International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 5 Issue: 5 707 – 710

Use of Transcutaneous Nerve Stimulator (TENS) for localized Pain relief – A REVIEW

Jyotsana Tripathi, Sakshi Sethi
Department of Biomedical Engineering
Amity UniversityHaryana
Gurgaon, India
E-mail: jyotsana.tripathi@yahoo.co.in, sakshisethi.798@gmail.com

Abstract: The term Transcutaneous Electric Nerve Stimulation (TENS) was coined to depict a method used by medical professionals to treat patients with chronic and acute conditions which causes the patient to be in pain and has become popular among healthcare professionals.TENS is popularly used by healthcare professionals for treatment of pain, as a first line-treatment most often. TENS equipment is manufactured by a large number of manufacturers and can be bought by patients suffering from chronic pain from retail outlets or online stores. However, despite of its wide use, the analgesic effectiveness of the TENS equipment remains uncertain. There's insufficient evidence to conclude how effective TENS really is when it comes down to the treatment of any kind of agony. Better designs and new trials on new models are required to be made so as to give any recommendations to patients and doctors.

***Key Words**: Transcutaneous, Analgesic, TENS equipment, chronic pain.*

*****

I. INTRODUCTION

Pain has long been a twisted thorn in side of mankind. Hence, man has tried to create methods to control pain. These methods thus created can be divided into two categories: pharmacological and non-pharmacological. In some patients, pain results in limitations to the physical capabilities and hinders exercising. If the pain is under control, it allows freedom of carrying out a number of activities to the patient. This justifies the use of electrotherapy [1,2]. Electrotherapy, a noninvasive, non-pharmacological method involves electrical stimulation. It serves as an alternative for pain management. Use of local anesthesia induces fear in patient's mind because of the use of 'scary' syringes. One of the many non-pharmacological methods, to relieve pain, is called TENS or Transcutaneous Electric Nerve Stimulation [3]. TENS, classified as a class II device, has got an approval from FDA in 1972. TENS is a potentially effective in treatment of pain in place of pharmacologic analgesia for exercises during rehabilitation for downing severe pain. The anodyne action of the TENS equipment has PNS and CNS; nervous systems, mechanisms working at the back-end as proven by various studies [24]. The sensitivity of central neurons is dulled as the TENS equipment activates Endogenous Inhibition and Opioid reception in the spinal cord [8], and also reduces mechanical hyperalgesia (primary and secondary) induced by knee joint inflammation [9,10,11,12]. During the therapy, electric current pulses are induced either by alternating current power source or using 9 volt batteries and is delivered across the surface of skin by using conducting pads to stimulate the superficial nerves for localized pain relief [13].

II. LITERATURE REVIEW

History

Even in the time dating back to the Greeks, people have been making the use of electricity to numb the sensation of pain. The populace of Rome and Egypt also made the use of a type of live electric fish (Torpedo marmorata) for pain relief. Development of electrostatic-generators had led to an increased electricity usage in medical field, but the progress of pharmacological treatments and various clinical results has led to a decrease in the usage of electricity in the century prior to 20th century [14]. In the 18th century, John Wesley introduced electrotherapy, for the treatment and palliating of various types, for e.g.: pain from gout, kidney stone, headache, and angina pectoris [15].

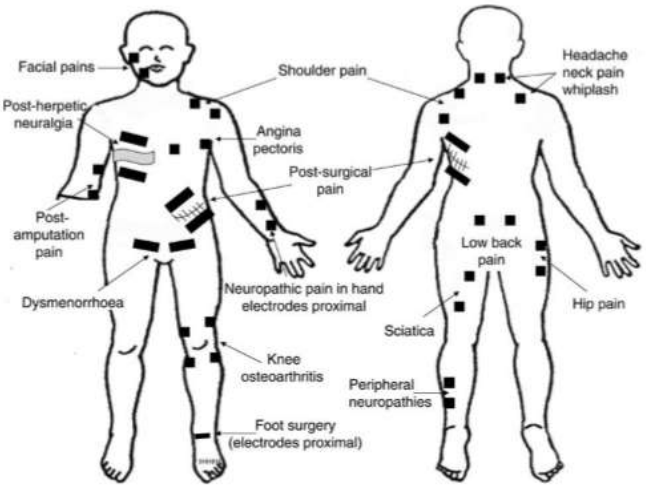

Fig: 1- Common sites for placement of electrodes in TENS therapy [14].

TENS Technology

For many years, clinical interest in electrical therapy for treatment and control of pain has existed, but in the mid-1960s, since the development of the "gate control theory", therapies making the use of electricity took a drastic improving turn. (Kahn, 1994: Melzack & Wall, 1965). This theory states, selectively stimulating the nerve fibres can jam pain signals being carried to the brain.

TENS units has two types of channels, single (2 electrodes) and double (4 electrodes). A stimulus generator transmits electrical pulses to electrodes (conducting pads), these are placed directly on the skin. Electrical pulses are of various shapes, they are exclusively positive or negative, monopolar (monophasic) or bipolar (biphasic). The frequency of pulses can be controlled [16].

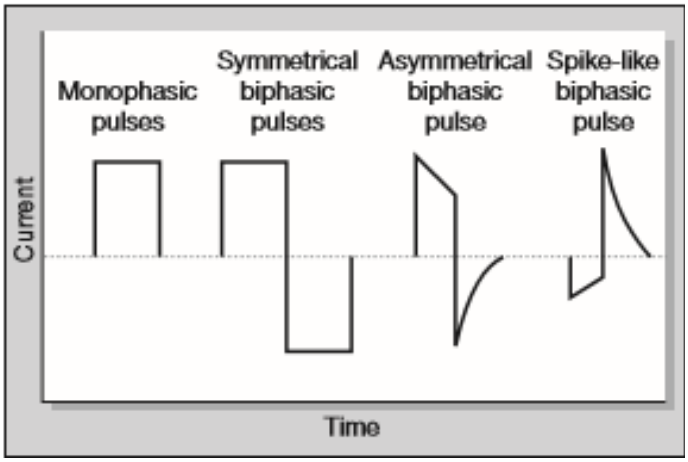

Fig.1 Common pulse waveforms used in TENS [17].

Generally in TENS therapy, frequencies in the 80 to 120 cycles per second range are considered "high" and used in treating acute pain. Frequencies of 1 to 20 cycles per second are considered "low" and applied for chronic pain. Pulse width or duration (microseconds) is the time the current acts on the skin of the patient during each pulse, and is usually between 50 and 400 microseconds. The final variable is intensity or amplitude of the current; most TENS (1 to 100 mA). It is also possible to modulate frequency, pulse width and amplitude.

Since the time, TENS first appeared in the healthcare field, the basic design has not undergone any major changes. For example, although today there is more understanding of the nervous system and its involvement in perception of pain than there was in the 1960s, very little research has been done on the placement of electrodes and aspects of the electrical stimulus such as frequency and pulse width. In spite of all this, TENS has grown into a multi-branded industry. Portable battery-powered TENS units, worn on a belt or carried in the pocket, are commercially available. During the initial phase reports that compared TENS with narcotic drugs in having an analgesic effect, suggested that the pain of different origins and of different types were either numbed or entirely removed using TENS [18]. The technology has quickly become popular among the health professionals and also has been adopted by them. Many acclamations have ever since been made about the analgesic effect of TENS in a variety of applications.

Reported applications of TENS have included post-traumatic acute pain, musculoskeletal pain, chronic pain, delivery pain and labor, pre and post-operative pain, dental pain, fracture, tinnitus, and other pediatric pain applications [19]. No hazards of significance have been reported yet with TENS therapy. Minor side effects include skin irritation possibly due to the gel used at the electrode site.

ActionMechanism

Action mechanism for pain-relieving effect provided by TENS has basis set in the following theories- Gate control theory and Endogenous Opioid theory.

- **Gate control theory:**

Gate control theory which was put forth by Melzack and Wall [21] in 1965 , is the most widely acknowledged theory. It explains the action mechanism of TENS by suggesting that the 'Substantia Gelatinosa' which resides in spinal cord's dorsal part acts as a gate control system, it can alter the conducting patterns of peripheral fibres before the affect the T-cells of spinal cord. Tiny unmyelinated fibers called the 'C' fibres transmit pain to the gate which keeps it an open position. Activities of large fibers (covered with Myelin sheath) called the 'A' fibres exert presynaptic inhibition on the activity or input of the 'C' fibres and aids in closure of the gate; It thus blocks transmission of signals to T cells [21]. By increasing large fiber input and by bringing a decrease in the small fiber input, thus closing the gate, will help in achieving pain control.

- **Endogenous opioid theory:**

Reynolds (1969) [22] showed in his study that stimulating the periaqueductal grey part of the midbrain using electricity provides anodyne like morphine. This eventually led to the discovery of endorphins which are found in the pathway of pain control at various levels. Thus, TENS mechanism can also be defined as the stimulation and release of opioids created by one's body itself in the spinal cord [7].

Classification of TENS

TENS can be classified on the basis frequency:

1. High frequency [greater than 50 Hz].
2. Low frequency [2-9 Hz] [7, 1, 23]

High frequency TENS operates via the gate control theory. Effect of this type provides a pain relief for a short term, and Low frequency TENS provide a long-term effect and operates via release of opioids created by the body [7, 1, 23].

Types of TENS

Three main types of TENS:

1. Conventional
2. Acupuncture-like [AL-TENS]
3. Intense

- Conventional TENS:

Conventional TENS is the most widely acknowledged mode of electrical therapy. High frequency, ranging from 10-200 pulses/sec, are used along with low intensity pulsed current to activate the large fibers without simultaneously activating the small ones and 'C' fibres (pain related) [15]. It produces segmental pain relief. This mode of TENS therapy can be used

throughout the entire length of the day but in order to reduce the risk of skin irritation, breaks are recommended [24].

- Acupuncture-like TENS [AL-TENS]:

It uses low frequency ranging from 2-4 pulses/sec, pulses of high intensity electrical currents. Electrically induced muscle twitching activates the small muscle fibres. It provides extra segmental pain relief. AL-TENS should only be used for 30 minutes in one session because fatigue may be developed due to the continuous contractions of muscles [24].

- Intense TENS:

Pulses of high intensity electrical currents, which a patient can bear with high frequency of 200 pulses/ sec, are used. Intense TENS activates small diameter cutaneous afferents. This mode of TENS has a usage limit about 15 minutes in one session as the continuous stimulations of high intensity may make the patient uncomfortable [24].

III. PRECAUTIONS AND CONTRAINDICATIONS

Hazardous and life-threatening events resulting rarely occur from using TENS. Occasionally, light electrical burns are reported due the improper use of the technique. Some patients experience minor skin irritation near the skin where the electrodes are placed. Transdermal drug delivery system and TENS should never be in close quarters [25].

Since TENS cannot be excluded as a cause of problems and complications from legal point of view for people with pacemakers, birth expectancy, people with epileptic problems, the TENS manufactures has listed them as contraindications. However, in some cases, healthcare specialists allow TENS usage in the patients listed above provided that the situation is discussed with the in-charge medical specialist and the person of interest so as to not hinder the health growth of that person [25].

- Birth Expectancy or Pregnancy:

The abdomen and pelvis region should remain untouched by TENS as the effect of TENS on fetus is not yet discovered and the therapy can cause uterine contractions and lead to premature labor.

- Inappropriate electrode sites:

TENS must be kept away from areas near or on the anterior neck because it may cause hypotension or spasm. It must not be placed over the eyes as it can increase the pressure inside the eye (intraocular pressure).

- Malignancy:

Areas of active malignancy must be kept away from the direct contact of TENS. A recent case series has shown the effective nature TENS has over bone pain caused by cancer.

- Epilepsy:

Doctors should be careful and cautious with epileptic patients and must keep the electrodes away from regions like head and neck as it has been reported that TENS induces seizures in post-stroke patients [26].

IV. RECENT DEVELOPMENTS

Proliferation of devices which are similar to TENS all over the market, including PainwGone, micro current electrical therapy, transcutaneous electrical acupoint stimulation (Relief Band), transcranial electrical stimulation, and transcutaneous spinal electro-analgesia is a result of advances in modern technology Most of the devices are successful. Recently, portable TENS like devices have been developed to assist the TENS device in scanning of the skin to find regions of skin that offer low impedance which makes treatment with TENS more effective.

V. DISCUSSION

TENS has gained a lot of popularity and acceptance as it is low cost, safe and easy to administer for the patients. The effectiveness of TENS depends on how appropriately it is used or administered to the patient. It has provided satisfaction to many patients. Clinical trials and uses have proved that TENS can be alone used for treatment of mild to moderate pain and for severe pain along with the use of pharmacotherapy. Systematic reviews and clinical research about TENS are inconclusive and less convincing. Negative results of the RCTs (randomized controlled trials) have been recognized due to inappropriate application of TENS technique, improper dosage of TENS (under dose), inadequate sample sizes and errors in measuring the outcomes of the therapy [24]. Systematic reviews are being compromised due to the poor quality RCTs being conducted. However, good quality trials are required to be conducted in order to find out the extent of desired result being obtained of the various TENS types and also keep the expenses in check when compared with conventional interventions of pain relief and other electrotherapy techniques.

Though TENS cannot be used as a replacement of anesthesia but it can prove as effective in many cases where pain needs to be controlled. Its analgesic and non-analgesic physiologic effect has an effective use in controlling different types of body pain. Action mechanism and pain-relieving effects of Intense TENS and AL-TENS are different from conventionally used TENS and they have proven to be more effective and useful while as benefits provided by conventional TENS is limited.

REFERENCES

[1] Walsh D., Sluka KA, 'Transcutaneous electrical nerve stimulation: basic science mechanisms and clinical effectiveness'. J Pain, 2003;4(3):109-21.

[2] Jarit GJ, Mohr KJ, Waller R, Glousman RE. 'The effects of home interferential therapy on post-operative pain, edema, and range of motion of the knee', Clin J Sport Med. 2003;13(1):16-20.

[3] Radhakrishnan R, Dickman JK, King EW, Johnston NF, Herold CA, Spurgin ML et al. 'Spinal 5-HT2 and 5-HT3 receptors mediate low, but not high', 'frequency TENS-induced antihyperalgesia in rats', Pain. 2003;105:205-13.

[4] Katch EM, 'Application of transcutaneous electrical nerve stimulation in dentistry', AnesthProg. 1986;33:156-60.

[5] DeSantana JM, Sluka KA, Da Silva LF, De Resende MA. 'Transcutaneous electrical nerve stimulation at both high and low frequencies activates ventrolateral periaqueductal grey to decrease mechanical hyperalgesia in arthritic rats'. Neuroscience. 2009;163:1233–1241. [PubMed: 19576962]

[6] Kalra A, Urban MO, Sluka KA. 'Blockade of opioid receptors in rostral ventral medulla prevents antihyperalgesia produced by transcutaneous electrical nerve stimulation (TENS)', J PharmacoExpTher. 2001;298:257–263.

[7] Sluka KA, Deacon M, Stibal A, Strissel S, Terpstra A. 'Spinal blockade of opioid receptors prevents the analgesia produced by TENS in arthritic rats', J PharmacolExpTher. 1999;289:840– 846. [PubMed: 10215661]

[8] Ma YT, Sluka KA, 'Reduction in inflammation-induced sensitization of dorsal horn neurons by transcutaneous electrical nerve stimulation in anesthetized rats', Exp Brain Res. 2001;137:94–102. [PubMed: 11310176]

[9] Radhakrishnan R, Sluka KA, 'Deep tissue afferents, but not cutaneous afferents, mediate transcutaneous electrical nerve stimulation-Induced antihyperalgesia', J Pain. 2005;6:673–680. [PubMed: 16202960]

[10] Sabino GS, Santos CM, Francischi JN, de Resende MA. 'Release of endogenous opioids following transcutaneous electric nerve stimulation in an experimental model of acute inflammatory pain', J Pain. 2008;9:157–163. [PubMed: 17988952]

[11] Sluka KA, Bailey K, Bogush J, Olson R, Ricketts A, 'Treatment with either high or low frequency TENS reduces the secondary hyperalgesia observed after injection of kaolin and carrageenan into the knee joint', Pain. 1998;77:97–102. [PubMed: 9755024]

[12] Vance CG, Radhakrishnan R, Skyba DA, Sluka KA, 'Transcutaneous electrical nerve stimulation at both high and low frequencies reduces primary hyperalgesia in rats with joint inflammation in a time-dependent manner', Phys Ther. 2007;87:44–51. [PubMed: 17142641]

[13] Banerjee G, Johnson MI., 'Transcutaneous electrical nerve stimulation (TENS): A potential intervention for pain management in India', Indian J Pain. 2013;27:132-41.

[14] Iain Jones MB ChB FRCA, Mark I Johnson PhD, 'Transcutaneous electrical nerve stimulation', Continuing Education in Anaesthesia, Critical Care & Pain, Volume 9, 2009, DOA: 19/3/2017.

[15] Quarnstrom F., 'Electronic dental anesthesia', AnesthProg. 1992;39:16277.

[16] Barr, J. T. 'Transcutaneous electrical nerve stimulation', In J. T. Barr, (Comp.), Critical literature review: Clinical effectiveness in allied health practices. Rockville, MD: U.S. Agency for Health Care Policy and Research. pp. 89-93.

[17] Mark Johnson, 'Transcutaneous electrical nerve stimulation (TENS)', file:///E:/TENS%20Explained%20Chapter.pdf, DOA: 19/3/2017.

[18] Augustinsson, L.-E., Bohlin, P., Bundsen, P., Carlsson, C.-A., Forssman, L., Sjöberg, P., Tyreman, 'Pain relief during delivery by transcutaneous electrical nerve stimulation', Pain. 4:59-65.

[19] Don, R. G., Tay, G., 'Transcutaneous electrical nerve stimulation for the relief of chronic pain', Singapore Medical Journal. 23 (6):322-324.

[20] Melzack R, Wall PD., 'Pain mechanism: a new theory', Science. 1965;150:971-9.

[21] Reynolds DV., 'Surgery in the rat during electrical analgesia induced by focal electrical stimulation', Science. 1969;164:444-5.

[22] Kalra A, Urban MO, Sluka KA., 'Blockade of opioid receptors in rostral ventral medulla prevents antihyperalgesia produced by transcutaneous electrical nerve stimulation (TENS)', J PharmacolExpTher. 2001;298:257-63.

[23] Vikrant Kasat , Aditi Gupta , RuchiLadda , MiteshKathariya , Harish Saluja , Anjum-Ara Farooqui, 'Transcutaneous electric nerve stimulation (TENS) in dentistry', J ClinExp Dent. 2014; 6(5):562-8.

[24] Iain Jones MB ChB FRCA, Mark I Johnson PhD, 'Transcutaneous electrical nerve stimulation', Continuing Education in Anesthesia, Critical Care & Pain, Volume 9, 2009.

[25] Searle RD, Bennett MI, Johnson MI, Callin S, Radford H., 'Letter to editor: transcutaneous electrical nerve stimulation (TENS) for cancer bone pain', Palliat Med 2008; 22: 878–9