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Extracorporeal Shock Wave Therapy Decreased Spasticity in Stroke

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Abstract

This study investigates effects of extracorporeal shock wave therapy (ESWT) on decreased spasticity in stroke in rats. 20 eight-week-old Sprague-Dawley rats were used and randomly divided into two groups: an experimental group, a control group. The experimental group received ESWT after the stroke. The Dartfish software was used to determine the effect of the stroke on functional changes. In the evaluation of the knee and ankle angle in the initial contact of the control and ESWT groups showed statistically significant deference. Application of ESWT reduced spasticity.

Keywords: *ESWT, Knee, Ankle*

1. Introduction

ICH sometimes develops voluntarily from continued chronic high blood pressure or secondarily develops due to cerebrovascular disease. Once ICH develops, blood accumulates inside the brain and destroys the central nerve system (CNS). Primary brain damage occurs as pressure around the hemorrhage drastically increases. Secondary damage follows due to the change of brain parenchyma, including blood–brain barrier destruction, inflammation, and edema [1].

Like other adult diseases, ICH currently exhibits a decreasing incidence age and an increasing incidence rate. Hence, interest in methods for the prevention of ICH and therapy after its incidence is increasing. Recently, diverse therapeutic intervention methods have been introduced that are aimed at the recovery of symptoms due to ICH, including medicinal treatment, operative treatment, and physical therapy. However, the conditions of patients vary according to their neurologic injury, and the progress of the disease differs because it is influenced by environmental factors. Hence, finding efficient rehabilitation therapy methods for ICH patients is difficult [2].

However, controlling the effects of therapy overlapped following the rehabilitation therapy of patients with stroke was difficult in most of the previous studies. The effects of therapy are difficult to generalize because differences existed in the flux density, the number

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and frequency of shock waves applied for treating walking impairment, and the occurrence time among patients with stroke. Moreover, most studies used spasticity evaluation using the MAS, pain evaluation, and the passive range of motion. As such, evaluation of the lower limb joint angle, stance phase time, and stride length during functional activities such as walking, and histologic evaluation have rarely been conducted.

This study examined the effects of applying ESWT to the affected side gastrocnemius muscle of stroke rats. The knee and ankle joint angles of the affected side at initial contact were assessed.

2. Subject and methods

2.1. Experimental animals

In this study, 20 eight-week-old Sprague-Dawley origin male white rats weighing 250–300g were tested. The experimental treatment was executed after a five-day adaptation period for the rats to become accustomed to the breeding environment. During the experimental period, solid feed (Cargill Agri Purina Inc., Seongnam, Korea) and water were freely supplied to the rats.

The total number of rats (n=20) was equally divided between the experimental group (n=10) and the control group (n=10) using the random classification method. The experimental group received ESWT after ICH injury (n=10). The control group did not receive therapeutic intervention after ICH injury (n=10).

2.2. Experimental surgery

For general anesthesia, Zoletil (Virbac Laboratories) and Rompun (Bayer Korea) were mixed in a 1:1 ratio and injected inside the visceral cavity of the rats (2 mL/kg). After the rat was anesthetized, a stereotaxic frame was affixed on the rat, and a hole was made 3.5 mm left of the bregma using a dental drill. A syringe (Hamilton Instruments) containing 1.0 μL of saline and 0.12 U of collagenase was affixed on the stereotaxic frame.

The contents of the syringe were injected at a depth of 7.00 mm from the brain surface over a period of five minutes. Subsequently, the needle was carefully removed, and the wound was sutured with stitching fiber. All surgical procedures and experimental protocols followed Daegu University's guidelines and were approved by the Institution of Animal Care and Use Committee (IACUC).

Initial evaluation on the affected side knee and ankle joint angles was conducted two days after initiation of the ICH. Post-evaluation was conducted after 30 days to examine the effects according to the experimental intervention.

2.3. Extracorporeal shock wave therapy

For ESWT, a magnetic-type ESWT device (HAEMIL, Soltar, Korea) was used and it was applied to the gastrocnemius muscle of the affected side hind limb with low intensity using the PAD5 head. After sterilizing with 70% alcohol before the therapy and applying an ultrasound gel to the contact area for preventing damage to the surrounding tissue and contact with the machine, ESWT was applied 1000 times with a frequency of 3 Hz and an energy flux density of 0.09 mJ/mm^2

2.4. Spasticity assessment

In this study, the Dartfish program was used to evaluate the locomotion of the rats. For evaluation of locomotion, the hind limb of each experimental animal was sheared after disinfection with 70% alcohol and lateral epicondyle of the knee, lateral malleolus of the ankle and the metatarsophalangeal joint of the little toe of the left paw were marked with a black dot before photographing a video. The image was videotaped while the subject moved inside a transparent tunnel (100 cm length, 8 cm width, and 10 cm height).

A darkroom was fabricated at the end of the tunnel to induce forward movement of the experiment animal. Rats first moved inside the tunnel three times to ascertain the direction of the tunnel. Afterward, a video was taped for each experimental animal three consecutive times. A 60 Hz digital video camera was used to obtain the image from a 1 m distance from the tunnel on the sagittal plane.

2.4. Statistical analysis

The results obtained from each experiment were reported as mean ± standard deviation (mean±SD). Paired t-test was used to examine the within-group changes in knee and ankle joint angles. The independent t-test was conducted to examine the between-group differences of the effects before and after the intervention. SPSS version 20.0 was used for data analysis, and the statistical significance level was set at 0.05.

3. Result

In the within-group comparison of knee and ankle joint angle during the initial contact before and after the intervention, both the control group and the experiment group showed statistically significantly decreased knee and ankle joint angles ($p<0.05$).

There was a significant difference between control group and experiment group in the change of knee and ankle joint angle during the initial stance phase after the intervention ($p<0.05$). The experimental group that received ESWT showed a statistically significantly smaller change in knee and ankle joint angles during the initial contact compared to the control group ($p<0.05$) (fig 1,2).

4. Discussion

Gait is a fundamental factor in human life, and patients with central nerve injury, such as damage to the descending motor pathway, have difficulties walking independently. After stroke, patients show asymmetrical sensorimotor cortex activity due to diminished activity of the affected side hemisphere during walking and excessive excitability of the corticospine. Because of these reasons, the gait of patients with stroke is limited in walking quality due to occurrence of a number of defects, including decrease of the affected side stride length, stance phase time, cadence, and gait speed, as well as an increase of spasticity [3].

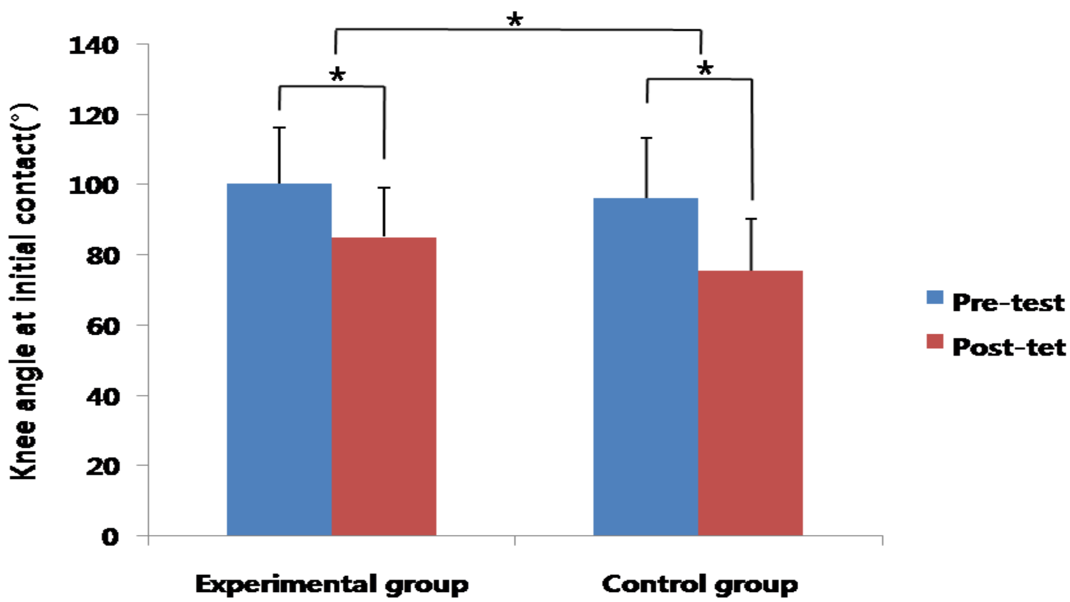

Figure 1. Time course evaluation of knee angle in initial contact in the experimental and control groups. Experimental group; extracorporeal shock wave treatment group. (n=10 per group; *p<0.05). Data are presented as the mean±standard deviation

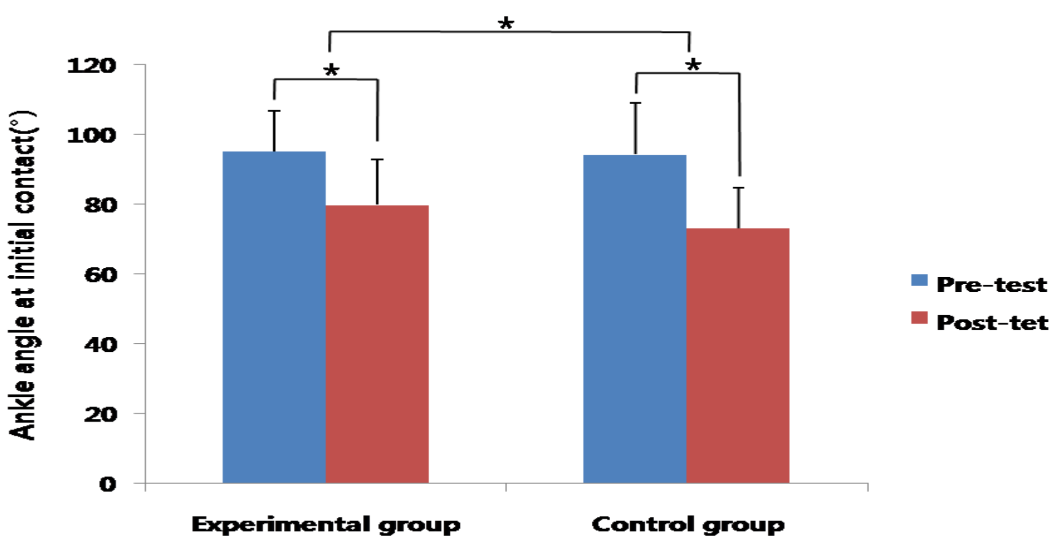

Figure 2. Time course evaluation of ankle angle in initial contact in the experimental and control groups. Experimental group; extracorporeal shock wave treatment group. (n=10 per group; *p<0.05). Data are presented as the mean±standard deviation

Spasticity is a neurologic symptom that frequently develops after a stroke and it is defined as the muscle tone that increases according to speed and excessive tendon reflexes. As spasticity causes pain and postural abnormalities and limits daily living activities and normal movement affecting the quality of life of patients, an appropriate therapy is required from the earliest stage of development. Because central nerve injury is the main cause of spasticity, most studies regard excessively increased spinal excitability as a cause of spasticity [4].

This study examined the effects on locomotion ability of applying ESWT to rats with central nerve injury due to ICH. In the experimental results, a statistically significant difference in the change of knee and ankle joint angles during walking existed between the experimental group that received ESWT and the control group.

In a study by Mense and Hoheisel (2013) that examined the impact of low-energy ESWT on the recovery of sense and function of muscles and regeneration of damaged nerves after nerve injury, the sense and function of rats that received injuries to nerve tissues in muscles were evaluated using the pressure pain threshold [5][6]. Exploratory activity and nerve regeneration were evaluated using an immunohistochemical experiment. The study results indicated an increase of sensory and functional recovery of muscles and regeneration of damaged nerves in the behavioral and immunohistochemical evaluation after ESWT [7][8].

Due to the lack of preliminary evaluation of the neurotrophic factors, it is hard to determine the impact on the post-evaluation. In future research, experiments that incorporate segmented and continuous evaluation will be applied to modify and supplement the limitations of this study.

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