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Rehabilitation treatment of spastic cerebral palsy with radial extracorporeal shock wave therapy and rehabilitation therapy

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Abstract

This aims to investigate the effect of combined use of radial extracorporeal shock wave therapy (rESWT) and conventional rehabilitation therapy on postoperative rehabilitation of children with spastic cerebral palsy.

Children with spastic cerebral palsy 6 weeks after multistage surgery were randomly divided into treatment group (received rESWT and conventional rehabilitation therapy) and control group (received conventional rehabilitation only). Before treatment, 2 weeks and 1 month after treatment, the Gross Motor Function Measure (GMFM), modified Ashworth Scale (MAS) of the hamstrings and triceps, plantar area and plantar pressure were examined for efficacy assessment.

A total of 82 children with spastic cerebral palsy were recruited, including 43 children in treatment group and 39 children in control group. There was no significant difference in the age, MAS score, and GMFM score between the 2 groups before treatment. There were statistically significant differences between the 2 groups at 2 weeks and 4 weeks after treatment, including the MAS score, GMFM score, plantar area and plantar pressure ($P < .05$). Within groups, there were also significant differences at different times ($P < .05$).

The rESWT combined with rehabilitation can quickly and effectively relieve paralysis of lower extremities, reduce the tension of hamstrings and calf muscles, relieve muscle spasm, and rapidly improve limb function in children with spastic cerebral palsy.

Abbreviations: GMFM = Gross Motor Function Measure, MAS = Modified Ashworth Scale, rESWT = radial extracorporeal shock wave therapy.

Keywords: cerebral palsy, extracorporeal shock wave, rehabilitation, spasm

1. Introduction

Cerebral palsy is caused by congenital developmental defects (malformations and intrauterine infections), or acquired non-progressive brain damages (preterm birth, low birth weight, asphyxia, hypoxic-ischemic encephalopathy, nuclear jaundice, trauma, infection, etc.).[1–3] The prevalence rate is about 2.0 to 3.5 per 1000 births.[4] The clinical symptoms are mainly dyskinesia with or without sensory and mental deficits.[5] The brain pathological changes in cerebral palsy are mainly white matter damage, abnormal brain development, intracerebral hemorrhage, and brain damage caused by brain hypoxia.[6]

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At present, it reported that cerebral palsy ranks third in basic living support needs and ranks fifth in the causes of disability, causing serious inconveniences and economic losses to families and individuals.[7] With proper treatment, the function and quality of life of children with cerebral palsy can be considerably improved.[8] The current treatment methods for relieving muscle spasms include exercise therapy, physical therapy, and traditional rehabilitation therapy.[9,10] The application of botulinum toxin, surgery, and brace is also a good way to relieve muscle spasms.[11,12] However, a single treatment does not guarantee absolute effectiveness. Therefore, rehabilitation requires comprehensive treatment, and parents and rehabilitation workers are still looking forward to finding more treatments that can effectively relieve muscle spasms.

Radial extracorporeal shock wave therapy (rESWT) has been widely used in cerebral palsy rehabilitation in recent years.[13] It is safe, non-invasive and painless.[14] It is reported that rESWT can relieve muscle spasm.[15,16] However, in China, the studies on the role of rESWT in children with cerebral palsy are still lacking.

In this study, radial extracorporeal shock wave combined with routine rehabilitation therapy was applied to children with disabilities who met the diagnostic criteria for spastic cerebral palsy. The results of the study were systematically analyzed to provide evidence for the comprehensive treatment of spastic cerebral palsy in children.

2. Materials and methods

2.1. Patients

Shandong Provincial Third Hospital is a designated hospital for correction of physical disabilities in Shandong Province since

Table 1

Patients' characteristics.

Groups	n	Age (years)	MAS before treatment		GMFM before treatment
			Hamstring	Triceps	
Treatment group	43	7.5±1.3	4.56±0.77	4.49±0.39	54.72±10.33
Control group	39	7.9±1.7	4.72±0.59	4.68±0.53	55.67±9.36
T value		1.2033	1.0481	1.8605	0.4348
P		.2324	.2978	.0665	.6649

GMFM=Gross Motor Function Measure, MAS=Modified Ashworth Scale.

April 2008. This is a prospective randomized controlled study. During the period from October 2014 to December 2017, 82 children with spastic cerebral palsy (6 weeks after multistage surgery) in our hospital were recruited. Patients were randomly assigned to the treatment group (n=43) and the control group (n=39) according to the random number method. The patient characteristics of the treatment group and the control group are shown in Table 1.

Patients were included if they

1. were 6- to 12-year-old children with spastic cerebral palsy;
2. received multi-stage surgical strategy in our hospital for 6 weeks after lower extremity lysis operation (including hip adductor muscle lysis, hamstring lysis, and Achilles tendon contracture-releasing surgery), and were able to participate in shock wave and routine rehabilitation.

Patients were excluded if they had severe organic dysfunction or severe psychosocial disorders affecting rehabilitation. Prior written and informed consent was obtained from the patients' family and the study was approved by the ethics review board of Shandong Provincial Third Hospital.

2.2. Treatments

Both groups underwent routine rehabilitation, including physiotherapy, occupational therapy, speech therapy, and orthotic treatment. The treatment group was also treated with rESWT. The rESWT was performed with MasterPlus MP100 (Storz Medical, Switzerland) according to the previously reported protocol.[17] Briefly, the children were in a prone position. Couplants were evenly applied to the ventral skin of the triceps and hamstring muscles. The probe was placed close to the abdominal muscles to give shock, avoiding major blood vessels and nerves. The treatment probe diameter was 15 mm, impact pressure intensity was 2.0 bar, impact frequency was 10 Hz, and the number of impacts was 2000 times. The probe was centered around the leg tricep hamstring and hamstring muscle belly with a radius of 2.5 cm. The treatment was performed once a week, each time for 10 min, and continued for 4 weeks.

2.3. Evaluation

The patients were evaluated before treatment, 2 weeks and 1 month after treatment.

The Modified Ashworth Scale (MAS) was used to assess the degree of muscle spasm in the hamstring and calf muscles. MAS was divided into Level 0, Level 1, Level 1 plus, Level 2, Level 3, and Level 4, scored as 0 points, 1 point, 1.5 points, 2 points, 3 points, and 4 points, respectively. The higher the level, the severer the degree of spasm.

Gross Motor Function Measure (GMFM) (88 items), which mainly assesses the function of standing, walking, and jumping of children, has 5 levels.[18] The standing function has a total score of 39 points, and the walking and jumping function has a total score of 72 points. The scoring method for each indicator: inability of motor function as 0 point, completion rate less than 10% as 1 point, completion rate between 10% to 99% as 2 points, and full completion as 3 points.[18]

Plantar support area and plantar pressure were measured using a footscan plantar pressure detection system to determine the plantar support area and plantar pressure.

2.4. Statistical analysis

SPSS 17.0 software was used for statistical analysis. Measurement data were expressed as mean±standard deviation. The t and χ^2 test were used for group comparisons. $P<.05$ was considered statistically significant.

3. Results

3.1. Baseline characteristics

The baseline characteristics were compared between the 2 groups. As shown in Table 1, there were no significant differences between the 2 groups, including in MAS and GMFM scores before treatment.

3.2. Efficacy of rESWT combined with routine rehabilitation

After treatment for 2 weeks and 1 month, the MAS scores of hamstring and triceps decreased significantly in the treatment and control groups compared with those before treatment ($P<.05$) (Table 2). And, the MAS scores of hamstring and triceps decreased significantly in the treatment group were significantly lower than those in the control group at 2 weeks and 1 month after treatment

Table 2

The MAS comparison of hamstring and triceps between control and treatment groups.

Groups		MAS score Before treatment	2 weeks after treatment	1 month after treatment
Treatment group	Hamstring	4.56±0.77	2.73±0.57*,†	2.26±0.71*,†
	Triceps	4.49±0.39	2.66±0.34*,†	2.20±0.33*,†
Control group	Hamstring	4.72±0.59	3.39±0.51	2.96±0.85
	Triceps	4.68±0.53	3.41±0.54	3.01±0.61

MAS=Modified Ashworth Scale.
* $P<.05$, Compared with control.
† $P<.05$, Compared with before treatment.

Table 3

The foot area comparison of control and treatment groups.

	Plantar area (cm^2)		
	Before treatment	2 weeks after treatment	1 month after treatment
Treatment group	50.43±6.82	60.98±5.96*,†	66.27±5.71*,†
Control group	50.88±6.73	54.34±6.01	56.77±5.85

* $P<.05$, Compared with control.
† $P<.05$, Compared with before treatment.

($P<.05$) (Table 2). After treatment for 2 weeks and 1 month in both groups, the plantar area (Table 3), plantar pressure (Table 4) and the GMFM scores (Table 5) were significantly increased compared with those before treatment ($P<.05$). And the values of each time period were higher than those of the control group ($P<.05$).

4. Discussion

Cerebral palsy is a type of early-onset disease characterized by chronic, non-progressive motor dysfunction or postural disorders.[19] Cerebral palsy is a complex disorder with significant variations in clinical manifestations, severity, and functional status in different patients.[20] The most common motor dysfunction in cerebral palsy is spasm, which is characterized by increased muscle tone and traction hyperreflexia.[21] In spastic cerebral palsy, simultaneous antagonistic muscle contraction and joint contracture are common.[22]

The main types of cerebral palsy are:

1. spastic cerebral palsy (60%–70%): featured by increased muscle tone, increased tendon reflexes, ankle clonus, knee claudication, and pathological signs[21];
2. Involuntary motor type of cerebral palsy: characterized by involuntary, uncontrolled, recurring, and occasionally stereotyped movements, mainly in the original reflex pattern and muscle tension changes[23];
3. Ataxia-type cerebral palsy: muscle coordination is weak, and movement presents as abnormal power and rhythm.[23]

The natural history of cerebral palsy is gradually worsening. If no intervention is taken, changes in gait and function are not conducive. Eventually, muscle contracture, joint stiffness, gait instability, bone deformity, scoliosis, subluxation or dislocation of the hip joint, torso deformity of the long bone, or malformation of the foot may occur.[24]

The most common ankle problem in patients with cerebral palsy is spastic Achilles tendon contracture and hamstring contracture.[13] Most experts in cerebral palsy suggest that surgery can be postponed until school age.[25] It is also necessary to avoid multiple lower limb surgeries during the rapid growth and development period of sick children, and to promote the development of motor function through comprehensive treatment of surgery and rehabilitation.[26] When assessing whether children with cerebral palsy need surgery, an overall assessment of the child by pediatricians, physicians, and rehabilitators is critical.[27]

Table 4

The foot pressure comparison of control and treatment groups.

	Plantar pressure (N/cm^2)		
	Before treatment	2 weeks after treatment	1 month after treatment
Treatment group	78.26±7.82	84.54±6.96*,†	88.67±7.71*,†
Control group	79.30±7.73	80.82±7.01	82.63±8.49

* $P<.05$, Compared with control.
† $P<.05$, Compared with before treatment.

Table 5

The GMFM comparison of control and treatment groups.

	GMFM (N/cm^2)		
	Before treatment	2 weeks after treatment	1 month after treatment
Treatment group	54.72±10.33	73.6±12.1*,†	75.9±6.6*,†
Control group	55.67±9.36	62.7±9.8	66.2±10.3

GMFM=Gross Motor Function Measure.
* $P<.05$, Compared with control.
† $P<.05$, Compared with before treatment.

Rehabilitation treatment for patients with cerebral palsy focuses on restoring range of joint activity, restoring muscle strength, and improving function.[28] If the lower extremity undergoes multiple surgeries, it will take longer time to restore preoperative strength and function.[29] In this study, both the control group and the treatment group were treated with systemic rehabilitation. Patients of both groups underwent hip adductor muscle lysis, hamstring lysis, and Achilles tendon contracture releasing surgery. Rehabilitation after adductor tendon cutting is similar to rehabilitation after hip adductor muscle lysis, which focuses on early activities and early ambulation activities, including gait training, joint activity training, and postural training to maintain a new muscle length. Recovery to preoperative rehabilitation may be possible.

The rESWT is applied to cerebral palsy rehabilitation treatment for the following aspects:

1 shock wave can relieve pain through producing super-strong stimulation on nerve ending, reducing nerve sensitivity, causing changes in free radicals around cells and release of inhibitory substances, and changing the threshold of pain[30];

2 shock wave can promote healing of the affected tendons, ligaments and its surrounding tissues, through increasing blood supply and inducing growth factors and stem cells into the tissues[31];

3 shock waves also have rehabilitation effect.[16] It greatly improves the metabolism of the treatment area, attenuates the calcification of the affected area, and reduces the inflammatory response and edema of the affected area.[32]

Additionally, the rESWT has mechanical effect, cavitation effect, and thermal effect. It could promote tissue damage repair and reconstruction and release tissue adhesion,[33] thus improving muscle spasm, and promoting the recovery of limb function.[34–36]

Shock wave has been used primarily to improve the biomechanical properties of damaged skeletal muscle in adults.[32] In theory, low-frequency vibrations help reduce muscle tone, and high-frequency vibrations increase muscle tone.[37] Low-intensity vibration can effectively improve the movement range of spastic cerebral palsy patients, maintain or increase their stretch ability.[4] Studies[38,39] have shown that rESWT can promote osteogenesis and muscle growth and prevent patients from bone loss and muscle depletion in both adults and children. In addition, a study[40] conducted on a group of patients with cerebral palsy showed that the patient's pace, step length, and ankle joint activity range were significantly improved. In this study, a 5-year-old child with spastic cerebral palsy received rESWT. The lower limb paralysis was relieved, and the preplanned botulinum toxin injection was canceled. The low limb function of this child was significantly improved.

Our study found that rESWT significantly reduced the muscle tension of the triceps and hamstrings of the calf, increased joint activity, and improved the plantar area and plantar pressure as well as the activity of the lower limb. And, the therapeutic effect increased over time. Our results are consistent with previous reports.[13,41] For example, Amelio et al[13] found that rESWT reduced the muscle tension of the triceps brachii muscle and improved the balance ability. Vidal et al[41] also showed that rESWT reduced muscle tension and this effect could last for at least 2 months.

The study has some limitations. First, there were no long-term follow-up data. Second, the effect of rESWT alone was not investigated in this study. Further studies are needed.

In conclusion, rESWT combined with rehabilitation can quickly and effectively relieve paralysis of lower extremities, reduce the tension of hamstrings and calf muscles, relieve muscle spasm, and rapidly improve limb function in children with spastic cerebral palsy.

Author contributions

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