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Effectiveness of neuromuscular electrical stimulation for wrist rehabilitation after acute ischemic stroke

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Abstract

This study investigated the effectiveness of neuromuscular electrical stimulation (NMES) for patients with wrist dysfunction after acute ischemic stroke (AIS).

A total of 82 patient cases with wrist dysfunction after AIS were selected in this study. Of these, 41 cases in the intervention group received physical training and NMES treatment. The other 41 cases in the control group received physical training only. The primary outcome was measured by Action Research Arm Test (ARAT) score. The secondary outcomes were measured by the Barthel Index (BI), and numerical rating scale (NRS).

After 4-week treatment, patients in the intervention group neither improved arm function recovery, measured by ARAT score ($P = .79$), and activities of daily living, measured by BI scale ($P = .62$), nor reduced pain, measured by the NRS scale ($P = .11$), compared with patients in the control group.

The results of this study demonstrated that NMES might not benefit for patients with wrist dysfunction after AIS after 4-week treatment.

Abbreviations: AIS = acute ischemic stroke, ARAT = Action Research Arm Test, BI = Barthel Index, NMES = neuromuscular electrical stimulation, NRS = numerical rating scale.

Keywords: acute ischemic stroke, effectiveness, neuromuscular electrical stimulation, wrist dysfunction

1. Introduction

Stroke is one of the most server conditions, which often results in high disability, mortality, and morbidity.[1–3] It is reported that it has affected 7 million adults in America with 3.0% of the population from 2007 to 2010, according to the American Stroke Association statistics.[4,5] Of those populations, many stroke survivors often suffer from limb paralysis, abnormal gait, aphasia, and other complications.[6–8]On the other hand, the large amount of burden brings for both those survivors and the society.[9]

Patients after stroke often require long-term rehabilitation therapy, especially for the hemiplegia in order to the restore and improve motor functions for the paralyzed limbs.[10,11] It has been reported that more than 50% patients can not recover arm function, although most stroke survivors can regain ability to walk independently after rehabilitation.[12] If arm function can not be recovered timely, this condition can also lead to secondary complications such as spasticity, contractures, and pain.[12,13]

To improve the upper extremity motor function after stroke, interventions should focus on not only enhancing the arm dysfunction, but also addressing the conditions of spasticity, contractures, and pain. It has been reported that alternative therapies, including neuromuscular electrical stimulation (NMES), acupuncture, and mirror therapy intervention have the potential to facilitate recovery of arm function and also help to prevent the development to the secondary complications.[14–18] Among these interventions, NMES is one of the most widely used therapies.[19–22] In spite of the promising results were reported from the previous studies, insufficient evidence is still available to support that NMES is an efficacious adjunctive therapy for patients with wrist rehabilitation after chronic stroke.[19–22]

In the present study, we investigated the effectiveness of NMES in patients with wrist rehabilitation after acute ischemic stroke (AIS) among Chinese population.

2. Patients and methods

2.1. Ethics

This study was approved by the Medical Ethical Committee of The People's Hospital of Yan'an. All patients provided the written informed consent.

2.2. Design

A total of 82 cases were selected in this retrospective study. Then, they were assigned to the intervention group and the control group according to the different interventions they received. Each group included 41 subjects. Of these, 41 cases in an intervention

Editor: Qinhong Zhang.

The authors declare no conflict of interest.

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Medicine (2018) 97:38(e12299)

Received: 17 July 2018 / Accepted: 16 August 2018

http://dx.doi.org/10.1097/MD.0000000000012299

group received physical training and NMES treatment, while the remaining 41 cases in a control group received physical training only. The cases in both groups received a total of 4 weeks treatment. After 4-week treatment, all the outcomes were measured. All these cases were collected between January 2015 and December 2017 at The People's Hospital of Yan'an.

2.3. Patients

In this study, 82 patient cases with the confirmed diagnosis of single AIS without other neurological deficits were included in this study. All patients had their first stroke attack within 6 weeks after stroke. The ages of all patients were from 29 to 77 years. All patients had no useful hand function. Patients were excluded if they had conditions that affect the outcome evaluations, or the case had incomplete data in this study.

2.4. Intervention schedules

Patients in both groups received the wrist training by 2 experienced physicians. The training was performed 3 sessions weekly, for a total of 4 consecutive weeks. Additionally, patients in the intervention group also received NMES therapy. It applied to patients with 30 minutes per session daily at the wrist and finger extensors, once daily, 3 days weekly, for a total of 4 weeks. Treatment was delivered by electrodes at the dorsal surface of the forearm with 300 μs pulse width; 40 Hz frequency; and 15 seconds of ON and OFF time, respectively.[23] Of these, frequency was set to achieve maximum possible range of wrist and finger extension, which was tolerable to the patients.

2.5. Outcome measurements

The primary outcome measure was arm function recovery. It was measured by Action Research Arm Test (ARAT) score.[24] This tool is a 19-item scale, and it is divided into 4 sub-tests (grasp, grip, pinch, and gross arm movement). Each item ranges from 0, can perform no part of test, to 3, perform test normally.

Secondary outcomes consisted of activities of daily living, measured by Barthel Index (BI);[25] and pain, measured by the numerical rating scale (NRS) (ranging from 0, no pain to 10, worst pain).[26] BI scale ranges from 0 to 20, with lower scores indicating worse disability. All the outcomes were measured before and after 4-week treatment.

2.6. Statistical analysis

All data were analyzed by using SPSS software (SPSS V.17.0, IBM Corp., Armonk, NY). Dichotomous variables were analyzed by Fisher's exact test; continuous data were conducted by Mann–Whitney U test. A value of $P < .05$ was set as the statistical significance.

3. Results

The characteristics of patients in both groups are summarized in Table 1. There were not significant differences in all values before the treatment between 2 groups in this study.

After 4-week treatment, patients in the intervention group did not exert better outcomes in arm function recovery, measured by ARAT score ($P = .79$, Table 2); activities of daily living, measured by BI scale ($P = .62$, Table 3); and pain reduction, measured by NRS scale ($P = .11$, Table 4), compared with patients in the control group.

Table 1

Patient characteristic before the treatment.

Characteristics	Intervention group (n = 41)	Control group (n = 41)	*P* value
Age (year)	70.4 (12.2)	68.9 (13.1)	.59
>65	26 (63.4)	29 (70.7)	.48
≤65	15 (36.6)	12 (29.3)	–
Race (Chinese)	41 (100.0)	41 (100.0)	–
Sex			
Male	18 (43.9)	22 (53.7)	.38
Female	23 (56.1)	19 (46.3)	–
Hypertension	25 (61.0)	28 (68.3)	.49
Diabetes	14 (34.1)	12 (29.3)	.64
Time to post stroke (week)	3.6 (1.4)	3.4 (1.3)	.50
Stroke type			
Ischemia	41 (100.0)	41 (100.0)	–
Total anterior circulation syndrome	24 (58.5)	21 (51.2)	.51
Partial anterior circulation syndrome	11 (26.8)	17 (41.5)	.16
Lacunar syndrome	5 (12.2)	3 (7.3)	.46
Posterior circulation syndrome	1 (2.5)	0 (0)	.50

Data are present as mean±standard deviation or number (%).

Table 2

Comparison of arm function recovery before and after 4-week treatment.

ARAT scale	Intervention group (n = 41)	Control group (n = 41)	*P* value
At baseline	0.3 (1.8)	0.4 (2.0)	.81
After treatment	4.2 (10.5)	3.6 (9.7)	
Difference from baseline	3.9 (1.6, 6.4)	3.0 (1.1, 5.2)	
Difference between groups		0.9 (0.3, 1.5)	.79

Data are present as mean±standard deviation. ARAT = Action Research Arm Test.

4. Discussion

Several clinical studies investigated the effectiveness of NMES in patients with wrist dysfunctions after stroke. Two studies conducted in Hongkong utilized NMES plus robot assisted wrist training to assess its effectiveness in hemiplegic patients with chronic stroke.[19,22] Their results found that NMES-robot assisted wrist training could enhance the functions of the attacked hand, wrist, and elbow.[19,22] The other 2 studies performed in UK and evaluated the effects of surface NMES for the stroke patients at early stage with no functional arm movement.[20,21] The results showed that NMES can either improve muscle strength, or reduce pain and contractures, although no significant effect was found on spasticity.[20,21]

Table 3

Comparison of activities of daily living before and after 4-week treatment.

BI score	Intervention group (n = 41)	Control group (n = 41)	*P* value
At baseline	2.7 (3.1)	2.9 (3.4)	.68
After treatment	4.5 (3.5)	4.1 (3.7)	
Difference from baseline	1.8 (0.9–3.0)	1.2 (0.4–2.1)	
Difference between groups		0.8 (0.4–1.3)	.62

Data are present as mean±standard deviation. BI = Barthel Index.

Table 4

Comparison of pain before and after 4-week treatment.

NRS score	Intervention group (n = 41)	Control group (n = 41)	*P* value
At baseline	0.3 (0.2)	0.3 (0.4)	1.00
After treatment	1.0 (0.4)	1.5 (0.7)	
Difference from baseline	0.7 (0.2, 1.3)	1.2 (0.6, 2.0)	
Difference between groups		−0.4 (−0.8, −0.1)	.11

Data are present as mean±standard deviation. NRS = numerical rating scale.

The results of this study are inconsistent with the previous studies.[20,21] This study found that patients in the intervention group did not show greater effectiveness of pain relief, measured by NRS, and wrist function improvements, as measured by the ARAT score, and BI scale, when compared with the patients in the control group. It indicated that NMES may not benefit for pain reduction, as well as the wrist function enhancement in AIS patients with wrist dysfunction.

This study has following limitations. Firstly, the dose of this study may be insufficient for treating the patients with wrist dysfunction after AIS, compared with the previous studies.[20,21] In this study, we applied NMES 30-minute session, once daily, 3 days weekly, for a total of 4 weeks, while the previous studies utilized the NMES at 30-minute sessions of NMES, twice daily or a maximum of 3 times daily, 5 days weekly for a total of 6 weeks.[20,21] Thus, it may be the reason that our study did not find positive effectiveness of NMES treatment. Secondly, the outcome measurements were not comprehensive in this retrospective study, because all the outcome data collected from the available cases with completed treatment. Thirdly, no randomization and blinding were utilized in this study, which may also affect the results of this study. Finally, this study had an intrinsic limitation because of the retrospective study itself, which may impact its results.

5. Conclusions

The results of this study demonstrated that NMES might not benefit for AIS patients with wrist dysfunction.

Author contributions

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