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Original Research Article

EFFECT OF COMBINING TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION WITH EXERCISE REGIME ON SPASTICITY AND UPPER EXTREMITY FUNCTION FOLLOWING CHRONIC MIDDLE CEREBRAL ARTERY STROKE

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ABSTRACT

Background: Post stoke hemiparesis limit the upper extremity function due to development of spasticity and synergy patterns, therefore rendering the patient impaired in activities of daily living. Transcutaneous electrical nerve stimulation (TENS) has recently been used to reduce spasticity. The purpose of this study was to evaluate the effects of TENS on spasticity and upper extremity function following chronic middle cerebral artery stroke (MCA).

Study design and setting: interventional study conducted on patients from clinical and hospital setting in Ahmedabad.

Methods: A total of 30 patients between the age group of 35-75 years of age. Group A received TENS for 30 minutes in addition to conventional exercise therapy regime where as group B received only exercise therapy regime. The intervention was given for 5 days a week for 4 weeks. The outcome measures were Modified Ashworth scale (MAS) and Fugl Meyer assessment for upper extremity (FMA-UE). The data collected was statistically analysed by using Wilcoxon's signed rank test for within group analysis and Mann Whitney U test for between the group analysis.

Results and conclusion: Group A showed a statically (P <0.05) as well as clinically significant improvement in both the outcome measures. There-fore it was concluded that TENS prove to be effective in reducing spasticity and improving upper extremity function in chronic MCA stroke.

KEY WORDS: Stroke, Spasticity, TENS, Modified Ashworth scale (MAS), Fugl Meyer assessment for upper extremity (FMA-UE).

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INTRODUCTION

Stroke is a leading cause of death worldwide [1-4]. Middle cerebral artery (MCA) is the most common site of occlusion. The most common characteristics of MCA syndrome is contralateral spastic hemiparesis, hemisensory loss affecting more upper extremity and face then lower extremity [5]. It is found that 43% of patients with first ever stroke develop spasticity[6]. The most basic neural circuit contributing to the development of spastic hypertonia is segmental reflex arc. The enhanced reflex response to the muscle stretch is produced by two major mechanisms namely, increased motor neuronal excitability and increased stretch evoked excitatory synaptic excitation of motor neuron [7,8]. TENS is a useful modality for pain relief [9]. TENS when applied for spastic muscles it has been shown that repeated sensory inputs can improve brain plasticity and thereby improving motor control [9]. The other possible mechanisms underlying for the effectiveness can be attributed to presynaptic inhibition of hyperactive stretch reflexes to the spastic muscles, disinhibition of descending voluntary commands to the motor neurons of paretic muscles and decrease in co contraction of spastic antagonists [10,12].

The purpose of this study is to investigate the whether combining electrically induced sensory inputs with conventional physical therapy has an effect on spasticity and upper extremity function in stroke patients.

METHODOLOGY

After obtaining ethical clearance from the institutional ethical committee a total of 30 patients who met the inclusion and exclusion criteria after obtaining an informed consent were included in this study. The subjects were divided into 2 groups , each group consisting of 15 subjects.

Inclusion criteria

1. Patients diagnosed with chronic MCA stroke (after 6 months of onset of stroke).
2. Both males and females
3. Any side of involvement (right or left)
4. Age 35-75 years
5. Spasticity with grade 1+ and above on MAS
6. Patients with Brunnstrom Stage III or above for upper extremity [13].
7. Patient with a good understanding of simple verbal commands

Exclusion criteria

1. Visual and/or auditory impairments
2. Mini mental state examination score <24
3. Unwillingness to participate
4. Any recent surgeries
5. Any active musculoskeletal impairments of upper extremity
6. Perceptual and sensory deficits
7. Any recent surgeries

Patient undergoing electrical stimulation of paretic muscles of upper extremity

Procedure: Patients were allocated to two groups by means of non probability sampling method.

Group A (interventional group): This group consisted of 15 patients who received TENS in addition to conventional exercise therapy regime. A four channelled TENS (Tapsi Sabe model number 200) was used. The parameters for the treatment were a frequency of 100Hz, pulse width of 200 microseconds and a duration of 30 minutes [9]. The electrodes were directly placed on the muscle bellies of spastic biceps, pronators, long wrist and finger flexors. The intensity was set according to patient's tolerance and enough to produce a visible or palpable muscle contraction. The treatment was given for 5 days a week for 4 weeks. The conventional treatment protocol remained same for both the groups.

Figure 1: Application of TENS on the muscle bellies of spastic muscle.

Group B (control group):

During each session emphasis was placed on [5].

· Prolong stretching of spastic muscles with each positioned held for 30 seconds with 3 repetition.

· Strengthening of paretic muscles according to the patient's repetition maximum, with 10 repetition of each movement

· Mat activities and gait training in parallel bars.

The treatment protocol was based individual needs of the patients with emphasis varied according to the nature of patient's impairments.

Outcome measures: The outcome measures were taken at the baseline and at the end of 4 weeks.

· **Modified Ashworth scale [14]:** Spastic hypertonia can be graded on modified ashworth scale a subjective 5 points ordinal scale the scale remains gold standard by which other tests are validated and has shown a good intrarater reliability (0.84) and inter rater reliability (0.83). Testing is conducted with each patient positioned supine on a padded mat table. the patient's elbow from a position of maximal possible flexion to maximal possible extension over a duration of about one second while the forearm was grasped distally (just proximal to the wrist). While the elbow was extended, the arm also was stabilized proximal to the elbow. The forearm was in neutral supination. A similar procedure was carried out for all spastic group of muscles i.e pronators, wrist flexors and long finger flexors.

· **Fugl –Meyer Assesment for upper extremity [15]**: The Fugl-Meyer motor assessment includes items dealing with the shoulder, elbow, forearm, wrist, and hand in the upper extremity .Reflex activity is assessed in the upper and lower extremities at the beginning and end of the motor assessment. Sensation, evaluated by light touch, is examined on two surfaces in both the upper and lower extremities, and position sense (kinesthesia) and range of motion (ROM) are tested on , four in each extremity.

Statistical method: At the end of the data collection there were 3 drop outs from group B, leaving a total of 27 patients in the study. The collected data was analysed by SPSS version 20. Shapiro – wilk test was used to check the normal distribution of data. As the data did not follow normal distribution, Wilcoxon's signed rank test was used for within group analysis and Mann- Whitney U test was used for between the group analysis. P value less than 0.05 is taken as significant level

RESULTS

Table 1: Age and gender distribution for both the groups.

Group	Gender	Age (in years) Mean ± SD
A (interventional)	Male : 11 Female :4	54.53±15.20
B (Control)	Male: 5 Female: 7	55.42±8.24

Table 2: Wilcoxon signed rank test for within group analysis for MAS in Group A.

MAS (GROUPA)	Pre Mean ± SD	Post Mean ± SD	Z	P
BICEPS	1.733±.4169	1.133±.7669	-3.21	0.001
PRONATORS	1.467±.6673	1.000±.7559	-2.49	0.01
WRIST FLEXORS	1.567±.4952	.900±.6036	-3.49	0.0001

Table 3: Wilcoxon signed rank test for within group analysis for MAS in Group B.

MAS (GROUP B)	Pre Mean ± SD	Post Mean±SD	Z	P
BICEPS	2 ±0.63	2.0±0.63	0	0.1
PRONATORS	2.08±0.46	2.0±0.56	-1.41	0.1
WRIST FLEXORS	1.8±0.57	1.6±0.67	-2.23	0.02

Table 4: Between Group Analysis Of Mas Scores For Group A And B.

MAS (MANN WHITNEY)	Z	P
BICEPS	-3.16	0.002
PRONATORS	-3.41	0.001
WRIST FLEXORS	-2.53	0.01

Table 5: Within group analysis for fugl meyer assessment for upper extremity by wilcoxon signed rank test.

FMA-UE	Pre Mean ± SD	Post Mean ± SD	Z	P VALUE
Group A	33.73 ± 6.74	48.80 ±10.18	-3.411	0.001
Group B	24 ± 7.43	26.6±9.48	-2.409	0.016

Table 6: Between group analysis for group A and group B.

FMA-UE (MANN WHITNEY)	Z	P
Group A and B	-3.694	0.0001

DISCUSSION

In this study the interventional group showed a statistically (P<0.05) as well as clinically significant difference. The clinically significant difference was evaluated on the basis of minimal detectable difference (MDD). The minimal detectable difference for MAS is reduction in one grade and for FMA-UE was a change between 4 to 7 points in chronic stroke [16,17].

The possible underlying mechanism can be quoted as follows. In this study the electrodes were directly place on the muscle bellies of biceps, pronators, wrist and finger flexors as these muscles are the strongest components of both the synergies. The possible mechanism for reduction of spasticity as quoted by Manigandan G et al. In their study on Effect of Transcutaneous Electrical Nerve Stimulation over Gastrocnemius Muscle Spasticity among Hemiparetic Patients It has been accepted that the anti-spastic effects of Transcutaneous Electrical Nerve Stimulation, may increases the release of endogenous Gamma Amino Butyric Acid (GABA)and Opiates, by which both act as an inhibitory neurotransmitters, on the dorsal horn of the spinal cord, and this shows the similar achievement on anti-spastic effects as those of baclofen and morphine.[18] Another proposed mechanism for anti spastic effects is due to electrophysiological changes. Which is quoted by Ahmet Karak oyun MD et al**.** In their study on Electrophysiological and clinical evaluation of the effects of transcutaneous electrical nerve stimulation on the spasticity in the hemiplegic stroke patients where TENS significantly reduced spasticity and improved walking speed and the stated underlying mechanisms. On the spastic side, TENS significantly reduced the M amplitude and increased the H reflex amplitude, the H/M maximum amplitude ratio, the H slope, and the H slope/M slope ratio. Also, the mean patient H reflex amplitude, the H/M ratio, the H slope, and the H slope/M slope ratio, decreased significantly, and the H reflex maximum latency increased, after TENS.

The hypothesis justifying the electrophysiological changes is Activating large diameter afferent nerve fibers through TENS may modulate interneuron activities in several spinal segments, which then activate inhibition mechanisms of the presynaptic nerve. An alternative hypothesis is that somatosensory stimulation through TENS due to continuous activation of peripheral nerv fibers causes insensitivity to prolonged central excitation accompanied by lower corticomotor neuron excitability.[19] Also Aydin et al. compared TENS with baclofen, the commonest drug prescribed to treat spasticity in patients with medulla spinalis injuries. Significant improvements in all parameters, except pain, were evident in the TENS group, and they were associated with decreases in the H amplitude and H/M ratio and the M response. The electrophysiological and clinical changes did not differ significantly between the TENS and baclofen group [20].

Another proposed mechanism for reduction in spasticity due to muscle fatigue. The mechanism is explained by Levin MF, et al. in their study on Relief of hemiparetic spasticity. Transcutaneous electrical nerve stimulation (TENS) at two to three times the sensory threshold produces vibrations in stimulated muscles and surrounding regions. Moreover, the rapid stimulation of vibrations triggers primary afferent neurons and increase the release of acetylcholine, a major neurotransmitter in the context of muscle contraction However, prolonged stimulation may reduce muscle contraction by lowering the excitability of homonymous motor neurons by depleting acetylcholine, as occurs during muscle fatigue [10].

This could be a possible mechanism as the stimulation was provided for 30 minutes. Another mechanism is reduced motor neuron excitability leading to reduction in spasticity supported by Goulet et al in 1996 explain that high TENS stimulate low threshold afferent which project to gamma motor neuron and modify their excitability which leads to reduction in spasticity. It seems that alpha and gamma motor neurons are controlled by pathways largely independent of each other. This above explanations could be underlying mechanism of reduction of spasticity [21]. According to previous study on effect of TENS on motor cortex excitability by Tinnazi et.al (2005) reported that excitability was attenuated in cortical areas of TENS stimulated muscles , but elevated in antagonist brain areas [11]. Similarly Tatsuya Mima et al. Conducted a study on Short-term high-frequency transcutaneous electrical nerve stimulation decreases human motor cortex excitability (2004) TENS The novel result presented in the experiment is that the sensory changes are accompanied by a reduction in cortico motor neuronal excitability The decrease in motor evoked potentials.

(MEP) amplitude is likely to be due to reduction in cortical excitability since spinal excitability, was unaffected by TENS The implication of the present results is that TENS transiently reduces the efficacy of excitatory inputs to corticospinal neurons [12]. Improve upper extremity function could be an indirect effect of reduction in spasticity which is supported by similar studies carried out by Hwi-young Cho et.al, conducted A single trial TENS improves spasticity and balance in patients with chronic stroke stated that improvement in postural function observed after application of TENS application are believed to be caused by reduction of spasticity and increased proprioceptive input [22]. Similarly R. Dickstein et al. conducted a study on TENS to the posterior aspect of the legs decreases postural sway during stance where Thirty healthy subjects were tested while standing on a force. A bipolar balanced stimuli, pulse width 200 micro seconds frequency of 100 Hz Two complimentary interpretations can shed light on the observed decrease in postural sway attributable to TENS. The most straightforward explanation is the enhancement of somato sensory information from the legs. Accordingly, the addition of TENS sensory stimulation enhances the natural Somato sensory inflow from the lower limbs, which is relevant for the maintenance and regulation of orthograde posture. The contribution of proprioceptive information from the lower legs, especially from structures near the ankle joint, to upright stance is well substantiated [23].

CONCLUSION

Therefore, the findings of the study conclude that TENS is a useful adjunct mode of intervention for reduction of spasticity and improving upper extremity function.

Limitations

· Long term follow up was not done

· The strength of muscles inhibited by TENS was not measured.

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ABBREVIATIONS

MMSE - Mini Mental State Examination

MCA - Middle Cerebral Artery

TENS - Transcutaneous Electrical Nerve Stimulation

MAS - Modified Ashworth Scale.

Conflicts of interest: None

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