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Efficacy of Different Treatment Modalities on Spasticity Management of Spinal Cord Injury Using H-Reflex Study

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Abstract

Background Spasticity is one of the most frequently observed phenomena after a lesion of the upper motor neuron system. Treatment of spasticity should not be aimed at its complete removal but rather at improving function, easing care or alleviating pain.

Objective To evaluate the effectiveness of oral antispasticity drugs, transcutaneous electrical nerve stimulation and physical therapy alone on the management of spinal cord injury spasticity by using the H-reflex.

Methods Fifty nine patients with traumatic spinal cord injury suffering from spasticity divided into 5 groups (positive controls, group I who were subjected to a regular physical therapy program, group II who were taking the oral anti-spasticity drug (Baclofen) and were performing the same previous physical therapy program, group III who were subjected to transcutaneous electrical nerve stimulation therapy and performed the same previous physical therapy program, group IV who were taking the oral anti-spasticity drug (Tizanidine) and were subjected to the same previous physical therapy program and 31 normal volunteers were studied. Electrophysiologic study of H-reflex including H latency, H duration, H-reflex conduction velocity and H max/M max ratio.

Results Highly significant difference was noticed between the pre- and post-treatment assessments in group I and III in H max/M max ratio.

Conclusion Spasticity can be effectively treated but a multidisciplinary approach is required since it is unusual for a single intervention, such as oral medication or physiotherapy alone, to be the only modality needed.

Keywords H-reflex, Spasticity, Spinal cord injury.

List of Abbreviation: SCI = spinal cord injury, GABA = gamma aminobutyric acid, TENS = Transcutaneous electrical nerve stimulation, CMAP = compound muscle action potential.

Introduction

Spasticity may be defined as a motor disorder characterized by a velocity-dependent exaggeration of stretch reflexes, resulting from abnormal intraspinal processing of primary afferent input [(1)]. Spasticity has severe negative effects on motor performance and quality of life in patients with an upper motor neuron lesion [(3)]. More than 50% of individuals report spasticity secondary to spinal cord injury (SCI) [(2)] which may be due to loss of descending tonic or phasic excitatory and inhibitory inputs to the spinal motor apparatus, alterations in the segmental balance of excitatory and inhibitory control, denervation supersensitivity, and neuronal sprouting [(4)].

Spasticity management often requires multiple interventions such as physical therapy, oral or intrathecal antispasticity medications, local chemical neurolysis with phenol or alcohol, botulinum toxin injections and surgical interventions such as dorsal rhizotomies, nerve root resections, neurotomies and tenotomies [(5)].

Baclofen, a derivative of gamma aminobutyric acid (GABA), is widely used as the first line of pharmacological treatment for spasticity in people with SCI [(6, 7)]. Baclofen, also identified as

Lioresal, crosses the blood-brain barrier more readily than GABA itself and is believed to reduce spasticity by enhancing inhibitory influences on the spinal stretch reflex via increasing presynaptic inhibition [6].

The anti-spasticity effects of tizanidine are thought to be mediated by its α2- adrenergic agonistic properties. This pre-synaptic inhibition of the release of excitatory amino acids in the spinal cord results in an overall inhibitory effect on alpha motor neurons and a clinical reduction in motor reflexes [8].

Physical therapy is one part of the fight against spasticity. Physical treatment modalities that have been used in spastic hypertonia are superficial heat and cold, diathermies, electrical stimulation, implanted spinal stimulation and massage [9].

Transcutaneous electrical nerve stimulation (TENS) is a non invasive, readily applicable method that has few side effects, no drug interactions, no potential toxicity, can be applied by the patient and is less costly in the long term compared with drug treatment [10].

The Hoffmann's reflex (H-reflex) [11] is an electrically elicited spinal monosynaptic reflex, which was originally described by Hoffmann (1910). It is equivalent in many aspects to the monosynaptic reflex elicited by a mechanical tap to the tendon but the stimulus for the H-reflex bypasses the muscle spindle [12]. The H-reflex is believed to be a compound muscle action potential (CMAP) arising from an electrical afferent activation of a monosynaptic reflex arc [13]. The ratio of the peak-to-peak maximum H-reflex amplitude to maximum M-wave amplitude (H/M ratio) provides a measure of motor neuron pool activation and therefore excitability [14].

Methods

This study was performed on 59 spinal cord injured patients with a mean age ± SD = 33.96 ± 11.12 years and a mean height ± SD = 168 ± 6.91 cm with lower limb spasticity who were attending the outpatient clinic of Ibn Al-Quf hospital for spinal cord injuries or were admitted to the same hospital from the period of January to June 2012. All these patients were with traumatic SCI (above L2 segment) and problematic spasticity. Exclusion criteria included those with complications that may increase spasticity (e.g. pressure ulcer), those with systemic diseases that cause peripheral neuropathy (e.g. diabetes), orthopedic problems (e.g. hip dislocation), or neurological problems. All the patients were subjected to complete history taking and thorough clinical examination. Laboratory investigations, including hemoglobin, paced cell volume, fasting blood sugar and renal function tests were done for all the patients.

Additionally, 31 normal volunteers with a mean age ± SD= 38.96 ± 13.24 years and a mean height ± SD = 170.41 ± 5.73 cm were randomly selected and included in the present study. They had no history of any disabling diseases.

All patients were subjected also to the following physical therapy program, one session daily that included massage, passive, assisted active and active range of motion exercises, stretching exercises and gradually strengthening exercises.

The patients were divided into 5 groups considering that some patients were examined more than one time in a way that did not interfere with the results and as follows:

Positive controls: This group included (12) patients who were not taking any type of treatment or performing a regular previous physical therapy program as they are newly admitted to the hospital after stabilization of their injury.

Group I: Included (31) patients who were subjected a regular physical therapy program (massage, passive, assisted active and active range of motion exercises, stretching exercises and gradually strengthening exercises) which was performed as 1 session/day without any other type of treatment.

Group II: Included (30) patients who were taking oral Baclofen (the full therapeutic dose) and

were performing the same previous physical therapy program.

Group III: Included (33) patients who had one TENS session which was applied to the tibial nerve of the spastic lower limbs, each session lasted 10 minutes and was applied once before the test, in addition to the same previous physical therapy program. Zimmer Galva 5 therapies device with high voltage, Rectangular impulse 20 µs, 10 Hz surged vibration program was used for TENS therapy.

Group IV Included (13) patients who had taken Tizanidine 4 mg tablets for only one time 2 hours before performing the test in addition to the same previous physical program.

H-reflex measurements were performed with 4-channels electrodiagnostic apparatus (CMS6600A EMG/EP system). Measurements were made at room temperatures of 20-25 degrees centigrade, with the muscles at rest and the patients in the prone position and the feet suspended over the edge of the couch.

The active electrode was placed over the soleus muscle and the reference electrode was placed over the Achilles tendon. The ground electrode was placed over the calf between the stimulating site at the popliteal fossa and the active electrode. Stimulus pulses of long duration (1 msec) were used to preferentially activate large sensory fibers [15]. The latencies were measured from the stimulus onset to the beginning of the initial deflection of H-reflex; amplitude was measured from peak to peak.

The formula used to calculate H-reflex conduction velocity (HCV) is [19]:

HCV (m/sec) = (distance popliteal fossa to T11 x2) / (H-reflex latency – M latency – 1 msec).

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 16 for Windows [17]. All the results were expressed as mean ± SD. The students (*t*) test was used to evaluate the differences between any two groups. The probability limit (*P* value) of less than 0.05 was considered to be statistically significant for the results under the study. Correlation analysis was performed with Pearson correlation [16].

Results

In this study 31 healthy controls were included with a mean age ± SD = (38.96 ± 13.42 years) and a mean height ± SD = (170.41 ± 5.73 cm). Also, 59 spinal cord injured patients (who were suffering from spasticity, more in their lower limbs) were included in this study with a mean age ± SD = (33.96 ± 11.12years) and a mean height ± SD = (168 ± 6.91 cm). There was no significant difference ($P > 0.05$) regarding age and height between control subjects and patients. Physiological variation in various parameters of H reflex due to sex could not be assessed due to very small sample size of females. Hb, PCV, random blood sugar and renal function test was normal in all the patients. A significant correlation was noticed between the height of control subjects and both the H and M latency. Accordingly, a regression equation was used to predict the optimal H latency and optimal M latency for the patients and controls.

Table 1 shows that there was no significant difference between the control group and patients concerning the H and M latency, H duration, HCV and F wave latency after confirming that any treatment modality did not affect these parameters.

Table 1. Neurophysiologic parameters in SCI patients and controls

Parameter	Control group N = 31 Mean ± SD	SCI patients N = 59 Mean ± SD
H latency (msec)	32.19 ± 1.63	32.62 ± 1.35
M latency (msec)	6.25 ± 0.42	6.39 ± 0.35
H duration (msec)	15.73 ± 2.32	15.02 ± 1.17
HCV (m/s)	53.04 ± 1.84	52.48 ± 2.0
F latency (msec)	39.76 ± 4.73	38.45 ± 2.73

SCI = spinal cord injury

Table 2 shows highly significant improvement in the H/M ratio when comparing the positive controls to the other groups while the H/M ratio in the negative controls shows no significant

difference with group II and group IV and a significant difference with the other groups.

Table 2. H/M ratio in the different treatment groups in comparison with the positive and negative controls.

Group		H/M ratio Mean ± SD
Control group	+ve controls	72.94 ± 12.93
	-ve controls	35.54 ± 18.82**
Group I	Group I	50.94 ± 21.81
	+ve controls	72.94 ± 12.93**
	Group I	50.94 ± 21.81
	-ve controls	35.54 ± 18.82*
Group II	Group II	43.86 ± 17.06
	+ve controls	72.94 ± 12.93**
	Group II	43.86 ± 17.06
	-ve controls	35.54 ± 18.82
Group III	Group III	49.15 ± 21.68
	+ve controls	72.94 ± 12.93**
	Group III	49.15 ± 21.68
	-ve controls	35.54 ± 18.82*
Group IV	Group IV	42.06 ± 20.14
	+ve controls	72.94 ± 12.93**
	Group IV	42.06 ± 20.14
	-ve controls	35.54 ± 18.82

* $P < 0.05$, ** = $P < 0.001$

Discussion

Spasticity is one of the disabling symptoms in patients with upper motor neuron syndromes like spinal cord injury and brain injury [18]. Treatment of spasticity should not be focused on its removal but rather at improving function, easing care or alleviating pain [20].

Because the SCI in this study was traumatic, there will be no reason that the peripheral nerve conduction velocity (NCV) will be affected in those patients. As a result, H-reflex latency, duration, conduction velocity and F-wave latency were not statistically different from the values obtained from healthy controls as the H-reflex latency reflects the fastest conducting fibers, while its waveform reveals the functional status of the remaining slower conducting fibers expressed by the wave duration [13]. The HCV is particularly useful in evaluating spinal cord circuitry in a non-invasive manner as it evaluates the sensory and motor fibers at the same time [13].

H-reflex amplitude is considered to be the index of the activities in the spinal cord as a final common pathway and used to evaluate the effects of the upper spinal organs and the input from sensory systems [21]. The maximal M-wave (M max) amplitude indicates that all the α-motoneurons of the innervated muscles were fired. It may be used as a base to normalize H-reflex amplitude [22].

The heightened H/M ratio observed in the positive controls was similar to many other studies [16,23,24]. Some researchers [25] stated that the cause behind the increase of the motoneuron excitability in upper motor neuron lesion may be attributed to the loss of the supraspinal inhibitory control and similar impulses from interneurons. The results of group (I) was somewhat close to the results of other researchers [16] who showed significant improvement in H/M ratio in patients receiving a full program of physiotherapy only without other interventions for 6 weeks, but didn't reach significance in other parameters. The reduction in the H/M ratio after physiotherapy can be attributed to that the massage technique used in this study activates a wide spectrum of afferents, including both cutaneous and muscular mechanoreceptors, as mentioned in studies dealing with similar manual modalities [26,27]. The role of the cutaneous mechanoreceptors in the amplitude changes of the H-reflex in both neurologically healthy [28] and neurologically impaired persons [29] has been studied. However, the decrease in the H/M ratio noticed in this group may also be attributed to enhancement of muscle contraction by the massage technique and other rehabilitation procedures that led to increase the M amplitude in relation to H amplitude [30]. But, the H/M ratio of group (I) showed a significant difference when compared to the healthy controls value. This finding is in acceptance with the study of Vittorio who noticed that physiotherapy alone in spinal

cord injured patients is not sufficient in the management of focal spasticity [31].

In group (II), the reduction in H/M ratio of this group was close enough to the value of healthy group that there was no significant difference between the two groups ($P > 0.05$). Our results gained agreement with the findings of other researchers [16,10] that showed significant reduction as regards H/M ratio with non significant reduction as regards other electrophysiological parameters. The action of Baclofen, which is widely used as the first line of pharmacological treatment for spasticity in people with SCI, is via its crossing the blood-brain barrier more readily than GABA itself and is believed to reduce spasticity by enhancing inhibitory influences on the spinal stretch reflex via increasing presynaptic inhibition [6]. Additionally, Koella thought that Baclofen have some supraspinal activity in addition to its action at the spinal level to reduce muscle tone [33].

The results of group (III) revealed highly significant improvement in H/M ratio in comparison to the positive control subjects. Some researchers [10,34] found nearly similar findings in agreement with our study, they reported that there was significant improvement of the degree of spasticity both clinically and electrophysiologically (reduction H/M ratio) after application of TENS on the spastic lower. TENS is believed to activate sensory Ia afferent fibers switching on presynaptic inhibition mechanisms leading to reduction in spasticity [35]. Also, TENS has been reported to indirectly affect the sympathetic outflow from the spinal cord by stimulating peripheral afferent fibers which increase the blood flow in the muscles. Increased blood flow in the spastic muscle is reported to improve its efficiency, oxygen uptake, and waist product removal [32]. On the other hand, Improvement in H/M ratio that resulted from TENS program did not reach the level of healthy subjects that may be attributed to the short duration of TENS application used in this study (approximately 10 minutes for only one time) while it was longer and frequent in other studies.

Group (IV) study showed a highly significant reduction in the H/M ratio when compared to the positive control subjects and no significant difference when compared with the negative controls. This effect is consistent with a documented Tizanidine-mediated potentiation of presynaptic inhibition, suppression of flexor reflexes, as well as its direct action on α-motoneurons [36]. Its action arises from agonistic activity of the compound at noradrenergic α2 receptors; resulting in both direct impairment of excitatory amino acid release from spinal interneurons (presynaptic inhibition) and a concomitant inhibition of facilitatory caerulospinal pathways (Cerulospinal tract provides nonspecific activation of the motor neuron pool in anterior horn) that part of the antispastic action of tizanidine may be supraspinal in origin [37].

We conclude from this study that the H-reflex can provide information regarding neural function after spinal cord injury and the H/M ratio can be used as a good indicator for both spasticity assessment and response to treatment. Spasticity can be effectively treated but a multidisciplinary approach is required. TENS is effective, economic, non invasive and readily applicable method that has few side effects but it should only be used as a supplement to other treatment methods in the management of spasticity. Tizanidine hydrochloride is useful in the management of spasticity caused by SCI and can be used as a routine drug treatment although liver function tests should be periodically monitored. So, for better controlling of spasticity, we can use a combination of the three methods (Oral medication, TENS and physical therapy).

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Author Contribution

Prof. Dr. Fakhir S. Al-Ani suggests the study and co-wrote the manuscript and Dr. Mohaimen A. Ridha collected and analyzed the data and wrote the paper.

Conflict of Interest

Authors disclose no conflicts of Interest

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References

1. Young RR. Spasticity: a review. Neurology. 1994; 44(11 Suppl 9): S12-20.
2. Walter JS, Sacks J, Othman R, et al. A database of self-reported secondary medical problems among VA spinal cord injury patients: its role in clinical care and management. J Rehabil Res Dev. 2002; 39(1): 53-61.
3. Horney T, Kahn G, Jennifer H. Temporal facilitation of spastic stretch reflexes following human spinal cord injury. J Physiol. 2006; 571: 593-604.
4. Rizzo MA, Hadjimichael OC, Preiningerova J, et al. Prevalence and treatment of spasticity reported by multiple sclerosis patients. Mult Scler. 2004; 10(5): 589-95.
5. Jang SH, Ahn SH, Park SM. Alcohol neurolysis of tibial nerve motor branches to the gastrocnemius muscle to treat ankle spasticity in patients with hemiplegic stroke. Arch Phys Med Rehabil. 2004; 85: 506-8.
6. Kirshblum S. Treatment alternatives for spinal cord injury related spasticity. J Spinal Cord Med. 1999; 22: 199-217.
7. Taricco M, Pagliacci MC, Telaro E, et al. Pharmacological interventions for spasticity following spinal cord injury: results of a Cochrane systematic review. Eura Medicophys. 2006; 42(1): 5-15.
8. Gracies JM, Nance P, Elovic E, et al. Traditional pharmacological treatments for spasticity. Part II: General and regional treatments. Muscle Nerve. 1997; 6 (Suppl.): S92-120.
9. Gracies JM. Physical modalities other than stretch in spastic hypertonia. Phys Med Rehabil Clin N Am. 2001; 12: 769-92.
10. Aydin G, Tomruk S, Keles I. Transcutaneous electrical nerve stimulation versus baclofen in spasticity: Clinical and electrophysiological comparison. Am J Phys Med Rehabil. 2005; 84: 584-92.
11. Hoffmann P. Beitrag zur Kenntnis der menschlichen Reflexe mit besonderer Berucksichtigung der elektrischen Erscheinungen. Arch Anat Physiol. 1910; 1: 223-46.
12. Nadeem AS, El-Yassin DI, Al-Ani FS. The H-reflex parameters with age in normal Iraqi infants and children. J Fac Med Baghdad. 2000; 42: 342-54.
13. Kimura J. Electrodiagnosis in disease of nerve and muscle. Principles and practice. 3rd ed. New York: Oxford University Press; 2001. p. 178-214.
14. Aminoff MJ. Electrodiagnosis in clinical neurology. 5th ed. Elsevier, Churchil Living stone. 2005.
15. Burke D, Adams RW, Skuse NF. The effects of voluntary contraction on the H reflex of human limb muscles. Brain. 1989; 112: 417-33.
16. Seliem HA, Nagieb GS, Eliewa EA, et al. Efficacy of different modalities on spasticity management of spinal cord injury: clinical and electrophysiological study. Egypt Rheumatol Rehab. 2007; 34(3): 405-16.
17. Norusis M. SPSS 16.0 Guide to Data Analysis. 2nd ed. New Jersey: Upper Saddle River, Prentice Hall; 2008. p. 1-34.
18. Voerman GE, Gregoric M, Hemens HJ. Neurophysiologic methods for the assessment of spasticity: The Hoffman reflex, the tendon reflex, and the stretch reflex. Disability Rehabil. 2005; 27: 33-68.
19. Troni W. Analysis of conduction velocity in the H pathway: Part 1. Methodology and results in normal subjects. J Neurol Sci. 1981; 51: 223-33.
20. Jellinger KA: Spasticity Management: A Practical Multidisciplinary Guide. Eur J Neurol. 2007; 1: e50-e50.
21. Crone C, Nielsen J. Spinal mechanisms in man contributing to reciprocal inhibition during voluntary dorsiflexion of the foot. J Physiol. 1989; 416: 255-72.
22. Nakazawa K, Miyoshi T, Sekiguchi, H et al. Effects of loading and unloading of lower limb joints on the soleus H-reflex in standing humans. Clin Neurophysiol. 2004; 115: 1296-304.
23. Maupas E, Marque P, Roques CF, et al. Modulation of the transmission in group II heteronymous pathways by tizanidine in spastic hemiplegic patients. J Neurol Neurosurg Psychiat. 2004; 75:130-5.
24. Little JW, Halar EM. H-reflex changes following spinal cord injury. Arch Phys Med Rehabil. 1985; 66: 19-22.
25. Enola RM. Neuromechanical basis of kinesiology. 2nd ed. Champaign: Human Kinetics. 1994. p. 151-91.
26. Leone JA, Kukulka CG. Effects of tendon pressure on alpha motoneuron excitability in patients with stroke. Phys Ther. 1988; 68: 475-80.
27. Belanger AY, Morin S, Pepin P, et al. Manual muscle tapping decreases soleus H-reflex amplitude in control subjects. Physiotherapy Canada. 1989; 41: 192-6.
28. Wolf SL, Minkowitz JA. Topical anesthetics effects on the Achilles tendon and H-reflexes, I: able-bodied subjects. Arch Phys Med Rehabil. 1989; 70: 531-6.
29. Wolf SL, Minkowitz JA. Topical anesthetics effects on the Achilles tendon and H-reflexes, II: stroke patients. Arch Phys Med Rehabil. 1989; 70: 673-7.
30. Frigon A, Carroll TJ, Jones KE, et al. Ankle position and voluntary contraction alter maximal M waves in soleus and tibialis anterior. Muscle Nerve. 2007; 35: 756-66.

31. Vittorio A. Electrical stimulation for modulation of spasticity in hemiplegic and spinal cord injury subjects. Neuromodulation. 2001; 4: 85-92.
32. Abram SE, Asiddao CB, Reynolds AC. increased skin temperature during transcutaneous electrical stimulation. Anesth Analg. 1980; 59: 22-5.
33. Koella WP. Pharmacological aspects of spasticity with special reference to Lioresal. Postgrad Med J. 1972; 48: 13.
34. Joodaki MR, Olyaei GR, Bagheri H. The effects of electrical nerve stimulation of the lower extremity on H-reflex and F-wave parameters. Electromyogr Clin Neurophysiol. 2001; 41(1): 23-8.
35. Lauer RT, Stackouse C, Shewokis PA et al. Assessment of wavelet analysis of gait in children with typical development and cerebral palsy. J Biomech. 2005; 38: 1351-7.
36. Delwaide PJ, Pennisi G. Tizanidine and electrophysiologic analysis of spinal control mechanisms in humans with spasticity. Neurology. 1994; 44(11 suppl 9): S21-S27.
37. Palmeri A, Wiesendanger M. Concomitant depression of locus coeruleus neurons and of flexors reflexes by an α2 adrenergic agonist in rats: a possible mechanism for an α-mediated muscle relaxation. Neuroscience. 1990; 34: 177-87.

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