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 [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 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-
tion and stimulation of endogenous endorphin produc-
tion 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 transcuta-
neous electrical nerve stimulation for analgesia. Melzack
and Wall suggested that the transmission of pain signals
through the substantia gelatinosa is subject to presynap-
tic 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
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 opiate antagonist). 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 sti-
mulation [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 gyn-
ecology, 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 nonin-
vasive 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 ade-
quate 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 mem-
brane 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 stimulus must be capable of supplying constant
current output. In this manner, the amplitude for a speci-
fic 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 cri-
tical for maximizing current flow at a set level (ampli-
tude) of electrical stimulation [35, 36].

Stimulation waveform

Recent studies on TENS and the effect of variation in sti-
mulation 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 non-invasive nature, its efficacy, ease of use and wide range of applications become better known.

**References**


