A comparison of high versus low intensity transcutaneous electrical nerve stimulation for chronic pain

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Abstract

Background and objectives: Over the last 35 years electrical nerve stimulation has been employed increasingly in the treatment of chronic pain. This study was carried out to compare the analgesic effect that produced by applying a fixed frequency (50 Hz) high intensity tolerably painful transcutaneous electrical nerve stimulation (TENS) with the conventional low intensity TENS.

Methods: Thirty six patients (26 Females and 10 males with age 18 – 54 years) were selected from patients consulting a private psychiatric clinic in Erbil city from March 2009 to march 2010. They had chronic pain in head and neck for more than 2 years. The cases were allocated randomly into two groups; group A treated by the conventional TENS of high frequency 100 Hz with low intensity current, by applying the electrical electrodes on the nucheal region (back of neck) for 20 minutes once daily for six days, and once weekly for one month then follow up the patients after 3 months, while in group B; the same procedure was applied but with fixed frequency 50 Hz and high intensity current adjusted to a tolerably painful level. The pain measured by verbal scale ranged from 0 to 4.

Results: Patients who received high intensity TENS; 94% of them got immediate pain relief and 17% got long lasting pain relief more than three months, while with the conventional TENS only 33% got immediate pain relief and no one got long lasting pain relief.

Conclusion: The tolerably painful high intensity TENS gives better analgesic effect than the conventional TENS, and in some patients it may leads to long lasting analgesic effect

Key words: transcutaneous electrical nerve stimulation, analgesia, pain.

Introduction

Thousands years ago the ancient Egyptians were first applied electrical current therapy using electric eels (type of fish) in the treatment of headache and gout[1]. Electrical stimulation was used also for pain control in ancient Greece, 63 A.D. It was reported by Scribonius Largus that pain was relieved by standing on an electrical fish at the seashore [2].

Transcutaneous electrical nerve stimulation (TENS) is a non-invasive, safe nerve stimulation intended to reduce pain, both acute and chronic. A number of systematic reviews or meta-analyses have confirmed its effectiveness for many types of chronic pain[3]. 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 musculoskeletal pain, atypical facial pain, neurogenic pain as phantom pain, low back pain, sympathetically mediated pain, and postsurgical pain [4,5] . TENS is the use of electric current produced by a device to stimulate the nerves for therapeutic purposes [6]. The unit is usually connected to the skin using two or more electrodes.

A typical battery-operated TENS unit is able to modulate pulse width, frequency and intensity [7].

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The mechanism of the analgesia induced by the TENS was explained by gate control theory which is proposed by Melzack and wall 1965. According to this theory the activation of the large diameter Aa/b afferent fibers excites small interneurons in lamina V of the substantia gelatinosa of spinal dorsal horn (hypothetical gate) which closes the pain stimuli traveling from presynaptic nerve terminal of Ad and C fibers in the peripheral nervous system to the dorsal horn cells including spinothalamic cells. This analgesic effect produced by TENS is explained by segmental mechanism involving inhibitory effect, by GABA nergic interneuron as described in gate control theory[1].

This was confirmed by a study carried on animal by Duggan & Foong in 1985, where they found that the analgesic effect of TENS was blocked by giving Bicuculline which is an GABA nergic receptor antagonist. This conventional type of TENS with high frequency (100 Hz) low intensity current, involves mediation of serotonin & noradrenalin, both of these neurotransmitter are linked with endorphenergic pathway in pain modulation. This form of TENS is not painful and it has a short lasting effect[8].

In 1991 Johnson et al in their studies on the analgesic effect of TENS, they found that the analgesia that lasted up to 2 hours after termination of stimulation was, however, achieved in less than 20% of patients[9].

A form of TENS related to electropuncture and requires stimulation at an intensity that produces a tolerable pain. It involves activation of Ad & C fibers, and it is mildly painful if applied at low frequency (1-10 Hz). This form of TENS activate endorphin system which is a pain modulating neurotransmitter. Further recent studies suggested that an increase in the level of endorphin in blood stream of healthy individuals occurs following the administration of high or low frequency TENS[10].

Garrison & Foreman in 1996 using animal models, recorded an increased level of endorphin in the dorsal horn neuron in cats after TENS, and after examining the effect of varying intensity and frequency of TENS on inhibition of the dorsal horn cell activity, they found that increasing the intensity and frequency of nerve stimulation increased the amount of inhibition produced by TENS[11].

In 2000 a cellular mechanism in the spinal dorsal horn was proposed by Sandkühler, that may underlie the long lasting analgesia following the high intensity or painful TENS. It was proposed that this long lasting analgesia achieved by stimulation of Ad and C fibers and not Aa/β fibers which can induces long term depression of synaptic strength in fine primary never fibers through release of glutamate from nerve terminals in superficial spinal dorsal horn that activate ionotropic glutamate receptors of the NMDA (N-methyl D- aspartate) subtype of receptor and metatropic glutamate receptors, this leads to a moderate increase in free cytosolic Ca concentration that is sufficient to activate protein phosphatase, lead to dephosphorylation of synaptic proteins of ionotropic glutamate receptors of AMPA (alpha-amino-3hydroxy-5methylsoxasole-propionic acid) subtype, leads to depression of synapic strength for prolonged period of time. This increase of Ca and activation of Phosphates are sufficient also to affect the synapses of C fibers[12].

The aim of the current study is to compare the analgesic effect that produced by the conventional TENS, with this method of applying a fixed frequency (50 Hz) with high intensity but tolerably painful electrical current to the patients.

Methods

Thirty six patients, 26 females and 10 males, with age ranged from 18 to 54years, suffer from chronic non malignant neck pain, as from fibromyalgia syndrome and cervical spondylosis due to osteophytes. In most of the cases, the pain radiate to their head, with chronisity for more than 2 years. The cases were selected from large numbers of patients consulting a private psychiatric clinic in Erbil city complaining from chronic pain in head and neck from march 2009 to march 2010.

Informed consent was obtained from all subjects. The cases were allocated randomly into two groups. In group A; 18 patients were treated by non painful conventional TENS with high frequency (100 Hz) low intensity electrical current, by applying two electrodes covered by saline soaked fabric pad on nucheal region (back of neck) for 20 minutes, once daily for 6 days, then once weekly for one month.

The pain was measured before applying TENS, and immediately after it, then we measure the pain after 6 days of applying TENS, after one month, and lastly after 3 months. The verbal scale for measuring the pain was in this way:

No pain = 0 Mild pain =1 Moderate pain = 2 Severe pain = 3 Intolerable pain = 4

In group B; includes 18 patients also, we apply the same method as group A but here we increase the intensity of the current to a painful but tolerable degree by the patient, where the apparatus adjusted to give a fixed frequency of 50 Hz, but the Amplitude or the intensity of the current is adjusted according to the patient's tolerance to pain.

Results

Table (1) represent group A; where by using the conventional TENS; 6 out of 18 (33%) of the patients got immediate pain relief, and 5 out of 18 (28%) got immediate improvement in their pain. At the end of 6 days of daily taking TENS, 1 out of 18 (6%) got no pain. One month later after taking once weekly TENS no one got pain relief or improvement, & patients after three months also no one got pain relief or improvement.

Table 2 represent group B; where by using the high intensity tolerably painful electrical current, 17 out of 18 (94%) got immediate pain relief, and 1 out of 18 (6%) got pain improvement. Six days later of daily taking TENS, 7 out of 18 (39%) got no pain, and 7 out of 18 (39%) got pain improvement. One month later of taking once weekly TENS, 5 out of 18(28%) got no pain, 1 out of 18 (6%) got pain improvement. Three month later 3 out of 18 (17%) got no pain and 1 out of 18 (6%) got pain improvement.

Table 1: Reported pain from group A; using conventional TENS.

Patients N0.	Pain Before TENS	Pain Immediately after TENS	Pain 6 days after TENS	Pain 1 month after TENS	Pain 3 months after TENS
1	3	2	2	3	3
2	2	1	2	2	2
3	2	2	2	2	2
4	3	3	3	3	3
5	3	3	3	3	3
6	2	0	2	2	2
7	2	0	2	2	2
8	2	2	2	2	2
9	2	2	2	2	2
10	2	0	0	2	2
11	3	2	3	3	3
12	3	0	3	3	3
13	3	0	2	3	3
14	3	2	2	3	3
15	3	2	3	3	3
16	3	3	3	3	3
17	3	0	3	3	3
18	2	2	2	2	2
No pain.		33%	5%	0%	0%
Pain improvement		28%	17%	0%	0%

Table 2: Reported pain from group B; using tolerably painful high intensity TENS

Patients No.	Pain Before TENS	Pain Immediately after TENS	Pain 6 days after TENS	Pain 1 month after TENS	Pain 3 months after TENS
1	2	0	0	0	0
2	2	0	2	2	2
3	2	0	0	2	0
4	2	0	2	2	2
5	2	0	0	2	2
6	2	1	2	2	2
7	3	0	1	3	3
8	3	0	0	0	3
9	2	0	0	2	2
10	3	0	2	3	3
11	2	0	2	2	2
12	3	0	2	2	2
13	3	0	0	0	0
14	2	0	1	2	2
15	3	0	2	3	3
16	3	0	2	3	3
17	2	0	0	2	2
18	3	0	1	3	3
No pain		94%	40%	17%	17%
Pain improvement		6%	39%	6%	6%

The verbal scale for measuring the severity of pain:

0 = No pain 1 = Mild pain 2 = Moderate pain 3 = Severe pain 4 = Intractable pain

Discussion

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)[9]. 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[13].

Recent clinical studies and meta-analysis suggest that having an adequate intensity of stimulation is necessary to achieve pain relief with TENS[14,15]. Thorsen and Lumsden in 1997 found that the painful form of TENS may achieve the best analgesic effect only after repetitive stimulation over several weeks, and its analgesic effect out last the duration of simulation by hours or days, & the pain reduction may be permanent in some patients[16]. This is consistent with our study which showed that the high intensity but tolerably painful TENS therapy produces more effective analgesic effect in comparison to the conventional low intensity TENS in spite of its unpleasant tolerably painful effect, where 94% of the patient got immediate pain relief, 6% got pain improved, & after 3 months 17% patients got pain relief, while in the conventional TENS about 33% got immediate analgesic effect, 28% got pain improvement, but no one got long term benefit or permanent pain relief.

In our study we start with low intensity current which is not painful for few minutes to activate touch & proprioceptive fibers (Aa/b) to induce analgesia at the site of application of electrodes, then followed by increasing the intensity of the current to a tolerably painful level to activate the nociceptive fibers (Ad & C) for 20 minutes, and so we may achieve analgesia by activation of various types of afferent fibers (Aa/β, Ad & C).

Conclusion

The tolerably painful high intensity TENS gives better analgesic effect than the conventional TENS, and in some patients it may leads to long lasting analgesic effect.

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