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Study on the Effect of Repetitive Peripheral Magnetic Stimulation Combined with Conventional Rehabilitation Measures on Shoulder Dysfunction in Early Stroke

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Abstract: *Objective:* To study the effect of repetitive peripheral magnetic stimulation (rPMS) combined with conventional rehabilitation measures on shoulder dysfunction in early stroke. *Methods:* 60 patients with shoulder dysfunction in early stroke were selected, and all of them were admitted to our hospital from August 2021 to August 2023. The patients were randomly grouped into a control group (conventional rehabilitation measures intervention, 30 cases) and an intervention group (rPMS and conventional rehabilitation measures intervention, 30 cases) according to the lottery method. The pain scores, shoulder mobility, and motor function scores of the two groups were compared. *Results:* The pain score was lower in the intervention group, and the shoulder mobility and motor function scores were higher in the intervention group ($P < 0.05$) as compared to that of the control group. *Conclusion:* The effect of combining rPMS and conventional rehabilitation measures in treating shoulder dysfunction in early stroke was remarkable and should be popularized.

Keywords: Repetitive peripheral magnetic stimulation; Conventional rehabilitation measures; Early stroke; Shoulder joint function

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1. Introduction

Stroke is defined as damage to the cerebral blood vessels from a variety of causes, resulting in focal damage or overall damage to brain tissue [1,2]. Stroke is characterized by high morbidity, mortality, and recurrence rates, and many patients are left with functional disabilities that adversely affect their quality of life. Early stroke patients have impaired innervation function and usually exhibit symptoms such as shoulder dysfunction, muscle weakness, pain, shoulder subluxation, sensory deficits, etc. These will hinder their functional recovery, making it difficult to improve their quality of life [3,4]. The treatment for these types of conditions is mostly conventional rehabilitation measures, such as upper extremity support, sensory stimulation, and strength training, which

are generally ineffective and inadequate for restoring neurological function. Repetitive peripheral magnetic stimulation (rPMS) is an emerging rehabilitation technology that can accurately localize and stimulate the corticospinal tracts. This method enhances the function of the corticospinal tracts, facilitates the reorganization of neural function, and improves muscle relaxation and contraction [5,6]. However, there is a lack of studies using rPMS for the improvement of shoulder joint function. Hence, this study selected 60 patients with shoulder joint dysfunction in early stroke to study the effectiveness of rPMS and conventional rehabilitation measures in treating shoulder joint dysfunctions, in hopes of providing a reference basis for future clinical practices.

2. Information and methods

2.1. Baseline information

The study was conducted from August 2021 to August 2023. The subjects of this study included 60 patients with shoulder dysfunction in early stroke who were admitted to our hospital, where they were randomly grouped by drawing lots. Two groups were formed, namely the control group and intervention group, with 30 subjects each,

The control group consisted of 20 males and 10 females from 36 to 75 years old, with an average age of (58.43 ± 10.38) years. There were 22 cases of ischemic stroke and 8 cases of hemorrhagic stroke. The affected limbs were left-sided in 17 cases and right-sided in 13 cases; the shortest length of the disease was 12 days while the longest was 86 days, with an average duration of (58.12 ± 10.35) days. The average level of education was (58.12 ± 10.35) days with 9 cases in junior high school or below, 13 cases in middle or high school, and 8 cases in college and above.

The intervention group consisted of 18 males and 12 females from 40-77 years old, with an average age of (59.26 ± 10.75) years old. There were 20 cases of ischemic stroke and 10 cases of hemorrhagic stroke. The affected limbs were left-sided in 19 cases and right-sided in 11 cases; the shortest duration of the disease was 15 days and the longest was 90 days, with an average of (59.43 ± 10.67) days. There were 11 cases of patients in junior high school, 14 in middle or high school, and 5 in college and above. This was submitted to the Ethics Committee and was conducted after obtaining approval.

Selection criteria: (1) Signs of stroke in the early stage, and shoulder dysfunction; (2) possess complete medical records; (3) recorded time of first onset of the disease; (4) a stable condition; (5) informed and consented. Exclusion criteria: (1) A history of shoulder joint disease; (2) presence of intracranial metal foreign bodies; (3) pacemaker; (4) epilepsy history; (5) cranial bone defects; (6) cognitive disorders; (7) mental illnesses; (8) difficulty communicating.

2.2. Methods

The intervention group underwent conventional rehabilitation measures combined with rPMS intervention. The patients were educated about stroke disease and adjustments were made to their diet and sleep schedule, along with the prohibition of smoking and drinking. As per the doctor's instructions, the patients were administered medication to control their blood pressure, glucose level, blood lipid level, and nutritional nerves. Rehabilitation exercises, such as proper limb placement, sensory training, muscle training, etc., were carried out for 4 weeks. To carry out rPMS, a magnetic field stimulator, (model YRD CCY-II, registration certificate No.: Hubei medical device registration certificate No. 20142211249), was selected as the intervention tool. The "8" coil was selected and the affected side of the upper limb of the Erb's point (located in the triangle formed by the posterior edge of the clavicle and the sternocleidomastoid muscle, and the most superficial part of the brachial plexus nerves) was used as the stimulation site. The affected side deltoid muscle, biceps muscle, and the brachial

nerve were stimulated. The contraction of these muscles on the affected side was used to judge the stimulation intensity. The stimulation frequency was set to 20 Hz, and a string with three 20 Hz pulses was included. The string stimulation time was set to 200 ms and the muscles were stimulated for 2 seconds at 8-second intervals, for a total of 3 minutes. Before the stimulation treatment was carried out, the patient was instructed to adopt the supine position with their palms facing up and was also instructed to tilt his/her head 30° to the unaffected side when stimulating the Erb's point. The treatment was carried out once a day, 5 times a week for 4 weeks. On the other hand, the control group underwent conventional rehabilitation measures, with the same methods as those of the intervention group. The patients were subjected to 4 weeks of exercise and transcranial magnetic sham stimulation (TMS) was conducted.

2.3. Observation indexes

(1) Shoulder pain evaluation: A visual analog scale (VAS) [7] was used to evaluate the degree of pain from 0–10 points. The scores were proportional to the degree of pain.

(2) Shoulder joint mobility: mainly including flexion, extension, abduction, adduction, external rotation, internal rotation, and other activities.

(3) Evaluation of upper extremity motor function: the Fugl-Meyer (FMA) scale [8] was used to evaluate the upper extremity motor function. There were 66 points in total and the score level was proportional to the upper extremity motor function.

2.4. Statistical processing

The statistical software used was SPSS 22.0, and the measurement data were expressed as mean ± standard deviation and compared using the *t*-test; count data were expressed as rates using the chi-square (x^2) test. Results were considered statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of shoulder pain evaluation between the two groups

As shown in **Table 1**, the comparison of shoulder VAS scores between the two groups before intervention was not significant ($P > 0.05$); after intervention, shoulder VAS scores between the two groups were significant ($P < 0.05$).

Table 1. Shoulder VAS scores of both groups (mean ± standard deviation, points)

Group	Case, *n*	Pre-intervention	Post-intervention	*t*	*P*
Control	30	3.14 ± 0.85	2.67 ± 0.76	2.258	0.028
Intervention	30	3.21 ± 0.91	1.72 ± 0.52	7.787	< 0.001
t	-	0.308	5.650		
P	-	0.759	< 0.001		

3.2. Comparison of shoulder joint mobility between the two groups

As shown in **Table 2** and **Table 3**, the comparison of shoulder joint mobility between the two groups before intervention was not significant ($P > 0.05$); the comparison of shoulder joint mobility after intervention between the two groups was significant ($P < 0.05$).

Table 2. Active shoulder joint mobility of both groups (mean ± standard deviation, º)

Group	Case, *n*	Active forward flexion		Active backward Bend		Active inward		Active outward		Active internal rotation		Active external rotation	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control	30	66.75± 10.54	90.67 ± 15.34*	18.77 ± 6.32	29.12± 6.75*	26.35 ± 7.58	39.58± 8.13*	72.46 ± 10.67	88.96 ± 11.24*	35.74 ± 6.21	45.24± 7.13*	31.67 ± 5.24	44.15± 6.26*
Intervention	30	65.83± 9.57	107.49 ± 20.35*	18.26 ± 5.86	34.65 ± 7.23*	25.89 ± 7.26	47.61± 8.52*	72.08 ± 10.33	97.45 ± 10.26*	35.28 ± 6.35	55.28± 7.56*	31.58 ± 5.33	55.75± 7.45*
t	-	0.354	3.615	0.324	3.062	0.240	3.735	0.140	3.056	0.284	5.292	0.066	6.529
P	-	0.725	0.001	0.747	0.003	0.811	< 0.001	0.889	0.003	0.778	< 0.001	0.948	< 0.001

Table 3. Passive shoulder joint mobility of both groups (mean ± standard deviation, º)

Group	Case, *n*	Passive forward flexion		Passive backward Bend		Passive inward		Passive outward		Passive internal rotation		Passive external rotation	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control	30	152.67 ± 10.48	162.42 ± 11.85*	36.84 ± 4.51	40.21 ± 4.05*	60.02 ± 6.37	66.18 ± 5.92*	150.75 ± 10.68	163.74 ± 11.46*	74.36 ± 5.29	78.69 ± 5.03*	71.68 ± 5.46	77.25 ± 5.19*
Intervention	30	153.12 ± 10.64	175.13 ± 10.26*	36.25 ± 4.33	45.76 ± 4.11*	59.84 ± 6.26	72.04 ± 5.58*	149.77 ± 10.26	171.24 ± 10.58*	74.53 ± 5.32	84.66 ± 5.12*	71.15 ± 5.29	83.65 ± 5.48*
t	-	0.165	4.441	0.517	5.268	0.110	3.945	0.362	2.634	0.124	4.556	0.382	4.644
P	-	0.869	< 0.001	0.607	< 0.001	0.912	< 0.001	0.718	0.011	0.902	< 0.001	0.704	< 0.001

Note: Compared with the pre-intervention of this group, *$P < 0.05$

3.3. Comparison of upper limb motor function evaluation between the two groups

As shown in **Table 4**, the FMA scores of the two groups before the intervention were compared and the results were not significant ($P > 0.05$); after the intervention, the FMA scores of the two groups were compared and the results were significant ($P < 0.05$).

Table 4. FMA scores of the two groups (mean ± standard deviation, points)

Group	Case, *n*	Pre-intervention	Post-intervention	*t*	*P*
Control	30	29.12 ± 5.67	35.43 ± 5.27	4.465	< 0.001
Intervention	30	28.57 ± 5.73	40.29 ± 6.12	7.657	< 0.001
t	-	0.374	3.296		
P	-	0.710	0.002		

4. Discussion

Among cardiovascular and cerebrovascular diseases, stroke is fairly common and has a high incidence rate, posing a serious threat to human health. In the early stages of stroke, the central nerve cells are damaged, and the nerve conduction pathways are obstructed and interrupted, causing the loss of limb control. This eventually results in the decline of limb function on the hemiplegic side of the patient, causing pain and affecting the quality of life of the patient [9–10]. Therefore, clinical intervention is required to relieve pain and improve limb function.

Recently, rPMS technology has been widely used in the rehabilitation treatment of post-stroke spasticity and other rehabilitation therapies, which can promote the recovery of limb function by stimulating the localization of muscle to restore the cortical function, neural network, neural pathway, and reduce muscle tension. In this study, the intervention group underwent rPMS intervention combined with conventional rehabilitation measures to accurately stimulate the cerebral cortex that corresponds to shoulder dysfunction. As a result, the function of the affected limbs was improved, muscle function was restored, and the degree of paralysis was alleviated. Furthermore, pain in the shoulder was relieved, and its motor function and the patient's quality of life were improved.

This study showed that the VAS score of the intervention group with increased rPMS intervention was lower as compared to that of the control group, suggesting that increased rPMS intervention significantly relieved pain in shoulder dysfunction patients with early stroke, which may be because rPMS intervention reduces muscle tension and relieves spasm through the peripheral stimulation, thus reducing pain. In regards to shoulder mobility, the intervention group had significantly better results than the post-intervention control group, indicating that increased rPMS intervention was able to improve shoulder mobility. The FMA score of the intervention group was higher than that of the control group after receiving rPMS intervention, indicating that the motor function of the affected limb of the patients was significantly improved after increasing rPMS intervention.

5. Conclusion

rPMS combined with conventional rehabilitation measures for shoulder dysfunction in early stroke was able to reduce the VAS score, improve shoulder mobility, and increase the FMA score, making rPMS worthy to be popularized in the rehabilitation of stroke patients with shoulder joint dysfunction.

Disclosure statement

The authors declare no conflict of interest.

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