high current. At present, self-adhesive electrodes are available that are semi-disposable and generally affordable. In this day and age of concern over deadly infectious diseases, it has become common practice for clinicians to keep a separate set of electrodes for the exclusive use of each patient.

Pulse Repetition Rate (PRR)

The reader will often see this listed as "frequency" on a typical TENS unit. According to the previous discussion in this chapter, the lower the PRR setting, the greater number of frequencies the patient will be exposed to; hence, the greater potential for pain relief. For the average pain patient, we recommend setting the PRR to the lowest setting for initial trials. Pomerantz (1981) has also shown by naloxone blocking studies that endorphins are only released at PRR settings of 8 Hertz or less.

Pulse Width

Wider pulses spread the current over greater distances. The maximum parameters in most TENS units ranges from 50 to 400 microseconds. The further apart the electrodes are, the wider the pulse width should be.

Electrode Placement

Electrode placement is perhaps the greatest variable in eliciting successful results with TENS. Electrodes can be placed "between the pain and the brain," along nerve roots,

dermatomes of the respective nerve levels, following the referred pain pathway, or on trigger points. Janet Travell, M.D. started researching trigger points in 1957 (Travell & Simons, 1983). Trigger points are named such because they trigger pain when pressed. They are areas of localized tenderness that usually form with a persistent muscle spasm. For the purpose of this discussion, they can be measured as having higher conductivity than normal tissue. In most cases, electrical treatment directly on the point is indicated. Sometimes, this will increase the pain (as explained by the pattern theory of pain). If this occurs, treating across the area with microcurrent stimulation at 0.5 Hz will almost always alleviate it.

With the parameters discussed, it is apparent that several combinations of PRR, pulse width, intensity, electrode placement, time and frequency of stimulation may have to be attempted before desirable results are obtained. Perhaps this is the reason why most major medical insurance companies prefer to rent a TENS device to a patient for the first month before approving it for purchase.

Indications

Several studies have documented the desirable effects of TENS. Loeser and his coworkers (1975) examined TENS-induced relief of pain for headaches, cervical arthritis, low back, phantom limb, arthritis and acute post-operative pain. Tapio and Hymes (1987) reviewed the efficacy of TENS on low-back pain, cancer pain, post-herpetic neuralgia, phantom limb pain, rheumatoid arthritis, angina pectoris, various acute conditions, dysmenorrhea, visceral pain and several other disorders. Andersson (1976) found TENS could raise the threshold for dental pain. By using low-frequency, high-intensity stimulation (the so-called "acupuncture-like TENS") he was able to increase his success rate in pain reduction from 40 to 60%.

Contraindications

There are very few contraindications with TENS. All electrical modalities are contraindicated for pregnant women and patients with demand-type pacemakers. In general it is advisable that patients not drive or operate heavy machinery while TENS is being applied. Also, it is essential that electrodes from milliamperage TENS units are not placed on the head or neck. This is especially true regarding the carotid sinuses as stimulation of the baroreceptors may result in a vaso-vagal syncope.

TENS Summary

TENS is now a widely used modality for the treatment of general acute and chronic pain syndromes. When effective, the ease of use, general safety and portability make it a treatment over the long term use of medications and nerve blocks for chronic pain. Modern drug practitioners would do well to recall Aesculapius' motto regarding healing; primo non nocere (first, do no harm).