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Research Article

Clinical Observation of Electrical Stimulation of Nerve Stem on Stroke Rehabilitation

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Abstract

Cerebrovascular diseases, one of the major types of illnesses that threatens the health and life of elderly people worldwide, commonly lead to serious sequelae which are difficult to treat. Current treatments have little effect on the restoration of muscle strength and the gaining of independent life. We applied electrical stimulation to some traditionally used acupuncture points and a few ones we discovered and studied the efficacy of this treatment for stroke rehabilitation. By measuring the European stroke scale which includes the level of consciousness, comprehension, speech, visual field, gaze, facial movement, maintenance of arm in a outstretched position, in raising position, extension of the wrist, fingers, maintenance of leg position, leg bending, dorsiflexion of the foot, and gait, We found that electrical stimulation of nerve stems is not only effective for acute cerebrovascular diseases but also for stroke sequelae by accelerating the functional recovery of muscles. The present study provided a new direction in stroke rehabilitation and it will accelerate the functional recovery of the paralysed limbs.

Keywords: Stroke; Electrical stimulation; Nerve stems; Muscle strength

Introduction

Cerebrovascular diseases are common neurological problems and they are one of the health and life threatening diseases affecting the middle aged and elderly people in China. There is a trend that these diseases are leading to more mortality in both urban and country areas [1]. Statistical data show that the incidences of cerebral infarction (ischemic stroke) and intracranial hemorrhage (hemorrhagic stroke) are 110 per 100,000 people and 60-80 per 100,000 people, respectively. In China, there are approximately 2 million new stroke patients each year and 70-80% of them are unable to live independently due to disability caused by stroke [2]. Cerebral infarction leads to not only disability and mortality, but also cognitive impairment and other mental illnesses such as depression, anxiety, even personality changes. These bring a heavy burden to the patients and their families and its consequence is detrimental.

We have been conducting research on electrical stimulation of nerve stems for many years and have found a few points, which were effective for stroke management by restoring the function of nerves and improve the patients' symptoms. We hypothesized that electrical stimulation of nerve stems will be an effective method for rehabilitation after stroke. The present study summarized the results from 33 stroke patients who received electrical stimulation of nerve stems by comparing the functional status of their limbs before and after the electrical stimulation.

Methods

Subjects

All patients were admitted to the Department of Neurology, Shenyang Red Cross Hospital, Shenyang, China (between Jan 2013 and June 2014). They all met the diagnostic criteria constituted at the Fourth National Cerebrovascular Diseases Conference in 1996 [3]. The patients had clear consciousness, neurological deficits, and their stroke was confirmed with CT or MRI. Among them, 26 were male and 7 were female. Their age ranged from 44-74 with an average of 59.09 ±7.26. Twenty five of the patients had cerebral infarction and the other 8 had intracranial hemorrhage. Among them, 11 patients were in the acute phase of cerebral infarction (within 1 month after onset of stroke), and the rest of them had sequelae from their stroke which occurred 4 month to 10 years ago. Exclusion criteria: (1) concurrent serious heart and kidney problems and severe malnutrition; (2) concurrent tumor; (3) bleeding diathesis or history of bleeding problems; (4) abnormal platelet count, abnormal bleeding time, thrombin time, prothrombin time, activated partial thromboplastin time; (5) abnormal liver function with hepatomegaly and jaundice; (6) badly controlled brain edema or hernia tendency; (7) acute intracranial hemorrhage.

Treatment plan

(1). General treatment: aspirin and rosuvastatin for cerebral infarction patients to prevent a secondary attack, anti-hypertensive for hypertension, and oral anti-diabetic for diabetes.

(2). Electrical stimulation of nerve stems: a few major points were chosen for limb stimulation. In the upper limb: a) the armpit point of the brachial plexus –patient's head turned to the other side of the puncture in a supine position, followed by 90° abduction of the upper arm with the elbow flexed and forearm supinated close to the head. After feeling the pulse of the axillary artery, the acupuncture needle was punched 2.0-3.0 cm into the area lateral to the highest point of pulse; b): stimulating point of the deltoid muscle – punched 2.0-3.0 cmat the middle point of the acromion and the termination point of the deltoid muscle; c) stimulating point of the biceps –punched 2.0-3.0 cm at the middle point of the muscle belly; d) radial nerve stimulating point – the meeting point of the lower 1/3 of the line between the

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acromion and the external epicondyle of the humerus and the upper 2/3 of it. In adults, it was about 10 cm above the external epicondyle of the humerus on the lateral side. The needle was punched 2.0-3.0 cm into the muscle; e) digital extensor stimulating point – slightly above the middle point between the radial aspect of the elbow and the middle point of the back of the wrist, the needle was punched 2.0-3.0 cm into the muscle; f) medial nerve stimulating point – 4 cm above the center of the wrist, between the tendons of the palmarislongus and the flexor carpi radialis muscles. The needle was punched 1.5-2.0 cm deep; g) ulnar nerve stimulating point – in the groove between the tip of the elbow and the medial epicondyle of the humerus that is the groove for ulnar nerve. The needle was punched 0.5-1.0cm deep. In the lower limb, a) the sciatic nerve stimulating point – the middle point of the line between the sacrococcygeal joint and the upper edge of the greater trochanter of femur. The needle was punched 6.0-8.0 cm deep; b) tibial nerve stimulating point – the meeting point of the lower 1/3 and the middle 1/3 of the back of the calf. The needle was punched 3.0-4.0 cm deep; c) deep peroneal nerve stimulating point – 4cm below the tibial tuberosity and 2 cm lateral to the tibial crest. The needle was punched 3.0-4.0 cm deep; d) superficial peroneal nerve stimulating point – 1-2 cm anterior to the middle point of the line between the caput fibulae and the external malleolus that is the anterior edge of the central fibulae. The needle was punched 2.0-3.0 cm deep; e) femoral artery stimulating point – at the meeting point of the inguinal ligament and the femoral artery, medial to the femoral artery. The needle was punched 6.0-8.0cm deep. On the head, a) motor cortical area – equals to the projection area of the primary motor cortex on the scalp. The upper point is 0.5 cm posterior to the middle point of the line between the middle point of the two eyebrows and the lower edge of external occipital protuberance, the lower point is 0.5 cm anterior to the meeting point of the horizontal line between the central eyebrow and the lower edge of the external occipital protuberance and the line perpendicular to the central zygomatic arch. The area between the two points is the motor cortex. It can be divided into 5 areas evenly: the upper 1/5 represents the lower limbs and the trunk, the middle 2/5 represents the upper limbs, the lower 2/5 represents the face. The needle was punched 0.5-1.0 cm deep; b) sensory cortical area – equals to the projection area of the sensory cortex on the scalp. It is 1.5 cm posterior to the motor area. The upper 1/5 represents the lower limbs, head, and the trunk, the middle 2/5 represents the upper limbs, the lower 2/5 represents the face. The needle was punched 0.5-1.0 cm deep.

Treatment was tailored to stimulate two points on the upper limb and two points on the lower limb depending on the symptoms of the patients. The depth of the needle was optimized until the patient felt something was radiating from the needle to the distal limb. Lifting, lowering, and twisting the needle was not applied in order to protect the nerves from injury. A pair of electrodes, connected to a BT701-1B electrical acupuncture treatment instrument, was applied to the upper limb and the other pair to the lower limb. Direct current at 6V was used. The output wave shape was bidirectional spike pulse. The width was 1.0 ms, the frequency was 1-40/s, and the intensity is 0-30C.With the low frequency and continuous wave, the stimulation lasted 20 minutes and it was applied once a day. The intensity was adjusted to trigger muscle fibrillation. The stimulating points were used alternatively and the efficacy of treatment was assessed after 32 days (one course).

Statistical analysis

European Stroke Scale (ESS), developed by Hantson et al in 1994 [4] for clinical trials was used for measurements in the present study. It measures the level of consciousness, comprehension, speech, visual field, gaze, facial movement, maintenance of arm in an outstretched position, in a raising position, extension of the wrist, fingers, maintenance of leg position, leg bending, dorsiflexion of the foot, and gait. It focuses on the motor aspect of the body. It is a reliable, sensitive, convenient to use method, and has a high predicting value of the outcome.

SPSS17.0 was used for statistical analysis. Gaussian distribution like data were expressed with $x \pm s$. Numeration data were analyzed with T test and non Gaussian distribution data were analyzed with Rank-sum test. $p<0.05$ indicates a significant difference.

Results

The ESS of all patients before electrical stimulation was 74.79±8.67, and it was 90.15±6.54 after 4 courses of electrical stimulation. The latter was significantly higher than the former one (Table 1). Compared with cerebral infarction patients, intracranial hemorrhage patients had similar before and after treatment ESSs (P>0.05) (Table 2).

Patients with a new stroke had a better before treatment ESS than those who had an old stroke (P<0.05). However, their ESSs were similar to each other after the treatment (P>0.05) (Table 3).

Age did not affect the efficacy of electrical stimulation as the middle aged (40-60y) patients had similar before and after treatment ESSs to those elderly (61-80y) patients (Table 4).

Both male and female patients benefited from electrical stimulation as shown by the similar after treatment ESSs (P>0.05) though male patients had a lower before treatment ESS (P<0.05) (Table 5).

Table 1: Comparison of ESS before and after electrical stimulation.

n	ESS
before treatment 33	74.79±8.67
after treatment 33	90.15±6.54

Table 2: Before and after treatment ESSs of intracranial hemorrhage patients and cerebral infarction patients.

n	before treatment ESS	after treatment ESS
hemorrhage patients 8	73.13±12.44$^{\triangle}$	90.13±6.56$^{\triangle}$
Infarction patients 25	75.32±7.35	90.16±6.67

Note: P>0.05

Table 3: Comparison of ESS of patients with a new stroke with that of patients with an old stroke.

n	before treatment ESS	after treatment ESS
new stroke 11	79.73±6.23$^{\blacktriangle}$	91.27±6.34$^{\triangle}$
old stroke 22	73.23±9.22	89.59±6.71

Note: $P^{\triangle}>0.05$, $P^{\blacktriangle}<0.05$

Table 4: Comparison of ESSs of patients of different age groups.

n	before treatment ESS	after treatment ESS
middle age (40 60y)	2074.35±9.35$^{\triangle}$	90.80±6.22$^{\triangle}$
elderly (61-80y)	1375.46±7.84	89.15±7.14

Note: $P^{\triangle}>0.05$

Table 5: Comparison of ESSs between male and female patients.

n	before treatment ESS	after treatment ESS
male patients	2674.73±8.28▲	89.85±6.23△
female patients	775.00±10.75	91.29±8.04

Note: P△>0.05, P▲<0.05

Discussion

The present study showed that electrical stimulation of nerve stems improved the neurological performance of stroke patients. Age, gender, type of stroke, and the time after stroke onset did not affect the efficacy of this treatment and all patients benefited from it.

Stroke, especially ischemic stroke (cerebral infarction) is mainly treated with medications which include well proved ones like aspirin and statins, and others that can remove free radicals or protect neurons. However, these medications are only somewhat effective for strokes at the early stage. They are hardly effective for old strokes with sequelae. So far, the best treatment module for stroke is Stroke Unit, which is awell organized medical management model, involving multi-disciplinary teams. It addresses early rehabilitation by providing early limb training, speech training, ADL training, cognition training, psychotherapy, and health education in addition to the conventional therapy, which leads to the systemic rehabilitation [5]. However, it also has its own shortfall. Firstly, there are 3 levels of rehabilitation in Stroke Unit. The first one is the early rehabilitation in the emergency or neurology ward with the conventional therapy. The second one is the rehabilitation in the ward or rehabilitation center. The third one is the continued rehabilitation in the community or patient's house. This requires a detailed rehabilitation plan and good compliance of the patients to the plan. In fact, many patients do not have this patience and stop the rehabilitation at a certain stage, which results in disability, cognitive impairment, personality changes, and incongruity. Secondly, many patients can not afford this long term and costly rehabilitation and they have to stop it after finishing the first level of rehabilitation. Thirdly, rehabilitation does not guarantee a full recovery, which leads to a low compliance. Compared with Stroke Unit, electrical stimulation has a few advantages. Firstly, patients can feel the difference in a short period, which is evidenced by the increased muscle strength within half an hour after the first treatment. This leads to more confidence and willingness to continue the treatment. Secondly, electrical stimulation of nerve stems can effectively improve the varus foot, shoulder-hand syndrome, and circled gait. This boosts the patients' confidence in the community and increases their compliance. Thirdly, it improves the neurological performance in all patients no matter they have or do not have aphasia, dementia, personality changes, and capability of communication. Fourthly, the expense incurred from this therapy is not high and patients will not withdraw from it because of financial issues, which enables the propagation of this treatment.

There are many possible mechanisms underlying electrical stimulation of nerve stems, but none can explain how it works from the cellular level. Some theoretical and experimental studies, including brain imaging, proposed the neural reflex theory, gate control theory, and the release of neurotransmitters based on the possibility that the central nervous system is involved in the transmission of the electrical stimuli to the target effector [6]. Zuo et al found that bilateral limb movement related cortex of acute cerebral infarction patients changed its metabolism of glucose due to electrical stimulation with a needle using the PET scan.As a result, they proposed that electrical stimulation with a needle can activate movement related cortex on both sides, excite movement related neural tissues, compensate or facilitate the reconstruction of the damaged neural network, accelerate the regeneration of capillaries and new collaterals, and increase the metabolism of glucose [7]. Another study found that electrical stimulation with a needle could prevent the toxic effect of nitric oxide to neurons by suppressing the overexpression of neuronal nitric oxide synthase (nNOS), which leads to the dilation of blood vessels and the recovery of vulnerable nNOS neurons in the ischemic area [8]. It was also reported that continuous electrical stimulation increased the number of synapses or their plasticity and converted dormant synapses to active ones. As a result, the nervous system restored its function by reshuffling itself [9]. Nerve stems, containing sensory, motor, and autonomous nerve fibers, are the major pathways relaying the sensory signals to the cortex and motor signals to the effector. By stimulating them, the cortex will be activated by the sensory signals and the effectors (muscles) activated by motor signals [10].

The authors discovered the femoral artery stimulating point and by stimulating it patients could increase their muscle strength in about half an hour. This increased patients' confidence and compliance to finish the entire course of treatment, which was very essential for restoring the muscle strength. In addition, it improves the sequelae such as varus foot, shoulder-hand syndrome, and circled gait compared with the traditional medications and acupuncture as we see in the daily clinical practice. We found that acute stroke patients had a quicker and better recovery from this treatment than those who had a long history of stroke and stroke sequelae.

In the present study, there was a significant difference in the before treatment ESS between the acute and the old stroke patients, as well as between the male and female patients. This might be due to the small number of patients included in the present study. Based on the findings from the present study, it is likely that electrical stimulation with a needle will be a good choice for stroke patients to gain their muscle strength and independence. It is worth dissemination around the world.

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