Efficacy of Radial Shock Wave Therapy on Spasticity in Stroke Patients

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Abstract

Background: Spasticity is a neurological symptom frequently appearing in stroke patients which hindering patients' ability for daily living and affecting the quality of life of patients. Recently extracorporeal shock wave therapy (ESWT) has been suggested as a non-invasive, alternative treatment for spasticity.

Purpose: The purpose of the study was to investigate the efficacy of radial ESWT on upper limb spasticity in stroke patients.

Materials and Methods: Thirty male patients, with upper limb spasticity post stroke participated in this study with a mean age of (52.25±6.3) years. They were assigned randomly into two equal groups. Group (A) received the traditional physical therapy treatment plus placebo radial ESWT. Group (B) received the traditional physical therapy treatment plus true radial ESWT. Spasticity of wrist and fingers was evaluated using Modified Ashworth Scale (MAS), Range of Motion (ROM) of the wrist was evaluated using digital goniometer and pain was measured by Visual Analogue Scale (VAS).

Results: There were a significant decreased in MAS scores in both finger flexors (from 3.2±0.5 to 1.4±0.4) and wrist flexors (from 3.4±0.4 to 2.1±0.6), also there were a significant changes in VAS scores (from 5.79±0.8 to 2.63±0.6) and ROM (from 51.4 ±4.8 to 75.7±5.5) after true ESWT stimulation, where no significant changes were noted after placebo ESWT stimulation (P>0.05).

Conclusion: Radial shock wave therapy is a promising therapeutic tool that could be used safely to reduce spasticity of the wrist and fingers flexors on stroke patients at low energy level.

Keywords: Radial shock wave, spasticity, stroke.

Introduction

Spasticity, which is a component of the upper motor neuron syndrome, is a neurological symptom frequently appearing in stroke patients and is defined as a velocity dependent increase in muscle tone with exaggerated tendon reflexes[1]. It has been reported that spasticity appears in approximately 35% of stroke patients. Spasticity should be appropriately treated because it inhibits normal movements and causes pain or postural abnormality, thereby hindering patients' ability for daily living and affecting the quality of life of patients [2].

The existing treatment methods to control spasticity include physical therapy, oral anti-spasticity drugs, chemical nerve block and motor point block using phenol or ethyl alcohol and botulinum toxin injection[3]. The necessity of new noninvasive treatment methods for spasticity has been raised because spasticity cannot be controlled sometimes even with diverse treatment methods as well as due to the existing side effects of oral drugs and the invasiveness of local treatment methods[4].

Extracorporeal shock wave therapy (ESWT) is a new technology using a ballistic source to generate pressure waves[5]. It has been used in diverse musculoskeletal diseases, such as plantar fasciitis[6], patellar tendinopathy[7], and calcifying and non-calcific tendonitis of the shoulder[8, 9]. Recently ESWT has been suggested as a non-invasive, alternative treatment for spasticity [4, 5, 10, 11].

Different types of ESWT modalities either radial ESWT[12] or focused ESWT[13,14] has been used in treatment of spasticity. Radial ESWT compared with conventional focused ESWT, is a low- to medium-energy shock wave generated when a projectile is accelerated by compressed air (1–5bar) with a low penetration power (less than 5 cm)[15]. Radial ESWT was recommended over focused ESWT for treating of musculoskeletal disease due to its better effectiveness in clinical practice, no anesthesia or analgesics required and lower cost of the unit[16].

Within the available literature, there are only few studies with no clear settled parameters investigated the effect of ESWT on spasticity. Therefore, the purpose of this study was intended to investigate the efficacy of radial ESWT on upper limb spasticity in stroke patients.

Materials and Methods

Subjects

Thirty male patients, with upper limb spasticity post stroke were recruited for the study from the neurological outpatient clinics of Cairo University hospitals and National Institute of Neuromotor System Cairo Egypt, their age were ranged from (45–65) years. Patients were randomly assigned into two equal groups. Eligible patients had to be at least three months post stroke and had spasticity of the wrist flexor and fingers flexors exceeding 1+ on the Modified Ashworth Scale (MAS)[4,17], first episode of unilateral stroke with hemiparesis, ability to understand instructions and medically stable.

Localization of the lesion was proved by Computed Topography (CT) and/or magnetic resonance imaging (MRI). Patients with prior or planned treatment of the upper limb with any botulinum toxin serotype or with phenol, alcohol, or surgery or had any contraindications for ESWT were excluded. A written consent form was obtained from all patients before participation.

Instrumentations

Radial Shock Wave Therapy

Intellects® RPW Shockwave by Chattanooga Corporation was used to deliver stimulation to the spastic muscle. It has the following technical specifications, compressed air output (1.4-5) bars, frequency (0.5-21 Hz), pulses or shots (10–10,000), size of applicator 15 mm and penetration depth (0-50 mm). It has unique optimal energy level adjustment feature that allows gradual ramping of the intensity during treatment which provide inherent safety as demonstrated by the manufactures guidelines. The safety also supported by many physical therapist practitioners in the field[12,15,16].

Digital Goniometer

It was used to evaluate the passive range of motion (ROM) of wrist. The digital goniometer has adequate concurrent criterion-related validity as a tool for assessment of joint ROM and equivalent inter- and intra-rater reliability to the universal goniometer [18].

Visual Analogue Scale

Visual Analogue Scale (VAS) was used to assess pain intensity. It consists of a 10-cm straight line anchored at one end by a label such as "no pain" and at the other end by a label such as "the worst pain imaginable". It was reported as valid and reliable tool for pain assessment [19-21].

Modified Ashworth Scale

Modified Ashworth Scale from 0 to 4 (0= No increase in muscle tone to 4= Affected part(s) rigid in flexion or extension) was used to assess spasticity. It was reported as valid and reliable tool for assessment of spasticity [22-25].

Procedure

The aims and procedure of the study was explained to each patient before participation.

Evaluative procedure

- Subjects' ages were recorded and their weight and height were measured
- Spasticity of wrist and fingers was evaluated pre and post treatment using MAS. For convenience in the statistical analysis, MAS 1+ was substituted by 2, and 2, 3, and 4 were substituted by 3, 4, and 5, respectively [4].
- Passive Range of Motion of the wrist was evaluated pre and post treatment by measuring the angles of the maximum flexion and the maximum extension and summing up the angles using digital goniometer [4].
- Pain was measured during passive ROM evaluation of the wrist in extension pre and post treatment by VAS. The patient

was instructed to simply mark the line to indicate pain intensity and the provider then measures the length of the line to the mark on the scale.

Treatment procedure

- Subjects in group (A) received the traditional physical therapy treatment which consists of (range of motion exercise and passive stretching exercise) plus placebo radial ESWT.
- Subjects in group (B) received the traditional physical therapy treatment plus true radial ESWT which consists of (0.23 mJ/mm^2 (2.5 bar), 1500 shots were used to treat flexor muscles of the forearm, and 3200 shots for palmar interosseus muscles of the hand (800for each muscle) at 8 Hz). For both groups ESWT was given one session per week for five weeks.

Statistical Analysis

Descriptive statistics including the mean and standard deviation was used to describe general characteristics of subjects. Paired t test was used to determine significant differences within each group while unpaired t test was used to determine significant differences between groups. The P-value < 0.05 was taken as significant.

Results

Subjects characteristics of both groups presented in table (1). There were no significant differences between both groups regarding age, body mass index (BMI) and mean duration after stroke onset (P>0.05).

Table (1): Subjects characteristics in both groups (A and B)

General Characteristics	Group (A)	Group (B)	Comparison	
	Value	Value	P-value	Significance
Age (year) [Mean±SD]	51.83 ± 6.80	52.72 ±5.90	0.70	NS
Body Mass Index (BMI) [Mean±SD]	27.41 ± 3.92	28.12 ± 4.35	0.64	NS
Mean duration after stroke onset (month)	14.6 ± 9.21	12.2± 8.12	0.45	NS
Stroke subtype (n (%))				
Ischemic	6 (40.0)	5 (33.3)	-----	-----
Hemorrhagic	9 (60.0)	10 (66.6)	-----	-----

±: standard deviation, P: probability, NS: non-significant.

There were no significant changes in the MAS were noted in either finger or wrist flexors after placebo radial ESWT stimulation, also there were no significant changes in VAS scores and ROM for group (A) as (P>0.05). But there were significant decreased in MAS scores were noted in both finger flexors (from 3.2±0.5 to 1.4±0.4) and wrist flexors (from 3.4±0.4 to 2.1±0.6) after

true radial ESWT stimulation, also there were a significant decreased in VAS scores (from 5.79±0.8 to 2.63±0.6) and increased in ROM (from 51.4 ±4.8 to 75.7±5.5) for group (B) as shown in table (2).

Table (2): Comparisons between mean value of both groups pre and post treatment

Parameters	Pre-Treatment				Post-Treatment		
	Group (A)	Group (B)	P-value	S	Group (A)	Group (B)	P-value
Ashworth wrist flexors	3.3±0.6	3.4±0.4	0.59	NS	3.0±0.5	2.1±0.6	0.0001*
Ashworth finger flexors	3.1± 0.5	3.2±0.5	0.58	NS	2.8±0.4	1.4±0.4	0.0001 *
Range of motion (°)	52.1±6.3	51.4±4.8	0.73	NS	55.9±4.5	75.7±5.5	0.0001*
Pain intensity (VAS)	5.81±0.9	5.79±0.8	0.94	NS	5.1±0.7	2.63±0.6	0.0001*

±: standard deviation, P: probability, NS: None significant ***:** Statistically significant

Discussion

The purpose of this study was to investigate the efficacy of radial ESWT on upper limb spasticity in stroke patients. The results of our study showed that there were a significant decreased in spasticity, increased ROM and decreased level of pain following stimulation with true radial ESWT.

These findings were in agreement with Yoo et al. (2008), Bae et al. (2010), Kim et al., (2013) and Moon et al. (2013) who showed that lower limb spasticity significantly improved immediately after the ESWT treatment for total 3 sessions. The investigators suggested that the effect produced by ESWT depends on the mechanisms of shock wave generation, energy per unit area and the number of application. [4]

Our study also supported that, radial ESWT at low energy level is a non-invasive therapy for spasticity and are in accordance with Chang et al. (2012) and Vidala et al. (2011) who evaluate the efficacy and safety of radial extracorporeal shock wave therapy in the treatment of spasticity in patients with cerebral palsy and concluded that, shock wave therapy, being a non-invasive therapy may be an interesting alternative in the treatment of spasticity[12,16].

The mechanism of how ESWT relieves spasticity has not yet been clearly determined however suggested variable mechanisms have been proposed, including;

1- Induce nitric oxide (NO) synthesis which involved in the formation of neuromuscular junctions in the peripheral nervous system and play important roles in neurotransmission,

memories, and synaptic plasticity in the central nervous system[26,27]. Neuromuscular transmission was hindered by ESWT in neuromuscular junctions [28].

2- Shock waves would directly act on the golgi tendon organ to suppress motor nerve excitability [10].
3- Stimulation effect of mechanical vibrations [29].
4- Decreasing the stiffness of connective tissue by directly acting on the fibrosis of chronic hypertonic muscles [14].
5- Localized ischemia in the areas of abnormal shortening of the muscles could improve, in turn inhibiting an increase in metabolism, reducing secretion of various pain inducing substances, inhibiting the induction of pain due to excessive stimulation of nociceptors of muscles, and increase the ROM [30].
6- The effect of ESWT on spinal cord excitability can be excluded as the main mechanism because no significant changes occurred in F-wave minimal latency, H-reflex latency, or H-M ratio after ESWT [31].

Conclusion

Radial ESWT at low energy level could be used safely to reduce spasticity of the wrist and fingers flexors on stroke patients. Repetitive or cyclic application of radial ESWT should also be considered to maintain the reduced spasticity. However further studies are needed to compare different treatment protocols and energy levels to determine which one has a greater anti-spastic effect.

Conflict of interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Source of funding

This research received no specific grant from any funding agency in the public, commercial, or not / for profit sectors.

Ethical clearance

We certify that this study involving human subjects is in accordance with Helsinky declaration of 1975 as revised in 2000 and it has been approved by the relevant ethical committee

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References

1. Langhorne P, Bernhardt J, Kwakkel G: “Stroke rehabilitation,” The Lance. 2011; 377: 1693–1702.

2. Mori F, Koch G, Foti C, Bernardi G, Centonze D: The use of repetitive transcranial magnetic stimulation for the treatment of spasticity. Prog Brain Res 2009; 175:429-39.

3. Stevenson VL: Rehabilitation in practice: spasticity management. Clin Rehabil 2010; 24:293-304.

4. Moon SW, Kim JH, Jung MJ, et. al.,: The effect of extracorporeal shock wave therapy on lower limb spasticity in subacute stroke patients. Ann Rehabil Med 2013; 37(4):461-470.

5. Sohn MK, Cho KH, Kim YJ, Hwang SL.: Spasticity and electrophysiologic changes after extracorporeal shock wave therapy on gastrocnemius. Ann Rehabil Med 2011; 35:599-604.

6. Aqil AM, Muhammad R.S, Siddiqui MR, et.al.,: Extracorporeal shock wave therapy is effective in treating chronic plantar fasciitis: A Meta-analysis of RCTs. Clin Orthop Relat Res. 2013;471:3645–3652.

7. Zwerver J, Verhagen E, Hartgens F, et. al.,: Effectiveness of extracorporeal shockwave therapy in jumping athletes with patellar tendinopathy. Design of a randomized controlled trial. BMC Musculoskeletal Disorders. 2010; 11:28-36.

8. Galasso O, Amelio E, Riccelli DA, Gasparini G: Short-term outcomes of extracorporeal shock wave therapy for the treatment of chronic non-calcific tendinopathy of the supraspinatus: a double-blind, randomized, placebo-controlled trial. BMC Musculoskeletal Disorders. 2012, 13:86.

9. Ioppolo F, Tattoli M, Di Sante L,et. al.,: Extracorporeal shock wave therapy for supraspinatus calcifying tendinitis: A randomized clinical trial comparing two different energy levels. PHYS THER. 2012; 92:1376-1385.

10. Bae H, Lee JM, Lee KH.: The effects of extracorporeal shock wave therapy on spasticity in chronic stroke patients. J Korean Acad Rehabil Med 2010; 34:663-669.

11. Price D, McGrath P, Rafii A, Buckingham B: The validity of the visual analogue scale as ratio scale for chronic and experimental pain. 1983:17: 45-56.

12. Bohannon RW, Smith MB: Interrater reliability of a modified Ashworth scale of muscle spasticity. Physical Therapy. 1987: 67 (2): 206-207.

13. Yoo SD, Kim HS, Jung PK.: The effect of shock wave therapy on upper limb spasticity in the patients with stroke. J Korean Acad Rehabil Med 2008; 32:406-410.

14. Vidal X, Morral A, Costa L, Tur M.: Radial extracorporeal shock wave therapy in the treatment of spasticity in cerebral palsy: a randomized, placebo-controlled clinical trial. NeuroRehabil 2011; 29: 413-419.

15. Amelio E, Manganotti P.: Effect of shock wave stimulation on hypertonic plantar flexor muscles in patients with cerebral palsy: a placebo-controlled study. J Rehabil Med 2010; 42: 339-343.

16. Manganotti P, Amelio E.: Long-term effect of shock wave therapy on upper limb hypertonia in patients affected by stroke. Stroke 2005; 36: 1967-1971.

17. Cleveland RO, Chitnis PV, McClure SR.: Acoustic field of a ballistic shockwave therapy device," Ultrasound in Medicine and Biology.2007; 33(8): 1327–1335.

18. Chang KV, Chen SY, Chen WS, Tu YK, Chien KL.: Comparative effectiveness of focused shock wave therapy of different intensity levels and radial shock wave therapy for treating plantar fasciitis: a systematic review and network meta-analysis. Arch Phys Med Rehabil 2012; 93: 1259-1268.

19. Kim YW, Shin JC, Yoon JG, Kim Y, Lee SC: Usefulness of radial extracorporeal shock wave therapy for the spasticity of the subscapularis in patients with stroke: a pilot study. Chin Med J 2013; 126 (24):4638-4643.

20. Carey MA, Laird DE, Murray KA, Stevenson JR.: Reliability, validity, and clinical usability of a digital goniometer. Journal of Prevention, Assessment and Rehabilitation. 2010; 36(1): 55-66.

21. Li D, Puntillo K, Miaskowski C: A review of objective pain measures for use with critical care adult patients unable to self-report. Journal of Pain 2008; 9 (1): 2-10.

22. Breivik H, Borchgrevink PC, Allen SM, Rosseland LA Romundstad L, Breivik Hals

EK, varstein GK, Stubhaug A: Assessment of pain. British Journal of Anesthesia 2008; 101 (1):17–24.

23. Allison SC, Abraham LD: Sensitivity of qualitative and quantitative spasticity measures to clinical treatment with Cryotherapy. International Journal of Rehabilitation Research. 2001: 24 (1): 15-24.

24. Gregson JM, Leathley M, Moore AP, Sharma AK, Smith TL, Watkins CL: Reliability of the Tone Assessment Scale and the Modified Ashworth Scale as clinical tools for assessing post stroke spasticity. Archives of Physical Medicine and Rehabilitation. 1999:80 (9): 1013-1016.
25. Pandyan AD, Price CI, Barnes MP, Johnson GR: 2003. A biomechanical investigation into the validity of the modified Ashworth scale as a measure of elbow spasticity. Clinical Rehabilitation. 2003:17 (3); 290-294.

26. Mariotto S, de Prati AC, Cavalieri E, Amelio E, Marlinghaus E, Suzuki H.: Extracorporeal shock wave therapy in inflammatory diseases: molecular mechanism that triggers anti-inflammatory action. Curr Med Chem 2009; 16:2366-72.

27. Mariotto S, Menegazzi M, Suzuki H.: Biochemical aspects of nitric oxide. Curr Pharm Des 2004; 10:1627-1645.
28. Kenmoku T, Ochiai N, Ohtori S, Saisu T, Sasho T, Nakagawa K, et al.: Degeneration and recovery of the neuromuscular junction after application of extracorporeal shock wave therapy. J Orthop Res 2012; 30:1660-1665.

29. Leone JA, Kukulka CG.: Effects of tendon pressure on alpha motor neuron excitability in patients with stroke. Phys Ther 1988; 68: 475-480.
30. Jeon JH, Jung YJ, Lee JY, Choi JS, Mun JH, Park WY, et al.: The effect of extracorporeal shock wave therapy on myofascial pain syndrome. Ann Rehabil Med 2012; 36: 665-674.

31. Sohn MK, Cho KH, Kim YJ, Hwang SL.: Spasticity and electrophysiologic changes after extracorporeal shock wave therapy on gastrocnemius. Ann Rehabil Med 2011; 35:599-604.

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