Transcutaneous Electrical Nerve Stimulation

Synonyms, Key Words, and Related Terms: TENS

eMedicine Journal, January 29 2002, Volume 3, Number 1

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Disclosure

eMedicine Journal, January 29 2002, **Volume** 3, **Number** 1

INTRODUCTION

Transcutaneous electrical nerve stimulation (TENS) currently is one of the most commonly used forms of electroanalgesia. Hundreds of clinical reports exist concerning the use of TENS for various types of conditions such as low back pain (LBP), myofascial and arthritic pain, sympathetically mediated pain, bladder incontinence, neurogenic pain, visceral pain, and postsurgical pain. Because many of these studies were uncontrolled, there has been ongoing debate about the degree to which TENS is more effective than placebo in reducing pain.

The currently proposed mechanisms by which TENS produces neuromodulation include the following:

- Presynaptic inhibition in the dorsal horn of the spinal cord
- Endogenous pain control (via endorphins, enkephalins, and dynorphins)
- Direct inhibition of an abnormally excited nerve
- Restoration of afferent input

The results of laboratory studies suggest that electrical stimulation delivered by a TENS unit reduces pain through nociceptive inhibition at the presynaptic level in the dorsal horn, thus limiting its central transmission. The electrical stimuli on the skin preferentially activate low- threshold myelinated nerve fibers. The afferent input from these fibers inhibits propagation of nociception carried in the small unmyelinated C fibers by blocking transmission along these fibers to the target or T cells located in the substantia gelatinosa (laminae 2 and 3) of the dorsal horn.

The mechanism of the analgesia produced by TENS is explained by the gate control theory proposed by Melzack and Wall in 1965. The gate usually is closed, inhibiting constant nociceptive transmission via C fibers from the periphery to the T cell. When painful peripheral stimulation does occur, the information carried by C fibers reaches the T cells and opens the gate, allowing pain transmission centrally to the thalamus and cortex, where it is interpreted as pain. The gate control theory postulated a mechanism by which the gate is closed again, preventing further central transmission of the nociceptive information to the cortex. The proposed mechanism for closing the gate is inhibition of the C-fiber nociception by impulses in activated myelinated fibers.

TECHNICAL CONSIDERATIONS

A TENS unit consists of one or more electric signal generators, a battery, and a set of electrodes. The units are small and programmable, and the generators can deliver trains of stimuli with variable current strengths, pulse rates, and pulse widths. The preferred waveform is biphasic, to avoid the electrolytic and iontophoretic effects of a unidirectional current. The usual settings for the stimulus parameters used clinically are the following:

- Amplitude - Current at low intensity, comfortable level, just above threshold
- Pulse width (duration) - 10-1000 microseconds
- Pulse rate (frequency) - 80-100 impulses per second (Hz); 0.5-10 Hz when stimulus intensity is set high

When TENS is used for pain control, patients are instructed to try different frequencies and intensities to find those that provide the best pain control for that individual. Optimal settings of stimulus parameters are subjective and are determined by trial and error. Electrode positioning is quite important. Usually, the electrodes are placed initially on the skin over the painful area, but other locations (eg, over cutaneous nerves, trigger points, acupuncture sites) may give comparable or even better pain relief.

The 3 options for the standard settings used in different therapeutic methods of TENS application include the following:

1. Conventional TENS has a high stimulation frequency (40-150 Hz) and low intensity, just above threshold, with the current set between 10-30 mA. The pulse duration is short (up to 50 microseconds). The onset of analgesia with this setup is virtually immediate. Pain relief lasts while the stimulus is turned on, but it usually abates when the stimulation stops. Patients customarily apply the electrodes and leave them in place all day, turning the stimulus on for approximately 30-minute intervals throughout the day. In individuals who respond well, analgesia persists for a variable time after the stimulation stops.

2. In acupuncturelike settings, the TENS unit delivers low frequency stimulus trains at 1-10 Hz, at a high stimulus intensity, close to the tolerance limit of the patient. Although this method sometimes may be more effective than conventional TENS, it is uncomfortable, and not many patients can tolerate it. This method often is considered for patients who do not respond to conventional TENS.

3. Pulsed (burst) TENS uses low-intensity stimuli firing in high frequency bursts. The recurrent bursts discharge at 1-2 Hz, and the frequency of impulses within each burst is at 100 Hz. No particular advantage has been established for the pulsed method over the conventional TENS method.

Patient comfort is a very important determinant of compliance and, consequently, the overall success of treatment. The intensity of the impulse is a function of both pulse duration and amplitude. Greater pulse widths tend to be more painful. The acupuncturelike method is less tolerable because the impulse intensity is higher.

The amount of output current depends on the combined impedance of the electrodes, skin, and tissues. With repetitive electrical stimuli applied to the same location on the skin, the skin impedance is reduced, which could result in greater current flow as stimulation continues. A constant current stimulator, therefore, is preferred to minimize sudden uncontrolled fluctuations of current intensity related to changes in impedance. An electroconductive gel applied between the electrode and skin serves to minimize the skin impedance. Skin irritation can occur in as many as 33% of patients, at least in part, due to drying out of the electrode gel. Patients need to be instructed in the use and care of TENS equipment, with particular attention to the electrodes.

Medical complications arising from use of TENS are rare; however, skin irritation is a frequent problem and often is due partly to the drying out of the electrodes. Sometimes individuals react to the tape used to secure the electrodes. Skin irritation is minimized by using self-adhesive disposable electrodes and repositioning them slightly for repeated applications. The use of TENS is contraindicated in patients with demand-type pacemakers because their stimulus outputs may drive or inhibit the pacemaker.

A variety of newer transcutaneous or percutaneous electrical stimulation modalities recently has emerged.

- Interferential current therapy (IFC) is based on summation of 2 alternating current signals of slightly different frequency. The resultant current consists of cyclical modulation of amplitude, based on the difference in frequency between the 2 signals. When the signals are in phase, they summate to an amplitude sufficient to stimulate, but no stimulation occurs when they are out of phase. The beat frequency of IFC is equal to the difference in the frequencies of the 2 signals. For example, the beat frequency and, hence, the stimulation rate of a dual channel IFC unit with signals set at 4200 and 4100 Hz is 100 Hz.

- IFC therapy can deliver higher currents than TENS. IFC can use 2, 4, or 6 applicators, arranged in either the same plane for use on regions such as the back or in different planes in complex regions (eg, the shoulder).

- Percutaneous electrical nerve stimulation (PENS) combines advantages of both electroacupuncture and TENS. Rather than using surface electrodes, PENS uses acupuncturelike needle probes as electrodes, placed at dermatomal levels corresponding to local pathology. The main advantage of PENS over TENS is that it bypasses the local skin resistance and delivers electrical stimuli at the precisely desired level in close proximity to the nerve endings located in soft tissue, muscle, or periosteum.

Literature on the use of TENS in a variety of medical conditions reports a wide range of outcomes, from very positive to negative effectiveness. Currently, there is an overall consensus favoring the use of TENS, with authorities differing on its value in different clinical situations. Generally, TENS provides initial relief of pain in 70-80% of patients, but the success rate decreases after a few months or longer to around 20-30%. To exclude a false-negative response, a trial of TENS for at least 1 hour should be given to confirm potential benefit from subsequent continuous use.

According to Johnson, the time from the start of stimulation to the onset of analgesia varies from almost immediate to hours (on average 20-30 minutes in over 75% of patients and 1 hour in 95% of patients). The duration of analgesia also varies considerably, continuing only for the duration of stimulation in some patients and providing considerable prolonged poststimulation relief in others. The same TENS protocol may have different degrees of antinociception in acute experimental pain compared with chronic clinical pain in patients with chronic LBP.

Patients differ in their stimulus preferences and in their rates of compliance. In Johnson's study of compliance in patients who benefited from TENS, 75% used the device on a daily basis. Patients showed individual preferences for particular pulse frequencies and patterns and consistently adjusted their stimulators to these settings on subsequent treatment sessions.

Indications for the use of TENS

- Neurogenic pain (eg, deafferentation pain, phantom pain), sympathetically mediated pain, postherpetic neuralgia, trigeminal neuralgia, atypical facial pain, brachial plexus avulsion, pain after spinal cord injury (SCI)

- Musculoskeletal pain: Examples of specific diagnoses include joint pain from rheumatoid arthritis and osteoarthritis, acute postoperative pain (eg, postthoracotomy), and acute posttraumatic pain. After surgery, TENS is most effective for mild-to-moderate levels of pain, and it is ineffective for severe pain. The use of TENS in chronic LBP and myofascial pain is controversial, as placebo-controlled studies fail to show statistically significant beneficial results. Uncertainty also exists about the value of TENS in tension headache.

- Visceral pain and dysmenorrhea are other conditions in which TENS has been applied successfully.

- Other disorders: TENS has been used successfully in patients with angina pectoris and urge incontinence, as well as in patients requiring dental anesthesia. Reports discuss use of TENS to assist patients in regaining motor function following stroke, to control nausea in patients on chemotherapy, as an opioid-sparing modality in postoperative recovery, and in postfracture pain.

Contraindications for the use of TENS

- TENS should not be used in patients with a pacemaker (especially of the demand type).

- TENS should not be used during pregnancy because it may induce premature labor.
- TENS should not be applied over the carotid sinuses due to the risk of acute hypotension through a vasovagal reflex.
- TENS should not be placed over the anterior neck because of possible laryngospasm due to laryngeal muscle contraction.
- The electrodes should not be placed in an area of sensory impairment (eg, in cases of nerve lesions, neuropathies), where the possibility of burns exists.
- A TENS unit should be used cautiously in patients with a spinal cord stimulator or intrathecal pump.

COMPARISON BETWEEN TENS AND OTHER ELECTRICAL MODALITIES

A number of studies have compared TENS to other similar therapeutic modalities, including PENS, IFC, and acupuncture.

- In one study of elderly patients with chronic LBP, both acupuncture and TENS had demonstrable benefits, with the acupuncture group demonstrating improvement in spinal flexion.
- In patients with chronic LBP and sciatica, PENS was more effective than TENS in providing short-term pain relief and improved function, including an improved quality of sleep and sense of well-being.
- Overall, 91% and 73% of patients, respectively, chose PENS as the preferred modality for pain relief in LBP and sciatica.
- PENS has been used successfully for pain relief in patients with acute herpes zoster and cancer with bony metastases.
- Both IFC and TENS had a statistically significant effect on median nerve excitation threshold in young women.

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eMedicine Journal, January 29 2002, **Volume** 3, **Number** 1