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Effect of Circumferential Pressure Application by Sphygmomanometer on Spasticity and Motor Functions in Patients with Stroke

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ABSTRACT

One of the most common concerns in stroke patients is spasticity resulting in functional limitations such as hand dexterity, gait and balance disorders. Hence, this study was aimed to examine the effects of conventional physiotherapy versus circumferential pressure on spasticity, balance, hand dexterity and gait parameters. 28 subjects with stroke were recruited in the study and they were divided in two equal groups; namely interventional and conventional therapy groups. Standard sphygmomanometer (BP) cuff was tied around wrist flexors and inflated to 70-80 mm Hg for 5 min and then a rest pause was given for a min. This process was repeated two more times. The same was repeated for plantar flexors of the affected limb. Spasticity, balance, hand dexterity and gait were assessed using Modified Ashworth Scale (MAS) and Triple Spasticity Scale (TSS), Berg Balance Scale (BBS), Chedoke Arm and Hand Activity Inventory (CAHAI) and Dynamic Gait Index (DGI) respectively pre and post 4 weeks of intervention. On intra-group comparison in interventional group; MAS and TSS scores of both wrist and plantar flexors, DGI, BBS and CAHAI scores showed significant improvement. However, values of DGI, BBS and CAHAI were more significant in interventional than in conventional group. Significant improvement was seen on inter group comparison in spasticity of plantar flexors in MAS and TSS scores along with DGI and BBS scores. Thus, the present study provides good evidence of anti spastic effect of circumferential pressure by sphygmomanometer on wrist and plantar flexors and also its positive effect on motor functions like gait, balance and hand dexterity in patients with stroke.

key words: Sphygmomanometer, pressure, spasticity, functions, Triple Spasticity Scale.

INTRODUCTION

Stroke (Cerebrovascular accident [CVA]) is defined as rapidly developing clinical signs of focal disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin.[1, 2] Cumulative incidence of stroke in different parts of India ranged from 105 to 152/1, 00,000 persons per year during 2015-2016.[3] The most common type affecting more than 80% of the population with stroke is ischemic stroke and other being hemorrhagic stroke. The former occurs when a clot blocks or impairs the blood flow while the latter when blood vessels rupture, causing leakage of blood in or around the brain eventually causing the brain tissues to be deprived of essential oxygen and nutrients.[2]

Impairments of sensory, motor, cognitive, perceptual and language functions are observed post trauma to the central nervous system.[2] Motor deficits are characterized by paralysis (hemiplegia) or weakness (hemiparesis) typically on the side of the body opposite to the side of the lesion. The 'upper motor neuron syndrome'

can be defined by positive and negative signs. Spasticity characterized by a velocity-dependent increase in the excitability of tonic and phasic muscle stretch reflexes is a component of the positive signs. Extent of spasticity is generally been assessed clinically through physical examinations using measures such as Modified Ashworth Scale (MAS).

Wissel et al. (2010) found that 25% of patients with stroke suffer from spasticity within the first 6 weeks of the event.[4] They also observed that spasticity primarily affects the elbow (79% of patients), the wrist (66%) and the ankle (66%), elbow and wrist being affected more than the ankle. Lowering muscle tone is often desirable before and during therapy to increase range of motion, and to improve movement and posture.[5] Physical cost of spasticity is paramount as mobility limitations and limb impairments reduce their engagement in daily activities.[6] Patients with spasticity struggle with mobility, function and transfer issues, hand functions primarily is more affected than gait and balance post stroke. Mobility impairments eventually leads to possible falls & gait instability. Limitations in hand function has been observed to be a priority concern as it increases the level of dependence.

The effects of different treatments on muscle spasticity such as stretching[7], weight bearing[8], joint positioning[9], electrical stimulation[10], oral medications[11], shock wave therapy[12], ultrasound therapy[13], cryotherapy[14], vibration[15] have been extensively studied.

Deep pressure is proprioceptive inhibitory techniques used as per Rood's approach. It is proven to reduce motor neuron excitability in central nervous system disorder patient. Manual pressure applied to the tendinous insertion of a muscle or across long tendons produces an inhibitory effect. It is stated that Pacinian corpuscle is responsible for the inhibition of muscle.[16] The Golgi tendon organ may also play a role in this response. Circumferential pressure is a type of deep pressure given by encompassing the whole circumference of a limb exerting a constant pressure throughout its circumference. This type of pressure exerts a constant stimulus to peripheral receptors (muscle and cutaneous) of both agonist and antagonist musculature which produces a longer lasting H-reflex inhibition than with other types of administration of pressure such as massage[17], continuous[18], or intermittent tendon pressure.[19] Similarly, circumferential pressure has been shown to be comfortable, non-invasive, easy and effective in decreasing alpha motor neuron excitability/ muscle activity in patients following CVA.[20]Agostinucci et al[21, 22] stated that pneumatic pressure applied through air splints were found to be useful in reducing the excitability of spinal motor neurons after the stroke. A study conducted by Robichaud et al[23] showed that circumferential pressure applied with air splints decreased alpha motor neuron excitability among patients with spinal cord injury. But this effect lasted only as long as the pressure was applied.

To our knowledge, there is dearth in literature supporting application of circumferential pressure for spasticity.[24, 20] Moreover, the studies that have been conducted conclude only temporary reduction in tone after application of pressure.[24, 20] Further paucity in literature is seen to assess activity limitations and functional improvement post treatment.[20] Thus, need arises to determine whether there is an effect of circumferential pressure on spasticity and functional outcomes post intervention of circumferential pressure.

MATERIALS & METHODOLOGY

Following materials were used in the study; standard sphygmomanometer, stethoscope, two standard chairs (one with arm rests, one without), plinth, straps, goniometer, ruler, foot stool or stepper, stopwatch, Chedoke McMaster assessment kit which included; a box (shoebox), cones (2), stairs, pen and paper.

Study was commenced following approval by Institutional Ethics Review

Committee of MGM College of Physiotherapy. 6 different physiotherapy rehabilitation centres of Mumbai and Navi Mumbai were approached out of which 2 showed interest. Permission was taken from the head of those physiotherapy rehabilitation centres to implement the intervention in their respective centers. This was an interventional study with convenient sampling with sample population being stroke patients who were recruited on basis of the following inclusion criteria; patients diagnosed with stroke on computed tomography (CT) or magnetic resonance imaging (MRI) with onset of stroke for more than 6 weeks, both male and females of 30-70 years, increased muscle tone of the affected upper limb wrist flexors and affected lower limb gastro-soleus [MAS $\geq$ 1, TSS $\geq$ 2/3], voluntary control of affected upper, lower limb, ankle and hand $\geq$ 1, intact pressure sensation on the affected extremities. Participants with MMSE score < 23, receiving relaxant medications, fixed contractures of affected elbow, wrist or knee, any visual/ hearing problems, peripheral nerve injury, peripheral vascular disease of the affected side, any other neurological problem like head injury, cerebral palsy, multiple sclerosis and spinal cord injury or uncontrolled cardiovascular or neurological condition were excluded. Participants were explained about the procedure and written informed consent was signed in the language best understood by the patient. Group A: underwent conventional physiotherapy along with circumferential pressure by sphygmomanometer (Experimental group, ET). Group B: underwent only conventional physiotherapy (Conventional group, CT).

Outcome Measures

Basic demographic details were taken and various parameters like spasticity, balance, hand dexterity and gait parameters were assessed before and after 4 weeks of intervention.

Spasticity was assessed using Modified Ashworth Scale (MAS) [2] and Triple Spasticity Scale (TSS) [25].

Modified Ashworth Scale- When performing the stretch of the wrist flexors, the assessor kept the subject's arm in a neutral position. When performing the stretch of the plantar flexors, the assessor kept the subject's knee extended and controlled inversion of their ankle.

Triple Spasticity Scale includes 3 subsections- Increased resistance is graded in subsection 1. Clonus is scored in subsection 2. In subsection 3, dynamic muscle length, also known as angle difference is measured. Rotate the joint first at a slow through its full range of motion (R2). Then move the joint as rapidly as possible in the same direction and through the same arc, and the angle of muscle reaction is recorded as R1. Dynamic muscle length is the angle difference between R1 and R2 (R1–R2). Subjects were scored from 0-10, with 10 representing the maximum spasticity.

Hand dexterity was assessed using the Chedoke Arm and Hand Activity Inventory (CAHAI Version-8).[26] This scale consisted of 8 different components involving various hand activities where all activities have been performed with both hands consecutively and the lowest of both the scores were taken. Each component was graded on a 7-point scale, total score being out of 56. Here, higher the score indicating more the independence.

Balance was assessed using the Berg Balance Scale. This scale consisted of 14 components. Each component was graded on a 5-point scale (0-4) depending on amount of assistance, time taken and quality of performance.

Gait was assessed using the Dynamic Gait Index.[27] This scale consists of 8 components. Each component was graded on a 4-point scale (0-3) depending on amount of assistance, amount of imbalance observed, time taken and quality of performance.

Intervention

After initial assessment, treatment was started according to the following protocol:

Group A (ET):-

Patient was made to lie supine for 10 min to relax and Blood pressure (BP) was measured at the end of 10 minutes. Experiment was terminated if the diastolic BP was less than 50 mm of Hg. Patient was made to sit on a chair/ lie down in supine with affected foot tied with a BP cuff around calf 3 cm below knee joint line/maximum bulk. BP cuff was inflated to a range of 70-80 mm Hg [23] for 5 min and then a rest pause for a min. The process was repeated two more times 5 min each with a rest pause of 1 min. Patient will be made to sit on a chair with affected hand on arm rest at 30º elbow flexion. The affected hand was tied with a BP cuff around forearm 3 cm below elbow joint line/maximum bulk of forearm. BP cuff was inflated to a range of 70-80 mm Hg [24] for 5 min and then a rest pause of a min. Process was repeated two more times 5 min each with a rest pause of a min. Subjects were given conventional physiotherapy along with the above mentioned interventional therapy.

Group B (CT):- Conventional physiotherapy:

1. Sustained Stretching of all spastic muscles-3 sets with 30 seconds hold.
2. Antigravity/ Weight bearing postures such as kneeling and quadruped as tolerated by patient with necessary assistance.
3. Reach outs with unaffected hand in weight bearing in sitting and quadruped.
4. PNF pattern of B/L upper and lower extremity.
5. Strengthening of weak antagonist with manual resistance.
6. Peg board activities.
7. Grasp and release practice with a small ball (sponge).
8. Bridging with holds.
9. Balance training with perturbations.
10. Tandem standing, 1 leg standing, sit to stand, forward walking, backward walking, lunges.

Both the groups received treatment for a period of 4 weeks every alternate day. i.e. 15 sessions. At the end of 15 sessions, post assessment of all outcome measures were carried out.

Statistical Analysis

The data obtained was compared, coded, tabulated and analyzed and data entry was done using Statistical Package for the Social Sciences Version 16 (SPSS). Normality of the data was analyzed using the Shapiro- Wilk test. The data was found to be a distribution free. So intra group comparison was done using Wilcoxon test and inter group comparison was done using Mann-Whitney U test. $p - value \leq 0.05$ was considered to be statistically significant.

RESULTS

The total study population comprised 82% males (n=23) and 18% females (n=5). The mean age of the study population was 53.39 ± 8.67 years. Among the 28 stroke patients, 61% had hemorrhagic stroke (n=17) and 39% had ischemic stroke (n=11). Average time post stroke was 39.86 months. (25.29 months in group A and 54.43 months in group B).

Our results showed significant improvement in MAS of wrist flexors (p-value=0.025) and plantar flexors (p-value=0.046) and TSS scores of both wrist flexors (p-value=0.008) and plantar flexors (p-value=0.002) along with significant improvement seen in VCA of hand (p-value=0.008), DGI (p-value=0.001), BBS (p-value=0.001) and CAHAI (p-value=0.011) scores on within group analysis of the ET group. Also, within group analysis of outcomes in CT group revealed significant changes in TSS scores of wrist flexors (p-value=0.046), DGI (p-value=0.026), BBS (p-value=0.005) and CAHAI (p-value=0.026) scores. Inter group comparison showed significant changes in outcomes such as spasticity of plantar flexors in MAS (p-value=0.014) and TSS (p-value=0.007) scores, voluntary control of hand (p-value=0.014). Also, significant improvement was seen in gait and balance using DGI (p-value=0.028) and BBS (p-value=0.004) scores respectively.

Table 1: Intra group comparison

Outcome Measures	ET Pre (Mean ± SD)	ET Post (Mean ± SD)	P-Value	CT Pre (Mean ± SD)	CT Post (Mean ± SD)	P-Value
MAS WF	2.5*	2*	0.025	2.5*	2.5*	0.157
MAS PF	1.5*	1*	0.008	2*	2*	0.317
TSS WF	3.43±1.65	3.14±1.46	0.046	3.86±1.41	3.57 ± 1.55	0.046
TSS PF	2.93±1.54	2.21±1.67	0.002	2.93±1.44	2.71 ± 1.49	0.179
VCA H	3*	3.5*	0.008	2*	2*	0.317
DGI	16±4	18.21±3.56	0.001	13.86±15	14.93 ±16	0.026
BBS	41.86±9.57	47.14±8.66	0.001	37.79±45	39.86 ±47	0.005
CAHAI	17.43±11.61	19.5±13.10	0.011	12.93±8	14.29 ±9.5	0.026

***denotes median values**

Table 2: Inter group comparison

Outcome Measures	ET(Mean ± SD)	CT(Mean ± SD)	P-Value
MAS PF	0.5*	0*	0.014
TSS PF	0.71 ± 0.47	0.21 ± 0.58	0.007
VCA H	0.5*	0*	0.014
DGI	2.21 ± 1.42	1.07 ± 1.54	0.028
BBS	5.29 ± 2.79	2 ± 2	0.004

*** denotes median values**

DISCUSSION

This study was conducted to assess the efficacy of circumferential pressure application using sphygmomanometer as an intervention with that of conventional physiotherapy on spasticity of wrist flexors and plantar flexors and motor functions like hand dexterity, gait and balance in patients with stroke.

In our study we found a significant change in DGI, BBS and CAHAI scores in both the groups on intra group comparison. This improvement in both the groups can be attributed to the conventional therapy involving antigravity weight bearing activities, exercises for postural strategies, static and dynamic balance locomotor training & task oriented upper limb function. However, improvement was more significant in ET group as seen by change in mean values which could be due to the additional circumferential pressure intervention effect.

Additionally, there was significant change seen in median values of MAS, TSS scores of wrist and plantar flexors & voluntary control of hand in ET group on intra-group comparison. The reduction in tone that was observed could be due to manual pressure applied to tendinous insertion of a muscle or across long tendons producing an inhibitory effect on the pacinian corpuscles and golgi body that regulate muscle tone. [16]. Also, this type of pressure is assumed to exert a constant stimuli to peripheral receptors (muscle and cutaneous) of both agonist and antagonist musculature which in turn produces a longer lasting H-reflex inhibition than with other types of administration of pressure such as massage[17], continuous [18], or intermittent tendon pressure.[19] Pressure application additionally decreases the excitability of tactile receptors which slow a rapid adaptation to the stimuli thereby increasing the sensorial input.[24] Spasticity reduction seen in ET group can also be attributed to Tonic Pressure Reflex (TPR) which states that multiple continuous pressure stimuli initially produces intense contraction of spastic muscles (TPR) followed by relaxation of the same.[28,29] Golgi tendon organ have also been suggested to be a possible factor for the reflex inhibition by autogenic inhibition.[30, 31]

Our findings were supported by Kauser Sheeba et al. [24] who found that direct application of pressure through sphygmomanometer showed significant improvement in MAS scores. Also, Agostinucci [20] stated in his study that constant stimuli to peripheral receptors of both agonist and antagonist through circumferential pressure produces a longer lasting H-reflex inhibition and reduction in spasticity in flexor carpi radialis and soleus muscles. [17, 18, 19,30, 32, 33]

Further, VCA of hand showed significant improvement in ET group as circumferential pressure was applied to wrist flexors in addition to conventional therapy. Wrist flexors being long finger flexors are primarily responsible for dextrous activity and as well as voluntary control of hand. It is claimed that circumferential pressure causes autogenic inhibition which is ensured by the activation of Golgi tendon organs that eventually results in increased stability facilitating motor development and facilitating the normal motion patterns.[24] Also, hand function and fine finger dexterity training given as a part of conventional training could have had an additive effect on voluntary control.

There was mild to no change seen in the spasticity level of the CT group as assessed by MAS and TSS scores as only conventional therapy was given wherein treatment mainly included stretching, anti-gravity exercises and Rood's inhibitory techniques.

There was a significant change seen in mean difference values of BBS, DGI on intergroup comparison. The significance being attributed to the difference in its pre and post mean values showing a higher difference than the other outcome measures. It is said that there is a direct relationship between the level of spasticity and activity limitation of a patient. Spasticity seems to interferes with motor control processes involved in mobility and postural control. Hence, reduction in spasticity of plantar flexors indirectly improves the mobility of ankle joint and postural control which directly improves gait and balance. [31] As there was a significant decrease in spasticity levels of plantar flexors, we could see an improvement in DGI and BBS scores.

In this study we found spasticity scores improving in both wrist and plantar flexors, however, the post intervention scores were higher in plantar flexors than wrist flexors. Additionally, since all participants included in this study were ambulatory pre intervention, their lower limbs were more functional than upper limbs and hence more improvement was observed in balance and gait parameters as compared to hand dexterity outcome.

There were certain limitations in this study. Appropriate techniques to maintain efficacy of circumferential pressure at home was not considered and advised. Psychological factors such as fear and anxiety towards the treatment should have been assessed and taken into consideration because it could have an effect on the results. There is a future scope to conduct a longitudinal to assess long term effects of circumferential pressure.

This study supports the use of circumferential pressure by sphygmomanometer as a therapeutic modality in the treatment of lowering spasticity of wrist and plantar flexors and for improving motor functions like balance, gait and hand dexterity, thus being a cost efficient substitute of pneumatic splints. Hence, circumferential pressure can be used in conjunction with other therapeutic techniques to ensure effective outcomes.

CONCLUSION

The present study provides good evidence of anti spastic effect of circumferential pressure by sphygmomanometer on wrist flexors and plantar flexors and its positive effect on motor functions like gait, balance and hand dexterity in patients with stroke.

Abbreviations:

MAS WF: Modified Ashworth Scale Wrist Flexors
TSS WF: Triple Spasticity Scale Wrist Flexors
MAS PF: Modified Ashworth Scale Plantar Flexors
TSS PF: Triple Spasticity Scale Plantar Flexors
VCA H: Voluntary Control Assessment Hand

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