doi: 10.48095/cccsnn2023193

Effect of acupuncture in combination with sinusoidal medium frequency electrotherapy on upper limb motor function of stroke patients

Účinky akupunktury kombinované se sinusovou středněfrekvenční elektroterapií na motorické funkce horních končetin u pacientů po iktu

Abstract

Objective: The aim of this study was to evaluate the effect of acupuncture in combination with sinusoidal medium frequency electrotherapy on the upper limb motor function of stroke patients. *Methods:* A total of 160 stroke patients with hemiplegia were randomly divided into a control group (N = 80) and an observation group (N = 80). All patients received basic treatment. The control group was given sinusoidal medium frequency electrotherapy. The needle was kept for 30 min, once a day and 5-times a week for 4 consecutive weeks. On this basis, the observation group was given acupuncture. The selected frequency was 2,000–5,000 Hz, and the modulation frequency was 10–150 Hz, with two waveforms of intermodulation and transmodulation, and two sets of small electrodes. Before and after 4 weeks of treatment, all patients were evaluated for neurological impairment, motor function of the affected upper limb and activities of daily living using the National Institutes of Health Stroke Scale (NIHSS), Fugl-Meyer Assessment for Upper Extremities (FMA-UE) scale and Modified Barthel Index (MBI) Scale. The latency changes of somatosensory evoked potential (SEP) N20 of the affected upper limb were recorded. *Results:* After 4 weeks of treatment, the observation group had significantly improved NIHSS score, FMA-UE scale score, MBI scale score and N20 latency compared with those of the control group. *Conclusion:* Acupuncture in combination with sinusoidal medium frequency electrotherapy exerts a synergistic effect, which can effectively relieve neurological deficit and improve the motor function of upper limbs.

Souhrn

Cíl: Cílem této studie bylo zhodnotit účinky akupunktury kombinované se sinusovou středněfrekvenční elektroterapií na motorické funkce horních končetin u pacientů po iktu. *Metody:* Celkem 160 pacientů s hemiplegií, kteří prodělali CMP, bylo náhodně rozděleno na kontrolní skupinu (n = 80) a výzkumnou skupinu (n = 80). Všichni pacienti prošli základní léčbou. Kontrolní skupině byla aplikována sinusová středněfrekvenční elektroterapie. Jehla byla zavedena na 30 min 1× denně v 5 dnech týdně, a to po dobu 4 po sobě následujících týdnů. U výzkumné skupiny byla navíc provedena akupunktura. Zvolená frekvence byla 2 000–5 000 Hz a modulační frekvence 10–150 Hz se dvěma vlnami intermodulace a transmodulace a dvěma sety malých elektrod. Před léčbou a 4 týdny po ní byly u všech pacientů zhodnoceny neurologický deficit, motorické funkce postižené horní končetiny a každodenní aktivity pomocí škál National Institutes of Health Stroke Scale (NIHSS), Fugl-Meyer Assessment for Upper Extremities (FMA-UE) a modifikovaný index Barthelové (Modified Barthel Index; MBI). Byly zaznamenány změny latence somatosenzorických evokovaných potenciálů (SEP) N20 postižené horní končetiny. *Výsledky:* Po 4 týdnech léčby došlo u výzkumné skupiny v porovnání s kontrolní skupinou k významnému zlepšení NIHSS, FMA-UE, MBI a latence N20. *Závěr:* Akupunktura v kombinaci se sinusovou středněfrekvenční elektroterapií vykazuje synergické účinky, které mohou účinně zmírnit neurologický deficit a zlepšit motorické funkce horních končetin.

The Editorial Board declares that the manuscript met the ICMJE "uniform requirements" for biomedical papers.
Redakční rada potvrzuje, že rukopis práce splnil ICMJE kritéria pro publikace zasílané do biomedicínských časopisů.

L. Zou

Department of Acupuncture and Moxibustion, Jiangsu Taizhou People's Hospital, Taizhou, Jiangsu Province, China

✉
Lin Zou
Department of Acupuncturand Moxibustion
Jiangsu Taizhou People's Hospital
Taizhou 225300
Jiangsu Province
China
e-mail: hgzbbx959vvx@163.com

Accepted for review: 28. 9. 2022
Accepted for print: 18. 5. 2023

Key words
acupuncture – sinusoidal medium frequency electrotherapy – upper limb motor function

Klíčová slova
akupunktura – sinusová středněfrekvenční elektroterapie – motorika horní končetiny

Introduction

Stroke is a common neurological disease caused by sudden rupture or blockage of cerebral vessels, with high morbidity, mortality and disability rates [1]. With continuous improvement of medical diagnosis and treatment, the survival rate of stroke patients is increasing annually, but the disability rate remains high. Besides, cognition, motor, speech, sensation and other dysfunctions often occur, which seriously affect the functional recovery and quality of life of patients [2,3].

About 70–80% of patients have different degrees of motor dysfunction after stroke, especially in upper limbs [4]. This dysfunction not only seriously affects the quality of life of individuals, but also causes high economic burden on families and society. Therefore, how to effectively promote the recovery of upper limb motor function of stroke patients has attracted widespread attention.

As a crucial part of traditional Chinese medicine (TCM) and one of traditional rehabilitation therapies, acupuncture has been widely used to treat various neurological diseases by stimulating acupoints on the body surface, harmonizing Yin and Yang, dredging meridians and collaterals, and activating blood circulation and Qi [5]. Acupuncture has also been used in China for thousands of years to treat stroke hemiplegia.

After stroke, upper limb motor dysfunction is often caused by multiple factors. An individual rehabilitation method has often limited clinical effect. Recently, a "central-peripheral-central" closed-loop rehabilitation theory has been proposed [6]. Central intervention methods, such as sinusoidal medium frequency electrotherapy, transcranial magnetic stimulation and transcranial direct current, can directly stimulate and activate related brain functional areas and augment synaptic plasticity, thus promoting functional reorganization. Peripheral intervention methods, such as acupuncture and motor relearning, are based on the natural recovery process of stroke and the general rules of central nervous development. They input the peripheral stimulus feedback into the central nervous system through intensive motor control training, which thus facilitates brain function remodeling and neural reinnervation [7]. These two intervention methods jointly promote the rehabilitation of motor function after stroke, which not only improves clinical efficacy, but also shortens the treatment duration. Accordingly, combined central-peripheral therapy has been highlighted during stroke rehabilitation in recent years.

However, the combination of sinusoidal medium frequency electrotherapy with acupuncture in the treatment of upper limb motor dysfunction after stroke has rarely been referred. Thus, we herein combined acupuncture with sinusoidal medium frequency electrotherapy to evaluate the effect on the upper limb motor function of stroke patients, aiming to provide an optimized intervention method in clinical practice.

Patients and methods

Subjects

A total of 160 stroke patients with hemiplegia, who were treated in the Jiangsu Taizhou People's Hospital, Taizhou, Jiangsu Province, China from December 2016 to February 2020, were included and randomly divided into a control group (N = 80) and an observation group (N = 80).

TCM diagnostic criteria

The diagnosis referred to the Evaluation Criteria for Diagnosis and Therapeutic Effects of Stroke Diseases (Trial) formulated by the Acute Encephalopathy Scientific Research Collaboration Group of the State Administration of Traditional Chinese Medicine [8].

Main symptoms: sudden dizziness, slurred speech, slanting mouth and eyes, hemiplegia, hemianesthesia; secondary symptoms: headache, dizziness, pupillary abnormality, strabismus, choking and coughing by drinking water, ataxia; usually with acute onset and age of onset of over 40 years old; mostly with the history of headache, vertigo and palpitations, emotional disorders, or eating disorders. Patients can be diagnosed in the case of the presence of the above mentioned two main symptoms, one chief symptom and two secondary symptoms, together with age, etiology and medical history. Diagnosis can also be made by combing imaging examination results.

Western medicine diagnostic criteria

The diagnosis referred to the Diagnosis Criteria for Integrated Traditional Chinese and Western Medicine of Cerebral Infarction and Cerebral Hemorrhage (Trial) formulated by the Neurology Professional Committee of the Chinese Association of the Integration of Traditional and Western Medicine [9].

Cerebral infarction often has a sudden onset, accompanied by focal neurological impairment lasting for over 24 h. Main symptoms: hemianopsia, hemiplegia, hemiparesthesia, speech impairment, dysphagia and ataxia. The symptoms often become most severe within 1–2 days after onset, and low-density changes or infarct focus can be detected in the infarct area by craniocerebral CT or MRI examination.

Cerebral hemorrhage has an acute onset. Main symptoms: hemianopsia, hemiplegia, hemidysesthesia and other focal neurological deficits, accompanied by headache, vomiting, disturbance of consciousness, intracranial pressure or elevated blood pressure. Arterial hypertension, alcohol drinking, emotional hyperactivity, and overwork are the most common causes. Craniocerebral CT examination revealed high-density changes in the center of lesion, and a low-density edema zone was often found around the lesion.

Inclusion and exclusion criteria

Inclusion criteria were:

1) first onset, in line with the Diagnosis Standards for Integrated Traditional Chinese and Western Medicine of Cerebral Infarction and Cerebral Hemorrhage (Trial);
2) age between 20 and 75 years, with the disease course of 2 weeks to 3 months;
3) stable vital signs, and ability to cooperate with treatment and evaluation;
4) right handedness;
5) dysphagia and motor dysfunction induced by stroke;
6) hemiplegia in unilateral limb, Brunnstrom stage I–II [10], and muscle strength grade 0–IV.

Exclusion criteria were:

1) metal implants in the skull or body and skull defects;
2) history or family history of epilepsy;
3) severe injuries of heart, lung, liver, kidney and other organs or serious neurological diseases and tumors;
4) new infarcts or secondary hemorrhage and deterioration of the condition;
5) contraindications for acupuncture treatment;
6) pregnant women, patients with severe cognitive or communication disorders who cannot cooperate with treatment or evaluation.

Treatment methods

Control group: Sinusoidal medium frequency electrotherapy + basic treatment; observa-

tion group: sinusoidal medium frequency electrotherapy + acupuncture + basic treatment.

Basic treatment

All included patients received drug treatment and rehabilitation training according to the Chinese Guidelines for the Prevention and Treatment of Cerebrovascular Diseases [11].

Drug treatment: 1) Stable control of blood pressure: Blood pressure was controlled as stable as possible at about 140/90 mm Hg. Dynamic changes were monitored for timely adjustment; 2) Regulation of blood glucose and lipid levels: Blood glucose level was regulated at about 8–10 mmol/L by oral administration of hypoglycemic drugs or subcutaneous injection of insulin, and hypoglycemia was corrected in a timely manner. Blood lipid level was regulated by oral administration of atorvastatin calcium and rosuvastatin calcium; 3) Routine drugs were given to improve cerebral circulation, promote brain metabolism and nourish the brain; 4) Complications including respiratory infections and deep vein thrombosis were prevented; 5) Other cases were treated symptomatically.

Acupuncture

Both control and observation groups were subjected to acupuncture. The acupoint on the side of hemiplegia was mainly Yangming Meridian, supplemented by Shaoyang Meridian and Taiyang Meridian. For the patients with lower limb motor dysfunction, Biguan, Futu, Zusanli, Jiexi and Taichong were selected for acupuncture.

Apparatus: Disposable sterile acupuncture needles of ø 0.30 mm × 40 mm (Zhongyan Taihe Medical Devices Co., Ltd., Beijing, China) were selected.

Acupoint selection: Jianyu, Quchi, Shousanli, Waiguan and Hegu were selected as the acupoints according to the Study of Meridian and Acupuncture. Acupuncture was operated according to the Study of Acupuncture and Moxibustion Techniques (editor: Guirong Dong).

Procedure: Acupuncture was carried out by the same acupuncturist with more than 5 years of experience in the treatment of limb motor disorders after stroke. The patient took a quiet supine or lateral lying position. The acupuncturist disinfected his hands and acupuncture points with 75% ethanol solution. An acupuncture needle was inserted according to the direction and depth required for acupoint entry. The acupuncture was considered suitable in the case of obvious soreness, numbness, swelling, heaviness, tightness and astringency, or conditioned reflex of hemiplegic limbs. After procedure, the needle was retained for 30 min. This process was conducted once a day and 5-times a week for 4 consecutive weeks.

Sinusoidal medium frequency electrotherapy

BaHTCIY BA2008-III medium frequency therapy apparatus (Beijing Ben'ao New Technology Co., Ltd., Beijing, China) was used, and the prescription of sinusoidal medium frequency electrotherapy was selected. Two sets of electrode plates were placed on the extension side of upper limb, the flexion side of lower limb and the lower back, respectively. The frequency was 1.0 Hz, and the intensity was 100% of the resting motor threshold of the uninjured hemisphere. The therapy was performed once a day and 20 min each time for 8 consecutive weeks.

The selected frequency was 2,000–5,000 Hz, and the modulation frequency was 10–150 Hz, with two waveforms of intermodulation and transmodulation, and two sets of small electrodes. One set of electrodes was horizontally arranged above the hyoid bone, and the other set was placed on both sides of the cheek. The waveform and modulation frequency were selected. Two waveforms were used alternately each time, each of which lasted for 3–8 min, once a day and 20 min each time for 8 consecutive weeks.

Baseline clinical data

The baseline clinical data of patients, such as age, sex, disease course, lesion characteristics, side of hemiplegia and surgical treatment, were collected and compared.

Evaluation indices

1) National Institutes of Health Stroke Scale (NIHSS): NIHSS is mainly used to assess the severity of neurological impairment upon stroke, including 11 items such as consciousness, upper limb movement, limb ataxia, sensory function, visual field and language. The scores are summed up, ranging from 0 to 42 points. 0–1 point: normal or basically normal; 2–4 points: mild; 5–15 points: moderate; 16–20 points: moderate to severe; > 21 points: severe. A higher score indicates more serious neurological impairment [12].
2) Fugl-Meyer Assessment (FMA) scale: The FMA scale (including upper and lower limbs) is mainly used to assess the degree of limb motor dysfunction in patients. FMA for Upper Extremities (FMA-UE) scale assesses only the motor function of the upper limbs, including 33 items such as reflex, shoulder, elbow, hand and wrist. Each item is divided into 3 levels (0–2 points), with a total score of 66 points. A lower score indicates more serious upper limb motor dysfunction [13].
3) Modified Barthel Index (MBI) Scale: The MBI scale is mainly used to evaluate the activities of daily living, including 11 items such as embellishment, eating, dressing, bathing, defecating and walking. Each item has 5 grades, with a total score of 100 points; ≥ 60 points: basic self-care; 41–59 points: moderate dysfunction, indicating that help is needed; 21–40 points: severe dysfunction, indicating obvious life dependence; ≤ 20 points: complete life dependence. A lower score indicates worse daily activities and higher degree of dependence [14].
4) Latency of somatosensory evoked potential (SEP) N20: Keypoint electromyographic evoked potential detector (Dantec, Skovlunde, Denmark) was used in an electrophysiology room equipped with magnetic shielding device and air conditioner, and operated by the same professional technician with over 5 years of experience. The patient was in the supine or semi-supine position with closed eyes and relaxed, and the upper limb wrist was subjected to median nerve stimulation. A saddle-shaped stimulation electrode was placed on the median nerve of the affected upper limb, 2–3 cm above the forearm and wrist transverse stripes, and the cathode was placed near the heart. The frequency was 1.9 Hz, the time limit was 0.2 ms, and the stimulation intensity was appropriate to cause slight contraction of abductor muscle of thumb visible to the naked eye. The head recording electrode C3′ or C4′ on the opposite side of hemiplegia was fixed with reference to an international EEG 10–20 system, and the reference electrode was placed at the Fz point in the middle of forehead. SEP test was repeated twice on the affected upper limb, and 200 times of detection were added. The latency values of N20 wave were recorded automatically, and two detection results were averaged.

Tab. 1. Baseline clinical data.

	Control group (N = 80)	Observation group (N = 80)	t/x²	P
age (year)	54.18 ± 10.29	53.98 ± 10.34	0.122	0.903
male/female	48/32	50/30	0.105	0.746
course of the disease (d)	15.00 ± 2.18	15.23 ± 2.08	0.683	0.496
nature of lesion (ischemia/hemorrhage)	32/48	34/46	0.103	0.748
side of hemiplegia (left/right)	36/44	34/46	0.102	0.750
surgery (yes/no)	40/40	38/42	0.100	0.752
type of bulbar palsy (true/false)	20/60	22/58	0.129	0.719
lesion			0.029	0.985
supratentorial brain	33	34		
brain stem	12	12		
mixed	35	34		

N – number

Tab. 2. National Institutes of Health Stroke Scale scores before and after treatment.

	Before	After	t	P
control group (N = 80)	9.12 ± 1.23	6.89 ± 0.71	10.298	< 0.001
observation group (N = 80)	9.14 ± 1.16	5.47 ± 0.67	15.487	< 0.001
t	0.106	13.010		
P	0.916	< 0.001		

N – number

5) Water swallow test: The patient was required to drink 30 ml of warm water. Then the drinking time, occurrence of choking cough, and water drinking status were observed. Level 1: Able to swallow water once smoothly; level 2: able to swallow water twice, without choking cough; level 3: able to swallow once but with choking cough; level 4: able to swallow water twice or more, with choking cough; level 5: frequent choking cough, failing to drink all water [15].

The patients were evaluated by using NIHSS, FMA-UE scale, MBI scale and SEP N20 latency test on the same days before and after 4 weeks of treatment. All assessments and tests were performed by the same therapists and technicians with over 5 years of experience. They were blinded to the treatment process and patient grouping.

Statistical analysis

All data were statistically analyzed using the SPSS21.0 software (IBM, Armonk, NY, USA). The numerical data were compared by the χ^2 test. The quantitative data were expressed as mean ± standard deviation (x ± s). Intergroup comparisons were performed with the two independent samples t test, and intragroup comparisons before and after treatment were conducted by the paired t test. $P < 0.05$ was considered statistically significant.

Results

Baseline clinical data

In the course of the study, 4 patients in the control group chose to withdraw from the study because they did not consider the efficacy to be significant; 4 patients in the observation group chose to transfer to the local hospital for further rehabilitation due to inconvenience in their life, and fell off. A total of 160 cases were included in the final statistics and analysis, including 80 cases in the control group and 80 cases in the observation group. According to the statistical analysis, the two groups of subjects before treatment were compared in terms of age, sex, course of the disease, nature of focus, side of hemiplegia, medulla oblongata type, and stage of oral disorder, of which the results showed no significant differences ($P > 0.05$). The clinical data were comparable (Tab. 1).

NIHSS scores before and after treatment

There was no significant difference in the NIHSS score between the control group and the observation group before treatment ($P > 0.05$). After 4 weeks of treatment, the NIHSS scores of the two groups decreased compared with those before treatment, with statistically significant differences ($P < 0.05$). The decrease of NIHSS score in the observation group was higher than that in the control group ($P < 0.05$) (Tab. 2).

FMA-UE scores of upper limb motor function and MBI scores of daily living activity before and after treatment

Before treatment, there were no statistically significant differences in the FMA-UE score of upper limb motor function and MBI score of daily living activity between the control group and observation group ($P > 0.05$). After 4 weeks of treatment, the FMA-UE and MBI scores in the two groups improved compared with those before treatment, with statistically significant differences ($P < 0.05$). The improvement of FMA-UE and MBI scores in the observation group was higher

Tab. 3. FMA-UE scores of upper limb motor function and MBI scores of daily life activity before and after treatment.

		Before	After	t	P
FMA-UE score	control group (N = 80)	8.34 ± 0.78	17.68 ± 3.28	8.225	< 0.001
	observation group (N = 80)	8.35 ± 0.87	23.32 ± 3.27	13.287	< 0.001
	t	0.939	10.892		
	P	0.470	< 0.001		
MBI score	control group (N = 80)	34.26 ± 4.39	47.67 ± 4.38	13.243	< 0.001
	observation group (N = 80)	34.48 ± 4.41	58.11 ± 3.79	22.261	< 0.001
	t	0.316	16.122		
	P	0.752	< 0.001		

FMA-UE – Fugl-Meyer Assessment for Upper Extremities; MBI – Modified Barthel Index; N – number

than that in the control group (P < 0.05) (Tab. 3).

Latency of SEP N20 before and after treatment

Before treatment, the difference in the latency of SEP N20 was not statistically significant between the control group and the observation group (P > 0.05); after 4 weeks of treatment, the SEP N20 latency in both two groups was statistically significantly shortened compared with that before treatment (P < 0.05). The improvement in the observation group was higher than that in the control group (P < 0.05) (Tab. 4).

Tab. 4. Latency of SEP N20 before and after treatment.

	Before	After	t	P
control group (N = 80)	21.17 ± 1.62	20.74 ± 1.63	2.017	0.029
observation group (N = 80)	20.98 ± 1.59	20.11 ± 1.61	3.287	0.008
t	0.749	2.460		
P	0.455	0.015		

N – number; SEP – somatosensory evoked potential

Rating of water swallow test before and after treatment

There were no statistically significant differences in the rating of water swallow test between the control group and the observation group before treatment (P > 0.05). After 4 weeks of treatment, the scores of the two groups were statistically significantly improved compared with those before treatment (P < 0.05). The improvement of the water swallow test rating in the observation group were higher than that in the control group (P < 0.05) (Tab. 5).

Discussion

Stroke causes damage to the structure and function of local brain tissues, resulting in the abnormality of limb muscle strength, muscle tension and movement pattern in the innervation area, and the decrease of balance and exercise ability with the impairment of limb function such as dyskinesia and abnormal gait [16]. According to the location and the extent of the lesion, it may be accompanied by abnormalities in cognition, verbal function, and sensation. Both basic experiments and clinical studies have shown [17] that post-stroke dyskinesia and swallowing function can spontaneously retreat, mainly based on the theories of central nerve plasticity and cerebral hemisphere suppression. The central system has its own repair ability, that is, structural plasticity and functional plasticity. There is a balance of competition and inhibition on both sides of the cerebral hemisphere in healthy people. Functional impairment and balance destruction caused by stroke weaken hemisphere inhibition of the affected side on the healthy side, while the hemisphere inhibition of the healthy side is relatively increased, so the double injury increases the difficulty of brain function recovery. Therefore, in the later stage of

Tab. 5. Rating of water swallow test and GUSS scores before and after treatment.

		Before	After	t	P
Rating of water swallow test	control group (N = 80)	3.92 ± 0.54	2.63 ± 0.40	4.327	< 0.001
	observation group (N = 80)	3.89 ± 0.55	2.97 ± 0.38	7.598	< 0.001
	t	0.348	5.512		
	P	0.728	< 0.001		

N – number

the disease, it is necessary to promote the accelerated recovery of limb and swallowing function jointly by central intervention, such as modulated medium frequency sinusoidal electrotherapy, transcranial magnetic therapy, transcranial direct current therapy, or peripheral intervention such as acupuncture, kinesitherapy and even comprehensive rehabilitation therapy.

Modulated medium frequency sinusoidal electrotherapy is a method of treating diseases by applying a medium frequency (2,000 to 5,000 Hz) sinusoidal current modulated by a low frequency (10 to 150 Hz), with the depth of amplitude modulation of 0 to 100%. This kind of current has the characteristics of both low and medium frequency currents, which can promote local blood circulation and lymphatic reflux, improve neuromuscular excitability, promote the recovery of muscle strength, relieve spasm, and prevent neuromuscular atrophy with obvious comfortable vibration feeling when acting on the body [18]. At the same time, we placed two sets of electrodes for oral disorders during the medium frequency electrotherapy: a group of electrodes placed on the hyoid bone stimulated the suprahyoid muscle group, and lifted up the hyoid bone when contracting to promote pharyngeal lift; a set of electrodes on the cheeks caused contraction of facial muscles, and promoted the movement of masticatory and orbicularis oris muscles which are the target muscles for the treatment of oral swallowing disorders [19]. Interference electrotherapy, modulated medium frequency sinusoidal electrotherapy and audio electrotherapy are commonly used medium frequency electrotherapies, of which the second is a kind of medium frequency current modulated by low frequency. It is currently believed that the most appropriate current for stimulating lesion muscles is no longer a low-frequency pulse current but a medium-frequency current modulated by a low frequency. Its characteristics are as follows: (1) different waveforms and modulation frequencies can appear alternately, so as to overcome the body's adaptability to electric current; (2) it can overcome tissue resistance and act on deeper tissues; (3) variable modulation wave can relieve pain and promote blood circulation; (4) intermodulation wave is suitable for stimulating neuromuscular tissue, not only for normal innervated muscles, but also for denervated muscles. There is an adjustable on-off time in the intermodulation waveform, which can prevent excessive stimulation from causing swallowing muscle fatigue [20].

"Jianyu", "Quchi", "Shousanli", "Waiguan", and "Hegu" belong to the upper extremity acupoints of Yangming Meridian respectively. Among them, the "Hegu" acupoint, which is located at the lateral edge of the elbow transverse line, and the midpoint of the connection line between the Chize acupoint and the external epicondyle of humerus, belongs to the He-Sea acupoint of the Large Intestine Meridian of Hand-yangming, which is the most important point from the meridian-QI to the end of the limbs. Studies on multi-point acupuncture have shown that all of them can promote the recovery of upper limb motor function after stroke. Therefore, the acupuncture scheme used in the control group of this study adopted the acupoints of "Jianyu", "Quchi", "Shousanli", "Waiguan", and "Hegu" on the Large Intestine Meridian of Hand-yangming of the upper limb on the affected side. This study combined acupuncture therapy with modulated medium frequency sinusoidal electrotherapy, and the results showed that after 4 weeks of treatment, the NIHSS score, FMA-UE score, MBI score, water swallow test score, N20 latency value and the swallowing time course in the observation group were improved compared with those before treatment, and were significantly different from those in the control group. The results showed that there was a synergistic effect of acupuncture therapy with modulated medium frequency sinusoidal electrotherapy, which could more effectively alleviate the degree of neurological deficit and improve upper limb motor function, swallowing function and daily living ability.

In summary, acupuncture in combination with sinusoidal medium frequency electrotherapy exerts a synergistic effect, which can effectively relieve neurological deficit and improve the motor function of upper limbs.

Ethical aspects

The entire study was conducted in accordance with the Helsinki Declaration of 1975 (as revised in 2004 and 2008). This study has been approved by the Ethics Committee of Jiangsu Taizhou People's Hospital on December 2nd, 2016 (approval No. JTPH201612003), and written informed consent has been obtained from all patients.

Acknowledgments

This study was not financially supported.

Conflict of interest

The authors declare that there are no conflicts of interest related to this article.

References

1. Béjot Y, Bailly H, Durier J et al. Epidemiology of stroke in Europe and trends for the 21st century. Presse Med 2016; 45(12 Pt 2): e391–e398. doi: 10.1016/j.lpm.2016.10.003.

2. Trupe LA, Mulheren RW, Tippett D et al. Neural mechanisms of swallowing dysfunction and apraxia of speech in acute stroke. Dysphagia 2018; 33(5): 610–615. doi: 10.1007/s00455-018-9879-6.

3. Liao X, Xing G, Guo Z et al. Repetitive transcranial magnetic stimulation as an alternative therapy for dysphagia after stroke: a systematic review and meta-analysis. Clin Rehabil 2017; 31(3): 289–298. doi: 10.1177/0269215516644771.

4. Lee SJ, Lee KW, Kim SB et al. Voluntary cough and swallowing function characteristics of acute stroke patients based on lesion type. Arch Phys Med Rehabil 2015; 96(10): 1866–1872. doi: 10.1016/j.apmr.2015.06.015.

5. De Raedt S, De Vos A, De Keyser J. Autonomic dysfunction in acute ischemic stroke: an underexplored therapeutic area? J Neurol Sci 2015; 348(1–2): 24–34. doi: 10.1016/j.jns.2014.12.007.

6. Forreider B, Pozivilko D, Kawaji Q et al. Hibernation-like neuroprotection in stroke by attenuating brain metabolic dysfunction. Prog Neurobiol 2017; 157: 174–187. doi: 10.1016/j.pneurobio.2016.03.002.

7. Yu H, Liu J, Cai L. Functional brain networks in healthy subjects under acupuncture stimulation: an EEG study based on nonlinear synchronization likelihood analysis. Physica A: Statistic Mech Appl 2017; 468(C): 566–577. doi: 10.1016/j.physa.2016.10.068.

8. Huang J, Tang X, Ye F et al. Clinical therapeutic effects of aspirin in combination with fufang danshen diwan, a traditional Chinese medicine formula, on coronary heart disease: a systematic review and meta-analysis. Cell Physiol Biochem 2016; 39(5): 1955–1963. doi: 10.1159/000447892.

9. Liu R, Yu X, Zhang L et al. Computed tomography (CT) imaging evaluation of integrated traditional Chinese medicine cooperative therapy in treating acute cerebral infarction: a randomized controlled trial. Medicine 2020; 99(18): e19998. doi: 10.1097/MD.0000000000019998.

10. Li X, Yang Z, Wang S et al. Impact of shoulder subluxation on peripheral nerve conduction and function of hemiplegic upper extremity in stroke patients: a retrospective, matched-pair study. Neurol Res 2021; 43(6): 511–519. doi: 10.1080/01616412.2020.1870360.

11. Zhong S, Sun K, Zuo X et al. Monitoring and prognostic analysis of severe cerebrovascular diseases based on multi-scale dynamic brain imaging. Front Neurosci 2021; 15: 684469. doi: 10.3389/fnins.2021.684469.

12. Chen SY, Liu JW, Wang YH et al. The conditions under which piracetam is used and the factors that can improve National Institute of Health Stroke Scale Score in ischemic stroke patients and the importance of previously unnoticed factors from a hospital-based observational study in Taiwan. J Clin Med 2019; 8(1): 122. doi: 10.3390/jcm8010122.

13. Trapl M, Enderle P, Nowotny M et al. Dysphagia bedside screening for acute-stroke patients. Stroke 2007; 38(11): 2948–2952. doi: 10.1161/STROKEAHA.107.483933.

14. Strowd L, Kyzima J, Pillsbury D et al. Dysphagia dietary guidelines and the rheology of nutritional feeds and barium test feeds. Chest 2008; 133(6): 1397–1401. doi: 10.1378/chest.08-0255.

15. Sayaca C, Sapcíoglu TY, Kaya D. Does the right or left hemisphere involvement affect swallowing in patients

with hemiplegia? NeuroRehabilitation 2020; 46(4): 501–509. doi: 10.3233/NRE-203089.
16. Jiang X, Andjelkovic AV, Zhu L et al. Blood-brain barrier dysfunction and recovery after ischemic stroke. Prog Neurobiol 2018; 163–164: 144–171. doi: 10.1016/j.pneurobio.2017.10.001.
17. Ng YS, Feeney C, Schaefer AM et al. Pseudo-obstruction, stroke, and mitochondrial dysfunction: a lethal combination. Ann Neurol 2016; 80(5): 686–692. doi: 10.1002/ana.24736.
18. Zhao L, Xiao B, Li Z. TCM thinking on rehabilitation of brachial plexus injury after repair. Traditional Chinese Med 2019; 8(4): 287–292. doi: 10.12677/TCM.2019.84048.
19. Tang Y, Lin X, Lin XJ et al. Therapeutic efficacy of neuromuscular electrical stimulation and electromyographic biofeedback on Alzheimer's disease patients with dysphagia. Medicine 2017; 96(36): e8008. doi: 10.1097/MD.0000000000008008.
20. Barikroo A, Hegland K, Carnaby G et al. The effects of electrical stimulation pulse duration on lingual palatal pressure measures during swallowing in healthy older adults. Dysphagia 2019; 34(4): 529–539. doi: 10.1007/s00455-019-09991-y.