The Immediate Effects of Transcutaneous Electrical Nerve Stimulation on Pain Intensity and H-reflex in Patients with Lumbosacral Radiculopathy

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ABSTRACT

Background: Lumbosacral radiculopathy is a common entity in clinical practice and is frequently caused by disc herniation or degenerative changes in vertebrae. Most patients recover with conservative care, including physical therapy. Objective: The purpose of this study was to evaluate the immediate neurophysiologic effect of transcutaneous electrical nerve stimulation on the pain intensity and H-reflex in patients with lumbosacral radiculopathy. Methods: Twenty male patients (age ranged from 27-49 years) with chronic unilateral lumbosacral radiculopathy and 20 matched healthy subjects participated in this study. Pain intensity and H-reflex latency and amplitude were measured at baseline level and immediately after transcutaneous electrical nerve stimulation application for 20 minutes. Results: The results revealed improvement in radicular pain after application of transcutaneous electrical nerve stimulation with no significant changes (P>0.05) in H-reflex latency and amplitude immediately after transcutaneous electrical nerve stimulation application in comparison to the baseline values. Conclusion: It can be concluded that transcutaneous electrical nerve stimulation application is effective in reducing pain with no immediate effect on the H-reflex parameters elicited from the compressed nerve root.

Key words: H-reflex; lumbosacral radiculopathy; transcutaneous electrical nerve stimulation; pain.

INTRODUCTION

Lumbosacral radiculopathy (LSR) is a common clinical problem in medicine with associated decrease in quality of life and major economic cost. Lumbosacral radiculopathy involves L5-S1 nerve roots and occurs as a result of disc herniation in younger population and foraminal narrowing due to osteophyte formation in older patient. Many studies have demonstrated the effectiveness of transcutaneous electrical nerve stimulation (TENS) on various pain conditions, especially on low back pain. The application of electrical current to the skin to stimulate afferent nerve fibers reduces pain in accordance with the gate control theory. TENS is likely to stimulate the large-diameter afferent fibers, which may reduce the transmission of pain signals through the small nociceptive afferent fibers, thus inhibiting pain discrimination and perception, with slow onset and gradual offset that persists after stimulation stops.

TENS has analgesic effect via the inhibition of afferent nociceptive transmission at a spinal cord level and the release of endogenous opioids. The application of TENS over the course of peripheral nerve could alter the normal conduction process in the nerve to produce "conduction block." Previous studies reported inconsistent effect of TENS upon the H-reflex. The H-reflex is a neurophysiological test, which has been used as an objective electrodiagnostic measurement of S1 radiculopathy. It involves stimulation of group Ia afferent fibers and results in monosynaptic facilitation of α-motoneurons of the compromised nerve root in patient with radiculopathy. H-reflex was first described by Hoffman as a monosynaptic reflex arch. Measurement of the H-reflex latency and amplitude has been described as a technique to help confirm the presence of an S1 radiculopathy. A prolonged latency and/or an absence of the H-reflex on the affected side are the most commonly used measures of the H-reflex.

The purpose of this study was to evaluate the neurophysiologic effect of TENS on the H-reflex in patients with LSR.
PATIENTS AND METHODS

Subjects Selection
Twenty male patients (age ranged from 27 to 49 years) were recruited from out-patient clinics of Department of Neurology, Kasr El-Aini Hospitals and Faculty of Physical Therapy participated in the study. All patients diagnosed as having chronic unilateral LSR due to L5-S1 discogenic lesion. The patients were able to meet job demands with pain. The lumbosacral disc lesion was confirmed by spinal MRI. In addition to the patients’ group, a matched group of 20 healthy subjects with no previous or current history of lumbosacral radicular symptoms or constant back pain participated as a control group for the purpose of comparison for H-reflex parameters. The healthy control group was medication free and had no active disease at the time of testing.

General Inclusion Criteria
All patients did not receive physical therapy program and had (1) Unilateral radiation symptoms (pain, numbness and/or weakness) matching the dermatological distribution of S1 nerve root, with duration from three to six months, (2) Side-to side latency difference in H-reflex more than 1 ms

Subjects were excluded if they:
1. Had history of lumbosacral surgery, tumor, infection or inflammatory disease affecting the spine.
2. Had spinal fractures or structural deformity (scoliosis, kyphosis), spinal canal stenosis, lumbar spondylolisthesis.
3. Had diabetes mellitus, peripheral neuropathy or history of upper motor neuron lesion.
4. Were receiving medications other than analgesics and non-steroidal anti-inflammatory drugs.

Procedures
The procedures were conducted at the outpatient clinic of Faculty of Physical Therapy, Cairo University. All patients were asked to avoid taking medication less than four hours prior to the evaluation protocol. The subjects were asked to avoid anxiety, emotional stress, exercises and eating (at least two hours) before conducting the procedures. After signing a written consent form, all subjects underwent the following evaluation protocol which included:
- All subjects (control and study groups) were interviewed guided by a clinical history taking (current behavior of the symptoms, factors surrounding the onset of symptoms and duration of radicular pain) and neurological examinations including sensory and motor examinations. The subjects’ criteria including age, weight and height were recorded in the examination sheet.
- H-reflex stimulation and recording: All subjects were asked to adopt prone position, with arms on the side and in comfortable position. The subject’s face was turned to one side throughout the investigation period to assure normal breathing, comfort and standardized head position. Hips and legs were placed on thin pillows to assure comfort and full relaxation of the subject while they remained immobilized. The feet were allowed to rest free over the edge of the bed, with the ankle joints in an anatomically neutral position. The skin of the popliteal fossa, calf muscle and soleus muscle of the examined leg was gently abraded with fine grade sandpaper and cleaned with alcohol.
- Amplaid EMG 12 (electromyography unit, made in Italy) was used to elicit and record the soleus H-reflex. A silver-silver chloride surface-stimulating bar electrode with coupling gel was placed longitudinally on the tibial nerve in the popliteal fossa midline with the cathode proximal to the anode. The recording surface bar electrode was positioned over the soleus muscle with the active electrode proximal to the reference electrode, and 3 cm distal to the bifurcation of the gastrocnemius and on the line with the Achilles tendon. A ground surface metal electrode was positioned midway between the stimulating and the recording electrode on the skin of the calf. Electrodes were firmly secured with adhesive tape to maximize skin electrode contact. The stimulation parameters were 1.0 ms pulse duration at a frequency of 0.2 Hz and intensity that elicited H-maximum with minimum and stable M-response. Two-minute practice trials of elicited H-reflex were obtained to familiarize the patients with the H-reflex stimulation and recordings. Three readings of the maximum H-reflex with minimum and stable M-response were recorded and averaged in each condition. The signals were amplified 500-2000 using differential amplification and filtered at 20-10,000 Hz bandwidth, digitized and stored on computer for analysis. Recording of H-reflex was done at baseline (control and study groups) and after the application of TENS over the sural nerve for the study group.
- Pain intensity recording: The patients were instructed to mark the Visual Analogue Scale (VAS) where “0” indicate no pain and “10” indicate extremely pain. The patients were instructed to mark the VAS to represent their pain intensity before and after 20 minutes of TENS application. The mark corresponds with the level of the patient’s level of comfort.

**Treatment Protocol**

TENS application: A 120 Z TENS unit (ITO, Tokyo, JAPAN) was used for stimulation. The unit produces an asymmetrical biphasic waveform, 100 Hz and pulse duration 125 µs. While the patient in the prone position two carbons rubber electrodes (3.5 × 5 cm) with hydro-gel pads were attach to the skin (1 cm apart, cathode proximal) directly over the course of the sural nerve of the involved leg at the ankle, with the anode 1 cm proximal to the stimulating electrode. Electrodes were secured with adhesion tape to maximize skin-electrode contact.

TENS was applied for a continuous 20 min period, once the TENS unit was switched on subjects were told to report the onset of tingling sensation beneath the TENS electrode, the intensity of the current was then increased until subjects reported a strong but comfortable sensation.

**Statistical Analysis**

The data are described and presented as mean±SD. Comparisons of means were done using paired t-test. Analysis was performed using SPSS for windows (V.13). The level of significance was at P≤ 0.05.

**RESULTS**

The study and the control groups were matched in age, weight and height (Table 1). There was a significant difference between the H-reflex latency (ms) recorded from the control group (29.1±1.8) and the study group (31.21±2.1) with P<0.001. In the study group, there was a non-significant difference in the H-reflex latency before (31.21±2.1) and after (31.35±2.4) TENS application P<0.51, (Table 2).

There was a significant difference between the H-reflex amplitude (mV.) recorded from the control group (6.8±2.8) and the study group (4.52±2.6) with P<0.001. There was a non-significant difference in the H-reflex amplitude before (4.52±2.6) and after (4.36±2.4) TENS application P>0.79 in the study group (Table 2). The pain intensity before and after TENS application was 6.2±2.5 and 2.9±2.1 respectively, which was significant with P<0.001 (Table 2).

**Table 1.** Mean values of age, weight and height in both groups (Patients with lumbosacral radiculopathy and controls).

<table>
<thead>
<tr>
<th></th>
<th>Study Mean±SD</th>
<th>Control Mean±SD</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>41.6±6.72</td>
<td>40.2±4.56</td>
<td>1.12</td>
<td>0.25</td>
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<tr>
<td>Weight (kilograms)</td>
<td>76.16±7.46</td>
<td>75.1±3.21</td>
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<td>0.7</td>
</tr>
<tr>
<td>Height (centimeters)</td>
<td>169.12±7.74</td>
<td>168±4.54</td>
<td>0.29</td>
<td>0.81</td>
</tr>
</tbody>
</table>

SD Standard deviation
*Significant at P<0.05.

**Table 2.** Mean values of H-reflex latency (ms) and amplitude (mV) and pain intensity (Visual Analogue Scale) at baseline and post transcutaneous electrical nerve stimulation in patients with lumbosacral radiculopathy and controls.

<table>
<thead>
<tr>
<th></th>
<th>Baseline Mean±SD</th>
<th>Post-treatment Mean±SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-reflex Latency (ms) Study group</td>
<td>31.21±2.1</td>
<td>31.35±2.4</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>29.1±1.8</td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-reflex amplitude (mV) Study group</td>
<td>4.52±2.6</td>
<td>4.36±2.4</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>6.8±2.8</td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain intensity</td>
<td>Study group</td>
<td>6.2±2.5</td>
<td>3.4±2.1</td>
</tr>
</tbody>
</table>

ms millisecond, mV millivolt, SD Standard deviation
*Significance at P<0.05.
DISCUSSION

This study investigated the effect of a 20 minute application of TENS over the sural nerve on the H-reflex in patients with LSR. The results showed that TENS has no positive effect on the H-reflex of the compromised S1 spinal root, but had only significant reduction in radicular pain.

The effect of TENS upon the H-reflex has previously been investigated by Goulet et al., who reported that neither 99 nor 50 Hz applied over the sural nerve produced a typical increase or decrease in the H-reflex amplitude. However, another study showed a significant decrease in H-reflex amplitude following the application of TENS (99 Hz, 250 µs) over the sural nerve. The H-reflex amplitude is a measure of the excitability of the motoneurons and may change as a result of segmental supra-spinal influences upon the motoneurons. The inhibitory effects of low threshold afferent stimuli upon the H-reflex have previously been reported to be mediated by pre-synaptic inhibition on group la fibres.

The application of TENS in this study seems to have no significant effect on the H-reflex in patients with LSR. This could indicate that TENS had no decompression effect on the compromised nerve root and also the application of 20 minutes of TENS have no effect on the large diameter nerve axon which are demyelinated and cannot be recovered within the treatment period.

The H-reflex latency and amplitude recorded in this study were within the published normal range. However, the larger latency and the reduction in peak to peak amplitude of the study compared to control subjects indicated the presence of nerve root compression, demyelination or both. It has been reported that both spinal root compression and demyelination increase the H-reflex latency and decrease amplitude.

Furthermore, the H-reflex latency and amplitude after application of TENS did not significantly change. This could be attributed to the fact that remyelination or axonal regeneration in chronic LSR is difficult to take place in one session during 20 minutes of TENS application. Literature suggested that recovery from the neurological deficit as a result of radiculopathy take up to one year or not fully recoverable at all.

At the same time, TENS application had no effect on pain intensity, which could be explained due to the effect of TENS on pain gate. The pain reduction after the application of TENS could be due to the physiological block on nerve conduction. The non changed H-reflex with reduction in pain intensity after TENS in this study could be placebo improvement rather than physiological changes. Another possible explanation of the significant improvement in pain intensity showed in this study is the prone position taken by the patients during treatment with TENS. This prone position may have caused sufficient anterior movement of the nucleus pulposus decompressing the involved spinal root but due to demyelination of some of the larger diameter nerve fibers of the compromised spinal root, the H-reflex did not show any significant changes, as demyelination has been reported to interrupt the passage of the impulses.

In conclusion, the application of TENS over the sural nerve has no immediate neurophysiological effect on the H-reflex latency and amplitude of S1 nerve root in patients with LSR. In contrast, TENS has a significant effect in reducing pain intensity.

[Disclosure: Authors report no conflict of interest]


الملخص العربي

التأثير القويري للتتبیب الكهربائي من خلال الجلد على شدة الألم ومنعكسة هوفمان

في مرضى اعتلال الجذور العصبية القطنية العجزية

أجريت الدراسة على عشرين مريضا من الرجال ممن يعانون من آلام ناتجة عن ضغط المنطقة القطنية العجزية وتم مقاراتهم بمجموعة من الأسماء متجانسة في السن والطول والوزن. تم قياس شدة الألم ومنعكسة هوفمان قبل وبعد استخدام التتبیب الكهربائي من خلال الجلد لمدة 20 دقيقة لمجموعة المرضى، كذلك تم تسجيل قياسات رد فعل هوفمان في المجموعة الضابطة بغرض المقارنة مع مجموعة المرضى.

أظهرت النتائج تحسن ذو دالالة إحصائية في درجة الألم ولكن لم يتم تسجيل أي تحسن ذو دالالة إحصائية في قياسات منعكسة هوفمان بعد استخدام التتبیب الكهربائي من خلال الجلد في مجموعة المرضى. من هذه النتائج يمكن الاستدلال على أن التتبیب الكهربائي من خلال الجلد له تأثير فقير على شدة الألم ولكن لا يوجد له تأثير ملحوظ على التغييرات الفسيولوجية العصبية في مرضى اعتلال الجذور العصبية القطنية العجزية.