Impact of Extracorporeal Shock Wave Therapy on Spastic Hand Function with Assistive Devices in Children with Cerebral Palsy

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Abstract

Background: The spastic cerebral palsy is considered the most common of cerebral palsy types. Spasticity of upper limbs is major problem in children that affected on hand function during grasping and through using assistive devices as walker and canes. Shock wave treatment on spastic muscles of upper limbs in stroke patients performed a significant decrease in muscle tone. The aim of current study was to determine the impact of extracorporeal shock wave therapy (ESWT) on spastic muscle of hand in children with spastic cerebral palsy.

Methods: Thirty twohemiplegic spastic cerebral palsy patients from both sexes were recruited in this study. The children were divided randomly into two groups equal in number; Group І (control) consisted of 16 children (7 boys and 9 girls) with mean±standard deviation age of 6.68±2.63 years received exercises program only (3 sessions/week for two months, Group ІІ (experimental) included (10 boys and 6 girls) with mean±standard deviation age of 6.37±1.44 years received the same exercises program in addition to sessions by extracorporeal shock wave therapy (BTL-6000WT) with energy flux (0.003mJ/mm²), frequency (10Hz) and (one session/week) for 8 weeks. The two groups were evaluated before and after therapy by Modified Ashworth Scale (MAS) and Modified House function Classification (MHC).

Results: The results showed a statistically significant improvement in spasticity and hand function post treatment.

Conclusion: We concluded that the ESWT is effective in decreasing spasticity (muscle tone) of upper extremities and enhancing hand function for patients with spastic cerebral palsy to help those children become independent and participate in different daily activities as grasping of walker or canes.

Keywords: Cerebral Palsy, Spasticity, Shock Wave Therapy, Hand Function, Assistive Devices.

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Introduction

Cerebral Palsy (CP) is referring to upper motor neuron syndromes secondary to a wide range of acquired and genetic disturbances of early development of brain (1). The propagation of cerebral palsy was reported to be between (1.86 cases per 1000 children) in the United Kingdom and (3.6 cases per 1000 in 8-year-old patients) in the United States with mild difference among Western nations. Recently, the analysis of 49 studies showed that the prevalence of cerebral palsy was 2.11 cases per 1000 live birth. The rates of cerebral palsy in China and India were (2 to 2.8 cases per 1000 births) (2-4). More disturbances accompanied the motor disturbances of CP such as cognition, sensation, perception, communication and/or behavior, and/or seizure disorders (5). Spasticity is a disturbance of the sensorimotor system, characterized by an increase in muscle tone (tonic stretch reflexes) and increase in
tendon jerks exaggeration, because of hyperexcitability of stretch reflex. In addition, spasticity is considered an upper motor neuron lesion\(^6\). The disorders of central nervous system (CNS) with dysfunction of upper motor neuron often result in spasticity and hypertonia in the extremities that is dependent both on range of motion and velocity. CP is the most common cause for spasticity in children\(^8\)\(^-\)\(^10\). Moreover, the most frequent spasticity that involves the upper limbs is the elbow flexors, wrist pronators, fingers, shoulder adductors and thumb flexors and in the lower limbs are the knee extensor, hip adductor, ankle plantar flexor and inverters perhaps have raised of spastic tone\(^9\). There are several causes to manage spasticity in patients with CP; reduction of pain and spasms of muscles, reduce contractures of muscle and deformity, facilitate brace use, improve posture, facilitate of mobility and dexterity, and refinement children's ease of care and hygiene\(^4\). There are a variety of options for the management of spasticity including anti-spasticity medications, intrathecal baclofen, phenol and ethanol injections, administration of botulinum toxin, physical rehabilitation modalities and surgery\(^1\)\(^1\)\(^1\)\(^1\)\(^4\). Recently, some studies reported effects of extracorporeal shock wave therapy (ESWT) on spasticity in patients with cerebral palsy\(^2\)\(^,\)\(^6\)\(^,\)\(^12\)\(^,\)\(^13\). ESWT is considered as a noninvasive, safe, effective and practical method to decrease spasticity. The definition of shock wave is as a sequence of single sonic pulses distinguished by high peak pressure (more than 100MPa), rapid pressure increase (<10ns), for short duration (10µs) and is transferred via an appropriate generator for a specific target area with energy flux density 0.03mJ/mm\(^2\)\(^1\)\(^4\). Furthermore,\(^1\)\(^2\) showed along lasting decrease of hypertonia after shock wave therapy for patients with stroke (≥9 months) in comparison with placebo. Assessment was performed by using the National Institutes of Health & Ashworth scale (AS) & video monitoring with a digital goniometer & the last follow up was performed at 12 weeks post-therapy. On the other hand,\(^2\) investigated the impact of radial extracorporeal shock wave therapy (rESWT) on spasticity in plantar flexion muscle and gross motor function (GMFM-88) for very young children with cerebral palsy CP. The patients were evaluated for 3 months 1 session of rESWT per week. The results revealed that the mixture of rESWT and rehabilitation conservation therapy more effective than traditional conservation only. Also,\(^6\) compared the effect of ESWT that applied on the muscle belly or myotendinous junction that suffered from spasticity in upper and lower extremities in chronic stroke patients. The results revealed that the ESWT could be effective for therapy of chronic spasticity after stroke when applied to the muscle belly or myotendinous junction.

Materials and Methods

**Subjects:** The study was conducted in Al-Imam al-Sadiq hospital, Babylon and Al-Kadhmia private hospital from the period of December 2018 to March 2019. All of their parents gave written consent to take part in this study. Thirty two children with hemiplegic spastic cerebral palsy (17 males and 15 females) with age ranged between (5-15) years, divided randomly into two groups; control group with mean age of 6.68±2.63 years and experimental group with mean age of 6.37±1.44 years. All groups were equal in number and met the same criteria of inclusion and exclusion.

**Inclusion criteria:** Children included in current study did
(a) Provide written informed consent by their parents,
(b) Have an age between 5-15 years,
(c) Have a mild to moderate degree of spasticity in wrist and elbow flexors, from (+1 to 3) to Modified Ashworth Scales\(^1\)\(^5\).
(d) Be able to sit alone and (e) have a sufficient cognition to allow them to perform simple verbal commands and instructions through assessment and management.

**Exclusion criteria:** children were excluded from this study when they (a) have fixed contracture defined as severe restriction of the range motion for joint passive stretch, (b) have deformities in the upper limbs, (c) are taking any oral antispastic or muscle relaxant drugs, (d) received previous management by botulinum toxin injection, alcohol or phenol for upper limbs administrated within 2 weeks before first assessment or during study, (e) had previous any surgical intervention in upper limbs and (f) have auditory defect or visual defect or autistic.

**Materials**
Modified Ashworth Scale (MAS): was used for assessment of scale of spasticity in wrist and elbow flexors. The Modified Ashworth Scale (MAS) includes a 6-point, criterion-referenced ordinal scale designed to measure the resistance that is encountered during passive movement of the limb. Scores ranged from 0 (no increase in muscle tone) to 4 (rigid).

Modified House Functional Classification System (MHC): The house scale was used to evaluate upper extremity and hand functions of children aged between 2-20 years. The house scale includes a nine-point scale (0 to 8) of descriptors that range from does not use (0) scale to active spontaneous use (8) scale. Because of lack of details refining these categories, the Modified House Classification was used. A modified House Classification that includes rating scales has been developed.

Shock wave device: An electromagnetic coil lithotripter (BTL-6000 SWT, with pressure up to 4 bars and frequency up to 15Hz).

Methods

Evaluation procedure

All children were evaluated before (pre-treatment) and after (post treatment) treatment two months by the same examiner who was blinded regarding the two groups. The degree of spasticity for both groups was evaluated according to Modified Ashworth Scale MAS, for wrist and elbow flexors. The degree that involved in this study from mild to moderate (+1 to 3). To accommodate the (+1) degree, it was modified for purpose of numeric analysis and was recorded as (1.5).

Modified House Functional Classification System (MHC) was used for evaluating the upper extremity and hand functions of children such as grasping and hand manipulation. The degrees involved were between (5-7) degrees.

Treatment procedures

Both groups underwent routine rehabilitation programs, including occupational therapy and physical therapy. Also, all children in this study received a one-hour session, 3 times/week for successive 2 months. This program involved manual passive stretching exercises for wrist and elbow flexor muscles, weight bearing exercises for the hand, strengthening exercises for antispastic muscles (wrist and elbow extensors) by using different toys and motivation to encourage children of CP to perform the different desired exercises, standing and balance exercises as well as exercises and training for using walker and parallel devices. Exercises lead to facilitating of hand skill patterns as grasping, carry and release of objects, reaching and etc.

Shock wave therapy: ESWT consisted of one session per week for 2 months, by using BTL-6000 SWT; the energy flux applied was 0.03mJ/mm² and frequency of 10Hz. The shock waves were focused on the flexor spastic muscles in the forearm and on the interosseus muscles in the hand; 2000 shots were used for forearm in flexor muscles mainly in the middle of the belly and 3200 shots were used to hand in interosseus muscles (each muscle receive 800 shots). During treatment, different points were used to treat several areas in muscles with hypertonic. The procedure was not painful and without anesthesia was needed because low energy was used. The ESWT was performed especially over intrinsic muscles of hands, over the flexor radials and the flexor ulnaris.

Statistical Analysis

Measurement data were analyzed by using SPSS. Median and (mean± standard deviation) were used for presenting patients' ages, Modified Ashworth Scale degrees MAS, Modified House Classification...
System MHCS. To express the differences between and within groups of the pre- and post-therapy values were assessed by using Mann Whitney Test (net difference between pre- & post-treatment and for comparison between groups).

**Study design:** randomize clinical trial.

## Results

### Clinical data

In this study, 16 children control group were included with a mean±standard deviation age of 6.68±2.63 years and median age of 5.7 years, all children received therapeutic exercises only. On the other side, 16 children experimental group (hemiplegic spastic cerebral palsy) with mean±standard deviation age of 6.37±1.44 years and median age of 6 years, all children received therapeutic exercises in addition sessions of ESWT.

Table (1) characteristics of the two groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age range</td>
<td>5-15(6.68±2.63) years</td>
<td>5-9(6.37±1.44) years</td>
</tr>
<tr>
<td>Sex</td>
<td>Seven boys and nine girls</td>
<td>Ten boys and six girls</td>
</tr>
</tbody>
</table>

### Spasticity

By comparison of pre- and post-treatment, (MAS) Modified Ashworth Scales scores for (experimental) group showed good significant reduction in spasticity of elbow \((P=0.00)\), wrist \((P=0.00)\). Comparison of pre- and post-therapy (MAS) of control group revealed no significant reduction in spasticity of elbow & wrist \((P=0.029)\), \((P=0.026)\), respectively. Comparison between two groups revealed a significant difference in spasticity scores (MAS) in elbow \((P=0.000)\) & wrist \((P=0.001)\).

Table (2) Mann Whitney test of comparison between net differences between the two groups

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Mean</th>
<th>Standard error</th>
<th>Median</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAS (elbow)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
<td>0.4062</td>
<td>.06799</td>
<td>0.5</td>
<td>0.000</td>
</tr>
<tr>
<td>Experimental</td>
<td>16</td>
<td>1.2812</td>
<td>0.16437</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>1.2812</td>
<td>0.16437</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>MAS (wrist)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
<td>0.3750</td>
<td>0.07217</td>
<td>0.5</td>
<td>0.001</td>
</tr>
<tr>
<td>Experimental</td>
<td>16</td>
<td>0.9375</td>
<td>0.11968</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>0.9375</td>
<td>0.11968</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Figure (1) Median MAS-elbow-diff for control and experimental groups.

Figure (2) Median MAS-wrist-diff for control and experimental groups.
Hand Function

The Modified House Function Classification (MHC) was used to evaluate the hand function for children. Comparison between pre- & post-therapy values showed a significant improvement in (experimental) group \((P=0.000)\) and not significant improvement in (control) group \((P=0.128)\). Comparison between the two groups revealed a significant difference in MHC \((P=0.001)\).

Table (3) Mann Whitney test for comparing MHC between net differences of the two groups

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Mean</th>
<th>Standard error</th>
<th>Median</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>16</td>
<td>0.5625</td>
<td>0.12809</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>16</td>
<td>1.5000</td>
<td>0.15811</td>
<td>1</td>
<td>0.001</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>1.0625</td>
<td>0.14407</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Discussion

The aim of our study was to identify the effect of ESWT on the mechanical properties of muscles and motor skills for upper limbs (hand) in children with spastic CP. Spasticity is one of the symptoms in children with spastic CP especially in upper extremities; it causes difficulty in hand function during daily activities such as grasping objects during walking or balance by using assistive devices such as walker, wheelchair and canes.

Spasticity

In our study the results of MAS showed significant difference between the two groups (experimental and control), and showed a decreased muscle tone or MAS, but the greater improvement was in the experimental group.
Our results were in agreement with (19) who studied the effect of rSWT on muscle spasticity in children with cerebral palsy and found a significant reduction in muscle tone of plantar flexor muscles in children with spastic CP. Also, our results were in agreement with (12) whom considered the first who studied the benefit of shock wave therapy in children with spastic CP and they found lasting reduction in spasticity of muscle. Our results showed that elbow flexor and wrist extensor muscles spasticity was decreased significantly after 8 weeks in children with spastic CP in experimental group, where the median MAS of elbow decreased (from 2.5 to 1) and the mean±standard deviation from (2.34±0.7 to 1.17±0.38) and median MAS of wrist from (2 to 1) and the mean from (1.96±0.46 to 1.18±0.25).

The mechanism of ESWT is unknown. In vivo studies on rats suggested that SWT has an effect on neuromuscular junction causing degeneration and reduction in number of acetylcholine receptors which plays a role in causing a significant decrease in the maximum compound muscle action potential (20, 21).

Previous studies showed the mechanism of ESWT as the effect on the generation of Nitric Oxide (NO) (15). The effect of ESWT might have enzymatic and non-enzymatic effects on synthesis of (NO) (22,23).

ESWT stimulates the synthesis of Nitric Oxide which plays an important role in increasing flow of blood, vasodilatation, neoangiogenesis and regulation of inflammation in diseases of musculoskeletal system (plantar fasciitis, calcific tendonitis and myofascial pain syndrome) (24-26).

**Hand function**

In our study the MHC scales showed improvement in both groups, but the greater was in the experimental group using ESWT in addition to exercises. According to (13) who studied effect of extracorporeal shock wave therapy (ESWT) in children with spastic cerebral palsy. The results of this study showed a reduction in MAS with almost 1 degree and noticed a significant difference in GMFM-66 scales which raised more 10 points in the study group of children with ESWT. Our results similar to this study, where showed a good significant difference in MHC scales between control and experimental groups, the MHC showed greater improvement in experimental group than control group ($P<0.001$). Spasticity is the major cause that leads to changes in the structure of muscle by increasing muscle fibrosis and contractures of soft tissue. ESWT might be a suitable and noninvasive method for reducing the spastic muscles (26, 27). Also the ESWT may improve the stiffness of connective tissue and spastic muscle fibrosis (6, 28). The mechanism of ESWT in improvement PROM remains unknown. Spasticity has two components biomechanical and neural. The biomechanical component is concerned with stiffness of muscle, it is affected by titin and collagen content in the muscle with spastic. The guessed mechanism of spasticity reduction instantaneous after a single session of ESWT may be related to change in the physical properties of muscle (thixotrophy), such as breaking the links between myosin and actin. The interaction between actin-titin can produce reduction in intrinsic stiffness of connective tissue in muscles with chronic hypertonic as a result of mechanical vibration (13,29,30). Our results showed that the ESWT produced a more significant improvement in MHC score in experimental group comparing with control group, and the hand functions of children were improved through hand skills as grasping of assistive devices such as walker, wheelchair or canes.

**Conclusions**

I could concluded that the ESWT is more effective in treatment of muscles spasticity than conventional method by using exercises only and improved hand function and skills of children’s upper limbs. In addition, all that helps the children become more independent and participate in daily activities through using assistive device as wheelchair or walker and canes.
Ethical Clearance

The Research Ethical Committee at scientific research by ethical approval of both environmental and health and higher education and scientific research ministries in Iraq

Conflict of Interest

The authors declare that they have no conflict of interest

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