Transcutaneous electrical nerve stimulation (TENS) as a pain-relief device in obstetrics and gynecology

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Summary

Transcutaneous electrical nerve stimulation (TENS) is a non-pharmacological and non-invasive pain-relief method that has been proven effective for a variety of conditions. Electrical therapy has been recognized for a long time but its practical clinical application in the form of TENS has been evaluated only during the last 30 years as a result of several theories on pain. The most known of these with regard to TENS development is the "gate theory", although several others have also played a role. In obstetrics and gynecology, TENS has been found to be effective in alleviating labor pain and in the treatment of primary dysmenorrhea. It has also been used successfully following obstetric and gynecologic surgery. In order to be effective in clinical use for obstetric and gynecologic indications, a TENS device must have certain properties, which are detailed in this review. Although new TENS devices that meet all the necessary requirements have been developed and tested, their use is still far from widespread. Patients and medical staff should be encouraged to try the TENS device for obstetric and gynecologic indications, since it is non-invasive, efficient, and easy to use.

Transcutaneous electrical nerve stimulation (TENS) is a non-pharmacological pain-relief method that has been proven effective for a variety of conditions [1, 2]. TENS, which has been under the medical fraternity microscope for more than a decade, has aroused an unprecedented amount of controversy and critical review. Following numerous successful double-blind trials, it is now accepted for a large number of clinical applications and as a complement to physical therapy in the fight against pain [3].

History

Since antiquity electrical current has been applied to human flesh to cure a multitude of afflictions. Electric eels were known to the ancient Egyptians and to Greeks [4], but it was only during the Roman Empire, in 46 AD, that the physician Scribonius Largus, recorded that "pain was eliminated" when a patient put his wounded limb into a tub that contained an electric eel. He also found this method effective for headache and gout. Unfortunately, the side-effects of the treatment did little to encourage it.

William Gilbert (1544-1603) was the first to classify and generalize the medical effect to electricity [5], and following his work, a series of devices were built to generate and store current for application to the body for all types of afflictions [5, 6]. In 1756, Richard Lovett published the first English-language book on medical electricity "The Subtil Medium Proved" [5]. Soon after, John Wesley, founder of the Methodist Church, wrote "Desideratum", in which he enthusiastically discussed the potential of electrical current to treat a multitude of diseases including sciatica, hysteria, headache, kidney stones, gout, cold feet (Raynaud's phenomenon), pleuritic pain and angina pectoris.

In 1772, John Birch, an English surgeon, described the successful use of electrical current in the treatment of chronic low back pain [7].

As technology advanced, Galvanic (DC) and Faradic (AC) current proved to be more adaptable to medical therapy than the earlier electrostatic charge generators. Preoperative evaluation with "transcutaneous" devices eventually led to the conclusion that they were so effective, they preempted the need for surgery.

Moreover, their relative ease of use increased their public acceptability. Early researchers such as Shealy [8] and Cooper [9] used implanted devices to stimulate the dorsal column of the spinal cord and thereby block incoming pain signals.

After a lapse of several years, when the technique fell out of favor, it was private companies such as Stim-Tech, Medtronic and Avery that revived it with new developments in the field. Apart from supporting clinical trials that advanced the knowledge and understanding of pain, the technical features of the innovative instruments developed by these companies were an extremely important part of TENS investigations.

The development of TENS

The large-scale applications of TENS today stem from recent innovations and discoveries based on the theoretical models of human neurophysiology [3] and new concepts such as gating, peripheral mechanisms, long negative feedback loop effects, diffuse noxious stimula-

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tion and stimulation of endogenous endorphin production and stress. The most important of these was the gate theory.

Gate theory: The early use of electrical stimulation for pain did nothing to enhance the understanding of the principles involved and each new theory put forward was disproved under trial.

Only in 1965, with the revolutionary gate theory of Melzack and Wall [10], was there a radical departure from earlier ideas and a considerable regrowth of interest and experimentation in the forgotten field of transcutaneous electrical nerve stimulation for analgesia. Melzack and Wall suggested that the transmission of pain signals through the substantia gelatinosa is subject to presynaptic inhibition by the activation of large, rapid conduction cutaneous afferent fibers and descending fibers from the brain. By enhancing large fiber input, the "gate" could be closed to pain signals at their level of entry into the spinal cord. Wall and Sweet [11] tested the theory by applying electrical current to the skin, and their encouraging results gave further impetus to the clinical use of this modality.

Other important theories

The "diffuse noxious inhibitory control" theory [12] is based on the fact that a stimulus outside the nervous system (e.g., pain, physical effort, etc.) increases the level of endogenous endorphins, resulting in a potent analgesic effect which can be countered by naloxone (an antiopiate drug). Studies have demonstrated both an increased release of endogenous endorphins as a result of TENS stimulation [13], and the counteraction of the pain relief effect by naloxone [14]. According to the diffuse noxious inhibitory controls theory the response of small diameter afferent fiber groups to continuous pain input to the convergent dorsal horn neurons, is effectively suppressed by noxious of intense cutaneous stimulation, (such as TENS), but not by nonnoxious stimulation [15]. As mentioned, these theories have greatly amplified our understanding of the mechanism of action of TENS and paved the way for its clinical application.

TENS in obstetrics and gynecology

TENS has been found to be effective in alleviating the pain of labor [1, 16-23], and of dysmenorrhea [12, 14, 24-30]; it has also been used successfully following obstetric and gynecologic surgery [31-34]. Based on the cumulative experience with TENS in obstetrics and gynecology, in order for these devices to be effective in this context, the following issues must be resolved: product objective, electrode type and size, stimulation waveform, use of two-tier stimulation, method of delivery, physical design, and operation. The characteristics for an ideal obstetric and gynecological TENS device are listed below.

Product objective

The objective is to develop a simple, effective, easy-to-use-and-wear device for pain control that is totally noninvasive yet can stimulate the production of endorphins to counteract the sensation of pain. The amplitude level of stimulation must be variable and achievable immediately upon demand.

Electrode type and size

The importance of electrode characteristics need to be understood in relation to impedances and current flow, current density and excitation of body tissues. Distance between electrodes, electrode size, and stimulation amplitude levels are all critical to the delivery of an adequate current. The stratum corneum of the skin is a good insulator and forms the main resistance of the body. The relative conductivity of other tissues is approximately proportional to their water content and available ions, with the deeper levels of skin, fat, muscle and bone having higher conductivity. Current density is maximal at the point of contact between the skin and the electrode and decreases with distance from the electrodes as the current spreads out over a large area. This is important, since it has been shown that current density rather than current flow between electrodes is a measure of the amount of charged ions that move through a particular cross-section of tissue.

High current density is required to depolarize the membrane sufficiently for excitation to take place. Electrode size also plays an important role in determining current density. If electrode size is increased, the current flow has to be increased to maintain a high current density thus ensuring that the excitation threshold at the nerve ending is exceeded and depolarization occurs. To minimize the variability carried by wide variations in skin resistance, the stimulator must be capable of supplying constant current output. In this manner, the amplitude for a specific dial setting will remain relatively the same for all normal variations in skin resistance. The electrodes must be pliable, maintain good skin contact at all times, maintain low electrical impedance (under a variety of body temperature and skin conditions) and be nonreactive to the harmful compounds that may form by the release of sweat and sodium ions that are formed in the skin under the electrodes.

The electrolytic interface (the substance that minimizes the impedance between the skin and the electrode) is critical for maximizing current flow at a set level (amplitude) of electrical stimulation [35, 36].

Stimulation waveform

Recent studies on TENS and the effect of variation in stimulation waveforms, have highlighted the importance of minimizing adaptation when production of endorphins ceases. Minimization of adaptation results in the continuous

production of endorphins at a minimal level of stimulation. The work of Shuster and Marsden [37] in particular has resulted in the adoption of the modulation technique.

Frequency of waveform

High frequencies have been found to achieve better results than low frequencies [14] and are currently used in studies of TENS efficacy [12, 30]. Trials with patients in labor and postoperative patients have established that during periods of high stress (such as during severe pain), the perception of pain relief is best at frequencies of 100 to 120 Hz. The new TENS models are adjusted to within that frequency zone.

Two-tier stimulation

The possibility to modify the perceptible intensity of the stimulus on demand enhances the devices pain reducing effect and promotes a positive feeling of being "in control of the pain". Patients have stressed this factor as an important benefit of TENS.

Method of delivery

Simplicity is the key word here. Connections and cables must be comfortable and simple to use. Standard cable sockets must be supplied and previous experience should not be a prerequisite to connect the system.

Physical design

The physical design of the TENS device is critical for success. The device should be applicable for both right-handed or left-handed persons. It should be small and have smooth curved attractive lines for comfortable wear. In a recent study by Kaplan *et al.* (unpublished data), in which 102 patients with primary dysmenorrhea were given a new TENS model to try for two cycles, may mentioned the smallness of the device as a very important advantage, enabling them to use the TENS for long periods of time (indoors or during outdoor activities) yet discretely keeping its use to themselves.

Operation

Modern TENS devices are battery-operated. Their control settings must be uncomplicated and the instruction manual simple, clear and easily understood by first time users. Operational usage should be by instinctive "push-release" action.

Conclusion

TENS is based on the age-old concept of analgesia by electrical stimulation.

Although the method was abandoned for many years, interest was renewed with the publication of the gate theory which provided a scientific basis for TENS use and opened the way for its clinical application. Recent clinical trials have substantiated the efficacy of TENS for a variety of medical indications and elucidated the optimal conditions for its use. In Obstetrics and Gynecology, TENS has proven to be successful in alleviating the pain of labor, cesarean section, and dysmenorrhea. Although new devices that meet all the necessary requirements have been developed and tested, their use is still far from widespread. Patients and medical staff should be encouraged to try the TENS device and familiarize themselves with the sensations caused by the electric stimulation. The use of TENS by medical staff and patients will increase significantly as more information on its noninvasive nature, its efficacy, ease of use and wide range of applications become better known.

References

[1] Augustinsson L. E., Bohlin P. H., Bundsen P. H. *et al.*: "Pain relief during delivery by transcutaneous electrical nerve stimulation". *Pain*, 1977, *4*, 59.

[2] Manheimer C., Carlsson C. A.: "The analgesic effect of transcutaneous electrical nerve stimulation (TENS) in patients with rheumatoid arthritis. A comparative study of different pulse patterns". *Pain*, 1979, *6*, 329.

[3] Tapio D., Hymes A. C.: "New frontiers in TENS". LecTec Corporation, 1987, pp. 1-5.

[4] Kellaway P.: "The William Osler Medal assay: The part played by electric fish in the early history of bioelectricity and electrotherapy". *Bull-Hist. Med.*, 1946, *20*, 112.

[5] Stillings D.: "A short history of electrotherapy in England to about 1800". 1974. Bakken Museum of Electricity in Life, Minneapolis, MN.

[6] Stillings D.: "A survey of the history of electrical stimulation for -pain to 1900". *Med. Instrum.*, 1974, *9*, 255.

[7] Birch J.: "Essay on electricity by George Adams". 4th ed., R. Hindmarch. London, 1772, pp. 519.

[8] Shealy C. N., Mortimer J. T., Reswick H. P.: "Electrical inhibition of pain by stimulation of the dorsal column". *Anaesth. Analg.*, 1967, *46*, 489.

[9] Cooper I., : "The vital probe". Norton, N. Y., 1981.

[10] Melzack R., Wall P. D.: "Pain mechanisms: a new theory". *Science*, 1965, *150*, 971.

[11] Wall P. D., Sweet W. H.: "Temporary abolition of pain in man". *Science*, 1967, *155*, 108.

[12] Kaplan B., Peled Y., Pardo J. *et al.*: "Transcutaneous electrical nerve stimulation (TENS) as a relief for dysmenorrhea". *Clin. Exp. Obstet. Gynecol.*, 1994, *21*, 87.

[13] Sjolund B. H., Ericksson M. B. E.: "The influence of naloxone on analgesia produced by peripheral conditioning stimulation". *Brain. Res.*, 1979, *173*, 295.

[14] Lundeberg T., Bondesson L., Lundstrom V.: "Relief of primary dysmenorrhea by transcutaneous electrical nerve stimulation". *Acta Obstet. Gynecol. Scand.*, 1985, *64*, 491.

[15] Basbaum A. I., Feilds H. L.: "Endogenous pain control mechanisms: review and hypothesis". *Ann. Neurol.*, 1978, *4*, 451.

[16] Miller-Jones C. M. H.: "Transcutaneous nerve stimulation in labour". Anaesthesia, 1980, 35, 372.

[17] Grimm L. C., Morrey S. H.: "Transcutaneous nerve stimulation for relief of parturition pain". *Phys. Theraw.*, 1985, *65*, 33.

[18] Robson I. E.: "Forum - Transcutaneous electrical nerve stimulation for pain relief in labor". *Anaesth.*, 1979, *34*, 357.

[19] Keenan P. L., Simonsen L., McCrann D. J.: "Transcutaneous electrical nerve stimulation for pain control during labor and delivery. *Phys. Ther.*, 1985, *9*, 1363.
[20] Mesheim B. R.: "The use of transcutaneous electrical nerve stimulation for pain relief during labor". *Acta Obstet. Gynecol. Scand.*, 1981, *60*, 13.
[21] Bundsen P., Ericson K.: "Pain relief in labor by transcutaneous electrical nerve stimulation: safety aspects". *Acta Obstet. Gynecol. Scand.*, 1982, *61*, 1.
[22] Kubista E., Kucera H., Riss P.: "The effect of transcutaneous nerve-stimulation on labor pain". *Geburthshilfe Frauenheilkd*, 1978, *38*, 1079.
[23] Neumark J., Pauser G., Scherzer W.: "Pain relief in childbirth: an analysis of the analgesic effects of transcutaneous nerve stimulation-(TNS), pethidine and placebos". *J. Pract. Anaesth.*, 1978, *13*, 13.
[24] Walker J. B., Katz R. L.: "Peripheral nerve stimulation in the management of dysmenorrhea". *Pain*, 1981, *11*, 355.
[25] Mannheimer J. B., Whalen E. C.: "The efficacy of transcutaneous electrical nerve stimulation in dysmenorrhea". *Clin. J. Pain*, 1985, *1*, 75.
[26] Santiesteban A. J., Burnhan T. L., George K. L. *et al.*: "Primary spasmodic dysmenorrhea. The use of TENS on acupuncture points". *Am. J. Acupunct.*, 1985, *13*, 35.
[27] Neighoburs L. E., Clelland J., Jackson J. R. *et al.*: "Transcutaneous electrical nerve stimulation for pain relief in primary dysmenorrhea". *Clin. J. Pain*, 1987, *3*, 17.
[28] Dawood M. Y., Ramos J.: "Transcutaneous electrical nerve stimulation (TENS) for the treatment of primary dysmenorrhea: a randomized crossover comparison with placebo, TENS and ibrufen". *Obstet. Gynecol.*, 1990, *75*, 656.
[29] Smith R. P., Heltzel J. A.: "Interrelation of analgesia and uterine activity in women with primary dysmenorrhea". *J. Reprod. Med.*, 1991, *36*, 260.
[30] Isom I., Hender N., Mannheimen C. A.: "A comparative study of the effect of high-intensity trascutaneous nerve stimulation and oral naproxen on intrauterine pressure and menstrual pain in patients with primary dysmenorrhea". *Am. J. Obstet. Gynecol.*, 1994, *170*, 123.
[31] Evron S., Schenker J. S., Olshwang D. *et al.*: "Postoperative analgesia by percutaneous electrical stimulation in gynaecology and obstetrics". *Eur. J. Obstet. Gynecol. Reprod. Biol.*, 1981, *12*, 305.
[32] Hollinger J. L.: "Transcutaneous electrical nerve stimulation after cesarean birth". *Physical. Tehrapy*, 1986, *66*, 36.
[33] Brown G., Machek V. J.: "TENS management of post-op pain in obstetrical and gynaecological procedures". *Pain Control*, 1981, *39*.
[34] Bortoluzzi G..: "A study of the practicality and effectiveness of TENS in a public hospital ward". Australian Physiotherapy Association, 1987, 5.
[35] Shriber W. J. A.: "Manual of electrotherapy". 4th ed. Philadelphia: Lea and Febiger, 1975, 120.
[36] Geddes L. A., Baker L. E.: "Principles of applied biomedical instrumentation". New York, John Wiley and Sons Inc., 3rd Edition, 1968, 196.
[37] Schuster G. D., Marsden B.: "Treatment of pain with TENS". *J. Neurol. Orthopaed. Surg.*, 1980, *1*, 137.

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