Pathogenesis and Treatment in Stroke

ORIGINAL RESEARCH

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The Application Value of Bilateral Repetitive Transcranial Magnetic Stimulation Assisted by Swallowing Respiratory Guidance in the Treatment of Patients with Dysphagia After Stroke

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Keywords

Dysphagia after stroke
Swallowing respiratory guidance
Repetitive transcranial magnet stimulation
Application value

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Received: 5 September 2023
Revised: 20 September 2023
Accepted: 28 September 2023
Published: 13 October 2023

Pathogenesis and Treatment in Stroke **2023; 1(1): 10–19.**

Abstract

Objective: This study investigates the application value of bilateral repetitive transcranial magnetic stimulation (rTMS) assisted by swallowing respiratory guidance in the treatment of patients with dysphagia after stroke. **Methods:** 46 patients with dysphagia after stroke in our hospital from January 2022 to December 2022 were treated with bilateral rTMS and allocated into group A, and 46 patients with dysphagia after stroke that treated with bilateral rTMS assisted by swallowing respiratory guidance were assigned into group B. The clinical efficacy in the two groups was compared, the information on the grade of water swallow test and levels of respiratory function and nerve injury indexes in the two groups was collected, and the occurrence of adverse reaction in the two groups was recorded during the treatment. **Results:** The total effective rate in group B was higher than that in group A ($\rho < 0.05$). Compared with before treatment, the grade of water swallow test and the levels of neuron-specific enolase (NSE), visinin-like protein 1 (VILIP-1), neuropeptide Y (NPY), and breath frequency (BF) in two groups were decreased after treatment, and those in group B were lower than those in group A ($\rho < 0.05$). Compared with before treatment, the levels of forced vital capacity (FVC) and maximum voluntary ventilation (MVV) in two groups were increased after treatment, and the levels in group B were higher than those group A ($\rho < 0.05$). There was no significant difference in the incidence of adverse reaction between the two groups ($\rho > 0.05$). **Conclusion:** Bilateral rTMS assisted by swallowing respiratory guidance is effective in the treatment of dysphagia after stroke, which can alleviate the symptoms of dysphagia, improve respiratory function, effectively relieve nerve damage, and will not cause more serious adverse reaction.

1 Introduction

Stroke is the second leading cause of disability and death in the world, frequently occurring in middle-aged and elderly people [1]. The incidence of stroke in China continues to be higher than the global average, and the number of people aged 40 years and older in China who are suffering from and have suffered from stroke will be about 17.04 million by 2019 [2,3]. Stroke is a clinical syndrome of cerebral dysfunction caused by blood circulation disorders in the brain, and it is prone to many sequelae, among which dysphagia is one of the most common complications [4]. The main reason for dysphagia is that stroke can cause related nerve damage, affect the body's ability to control the muscles of the pharynx, and lead to respiratory diseases such as choking or aspiration pneumonia in serious cases, thereby jeopardizing patients' health and even life. At present, the clinical treatment of dysphagia is mainly based on neuromodulation technology and comprehensive rehabilitation training [5,6].

Massive studies have revealed that bilateral repetitive transcranial magnetic stimulation (rTMS), as a neuromodulation technique, can effectively regulate patients' brain function and improve symptoms such as dysphagia and aphasia, making it a safe treatment for dysphagia after stroke [7,8]. Currently, it has been reported that rTMS can improve overall swallowing function and activity of daily living ability in post-stroke dysphagia patients with good acceptability and mild adverse effects [9,10]. In comprehensive rehabilitation training treatment, research has demonstrated that respiratory training can improve the respiratory function of patients with dysphagia after stroke [11]. Swallowing respiratory guidance technique originating from the ancient Chinese guiding gong exercise, which innovatively combines modern rehabilitation therapy with traditional exercise therapy, can regulate the coordination between respiration and swallowing, and is clinically applicable to patients with dysphagia after stroke [12]. At the same time, the study by Li et al. has demonstrated that swallowing respiratory guidance plays a good supporting role in other treatment plans for dysphagia after stroke [13].

This study aims to further investigate the application value of bilateral rTMS assisted by swallowing respiratory guidance in the treatment of patients with dysphagia after stroke, with the purpose of promoting the recovery of swallowing function after stroke, improving the rehabilitation effect, and providing a reference for the actual clinical treatment of the patients with dysphagia after stroke.

2 Materials and methods

2.1 General data

46 patients with dysphagia after stroke in our hospital from January 2022 to December 2022 were treated with bilateral rTMS and allocated into group A, and 46 patients with dysphagia after stroke that treated with bilateral rTMS assisted by swallowing respiratory guidance were assigned into group B. There was no significant difference between the general data in the two groups of patients ($p > 0.05$), but these data were comparable, as shown in Table 1. The study was approved by the Ethics Committee of our hospital and all patients signed the written informed consent.

Inclusion criteria: (1) Patients were confirmed to have a stroke according to the diagnostic criteria in Chinese Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke 2018 [14]. (2) Patients were diagnosed by dysphagia after stroke according to the diagnostic criteria in Advances in Evidence-Based Nursing Practice for the Identification and Management of Swallowing Disorders in Stroke [15]. (3) Patients were confirmed as stroke by CT or MRI. (4) Patients who can complete respiratory function testing with assistance. (5) Patients aged 50 to 80, and they

were conscious, had no serious cognitive or sensory impairments, and could carry out simple motor commands. (6) Patients did not receive systematic treatment for dysphagia after stroke prior to the inclusion of the participants.

Exclusion criteria: (1) Patients with dysphagia caused by other factors. (2) Patients with exacerbation of the disease or recurrence of cerebrovascular disease during the course of our study. (3) Patients with inability to tolerate the magnetic stimulation used in this study. (4) Patients with other neurological disorders. (5) Patients with psychiatric disorders and poor treatment compliance.

Table 1 General data.

Groups	Cases	Gender (case)		Age (years old)	Type of disease (case)		Degree of dysphagia (case)		
		Male	Female		Cerebral hemorrhage	Cerebral infarction	Ⅲ	Ⅳ	Ⅴ
Group A	46	28	18	66.76 ± 10.21	23	23	10	13	23
Group B	46	32	14	67.93 ± 9.12	20	26	15	16	15
$\chi^2/t/Z$		0.767		0.582	0.393		-1.679		
p		0.381		0.562	0.531		0.093		

2.2 Inclusion, exclusion and dropout criteria

2.2.1 Group A

Patients were treated with bilateral rTMS using YRD CCY-II pulsed magnetic fields stimulation instrument (Wuhan Yiruide Medical Treatment Equipment New Technology Co., Ltd.). The motor thresholds of the patients in the resting state were determined before the treatment, after which the frequency of 3 Hz and the stimulation intensity of 80% RMT were selected to stimulate the pre-cranial external cortex of the patients' cerebral hemisphere for 10 s, with an interval of 5 s. The treatment of bilateral rTMS was performed once a day, with 5 days as a course. After 1 course of treatment, patients rested for 2 days. The treatment was continued for 4 courses.

2.2.2 Group B

Patients were treated with swallowing respiratory guidance as an adjuvant therapy on the basis of bilateral rTMS. The treatment was performed once a day, with 5 days as a course. After 1 course of treatment, patients rested for 2 days. The treatment was continued for 4 courses. The swallowing respiratory guidance was divided into three sections, including relaxation training, formal training, and end training. Relaxation training included 4 sections. ① Training to relax the muscles of the mouth and face was performed, such as opening mouth, closing mouth, puffing cheeks, showing teeth, sticking out tongue, and retracting tongue. ② The head was bent forward, backward and sideways to relax the neck muscles. ③ The fist was clenched and the shoulders

were lifted to relax the muscles of the shoulder and arm. ④ Flexion and extension of the trunk were conducted to relax the muscles of the back. After patients completed each of the above movements for 10 s, they are allowed to relax for 10 s. Formal training was specifically divided into five sections: ① Patient sit in a seated position, flexed the hips and knees, separated their feet, put their hands on the knees, and closed their eyes slightly. The trainee was guided to imagine that he or she was in the open nature world, breathing slowly and evenly for 30 s. ② Patient sit in a seated position, flexed the hips and knees, separated their feet, and hung down their hands naturally. The trainee was guided to close the lips and mouth tightly, close the jaw slightly, inhale deeply through the nose for 3 s, exhale slowly with the narrowed mouth for 6 s, and repeat the breathing for 6 times. ③ Patient sit in a seated position, flexed the hips and knees, separated their feet, and put their hands on abdomen. The trainee was guided to close the lips and mouth tightly, close the jaw slightly, inhale deeply through the nose for 3 s, feel the abdomen bulge on inhalation, exhale slowly by contracting the mouth, press the abdomen with the hand on exhalation for 6 s, and repeat the breath for 6 times. ④ Patient sit in a seated position, flexed the hips and knees, separated their feet, performed Bobath grip through hands crossing. The trainee was guided to inhale deeply through the nose for 3 s while lifting both upper limbs, exhale slowly for 6 s while lowering both arms with the mouth contracted, and repeat the breath for 6 times. ⑤ Patient sit in a seated position, slightly closed eyes, kept body and head straight, flexed hips and knees, separated their feet, put their hands on the knees. The trainee was guided to close the lower jaw slightly, pronounced "Xu, He, Hu, Si, Chui, and Xi", exhale to pronounce the word, breathe in through the nose at the end of the exhalation, and simultaneously imagine that the gas entered the Dantian along the meridians, one exhalation and one inhalation for one time, with a total of six pronunciations of each word. At the end of each pronunciation exercise, patients breathed evenly for two cycles.

2.3 Research indicators

In this study, we collected clinical data such as the grade of water swallow test and levels of respiratory function and nerve injury indexes that had been detected and registered during the treatment in two groups of patients with dysphagia after stroke, and recorded the symptomatic changes and the occurrence of adverse reaction during the treatment based on the medical records.

(1) Clinical efficacy: Clinical efficacy in the two groups after treatment was compared. Cured: dysphagia was completely disappeared, and the results of water swallow test were determined to be grade Ⅰ; significantly effective: dysphagia was basically disappeared, and the results of water swallow test were upregulated by 2 grades compared with the before treatment; effective: dysphagia was improved, and the results of water swallow test were upregulated by 1 grade compared with before treatment; ineffective: the above criteria were not met. Total effective rate of treatment = the number of (cured + significantly effective + effective) cases / total number of cases × 100%.

(2) Grade of water swallow test: The grade of water swallow test before and after 4 courses of treatment in both groups was compared, with a total of 5 grades; ① Grade Ⅰ (excellent): patients could swallow the water once; ② Grade Ⅱ (good): patients could swallow water twice or more without choking; ③ Grade Ⅲ (moderate): patients could swallow water once with choking; ④ Grade Ⅳ (OK): patients could swallow water twice or more with choking; ⑤ Grade Ⅴ (poor): patients could not swallow all the water with frequent choking [16].

(3) Respiratory function indexes: Respiratory function indexes in the two groups before and after 4 coursesof

treatment were compared. The Quark-PFT lung function monitor from Cosmed (Italy) was used to measure the levels of forced vital capacity (FVC), maximum voluntary ventilation (MVV), and breathing frequency (BF) in the two groups under resting state.

(4) Nerve damage indexes: Nerve damage indexes in the two groups before and after 4 courses of treatment were compared. 3 mL of venous blood was collected from both groups, and centrifuged to obtain the supernatant. Levels of neuron-specific enolase (NSE, SE120088), visinin-like protein 1 (VILIP-1), and neuropeptide Y (NPY) were measured by enzyme-linked immunosorbent assay (ELISA) using the kits provided by Shanghai Beinuo Biotechnology Ltd., Fujirebio Diagnostics AB, and Shanghai Huzhen Industrial Co., Ltd. Testing was conducted strictly following the instructions of the kits.

(5) Adverse reaction: Adverse reactions such as dizziness, nausea, and tinnitus that may occur during treatment were recorded and compared between the two groups.

2.4 Statistical methods

Statistical analysis was performed using SPSS 20.0. Count data were expressed as cases (%), comparisons between the two groups were carried out using χ^2 test, and measurement data were described as mean ± standard deviation. Independent samples t-test was used for the comparison between the two groups, and paired samples t-test was used for the comparison in the same group at different time points. Differences were considered to be statistically significant at $p < 0.05$.

3 Results

3.1 Comparison of clinical efficacy between the two groups

The total effective rate in group B was higher than that in group A ($p < 0.05$), as seen in Table 2.

Table 2 Comparison of clinical efficacy between the two groups [cases (%)].

Groups	Cases	Cured	Significantly effective	Effective	Ineffective	Total effective rate
Group A	46	0 (0.00)	12 (26.09)	20 (43.48)	14 (30.43)	32 (69.57)
Group B	46	3 (6.52)	16 (34.78)	25 (54.35)	2 (4.35)	44 (95.65)
χ^2						10.895
p						0.001

3.2 Grade of water swallow test in both groups before and after treatment

Before treatment, there was no significant difference in the grade of water swallow test between the two groups of patients ($p > 0.05$). Compared with before treatment, the grade of water swallow test was decreased in both groups after treatment ($p < 0.05$), and the grade in group B was lower than that in group A ($p < 0.05$), as displayed in Table 3.

Table 3 Grade of water swallow test in both groups before and after treatment [case (%)].

Groups	Cases	Before treatment					After treatment				
		Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ
Group A	46	0 (0.00)	0 (0.00)	11 (23.91)	13 (28.26)	22 (47.83)	4 (8.70)	13 (28.26)	12 (26.08)	13 (28.26)	4 (8.70)*
Group B	46	0 (0.00)	0 (0.00)	16 (34.78)	17 (36.96)	13 (28.26)	10 (21.74)	22 (47.83)	9 (19.56)	5 (10.87)	0 (0.00)*
Z				-1.805					-3.436		
p				0.071					0.001		

Note: Comparison with the same group before treatment, *$p < 0.05$

3.3 Comparison of respiratory function between the two groups before and after treatment

Before treatment, there was no significant difference between the levels of FVC, MVV and BF in the two groups ($p > 0.05$). Compared with before treatment, the levels of FVC and MVV in the two groups were increased ($p < 0.05$), and the levels in group B were higher than those in group A after treatment ($p < 0.05$). Compared with before treatment, level of BF in the two groups was decreased ($p < 0.05$), and the level in group B was lower than that in group A after treatment ($p < 0.05$), as shown in Table 4.

Table 4 Comparison of respiratory function between the two groups before and after treatment (mean ± standard deviation)

Groups	Cases	FVC (%)		MVV (%)		BF (times/min)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Group A	46	68.76 ± 5.70	72.89 ± 4.72*	65.48 ± 6.16	72.84 ± 7.23*	20.80 ± 2.75	18.54 ± 1.12*
Group B	46	68.65 ± 5.35	83.10 ± 4.90*	65.67 ± 5.62	83.12 ± 7.84*	20.46 ± 1.90	16.20 ± 0.40*
t		0.095	10.178	0.155	6.538	0.690	13.345
p		0.924	0.000	0.878	0.000	0.492	0.000

Note: Comparison with the same group before treatment, *$p < 0.05$

3.4 Comparison of nerve damage indexes in the two groups before and after treatment

Before treatment, there was no significant difference between the levels of NSE, VILIP-1, and NPY in the two groups ($p > 0.05$). Compared with before treatment, the levels of NSE, VILIP-1, and NPY were reduced in both groups ($p < 0.05$), and the levels in group B were lower than those in group A ($p < 0.05$), as shown in Table 5.

Table 5 Comparison of nerve damage indexes in the two groups before and after treatment (mean ± standard deviation).

Groups	Cases	NSE (ng/mL)		VILIP-1 (pg/mL)		NPY (pg/mL)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Group A	46	16.08 ± 1.35	10.62 ± 1.00*	594.23 ± 44.58	453.85 ± 40.26*	246.89 ± 23.51	165.27 ± 15.69*
Group B	46	15.95 ± 1.30	7.24 ± 0.62*	588.74 ± 42.16	325.16 ± 29.65*	242.38 ± 21.15	103.76 ± 9.46*
t		0.470	19.483	0.607	17.456	0.967	22.770
p		0.639	0.000	0.546	0.000	0.336	0.000

Note: Comparison with the same group before treatment, *$p < 0.05$

3.5 Comparison of adverse reaction between the two groups

There was no significant difference in the incidence of adverse reaction between the two groups ($p > 0.05$), as shown in Table 6.

Table 6 Comparison of adverse reaction between the two groups [case (%)].

Groups	Cases	Dizziness	Nausea	Tinnitus	Epilepsy	Adverse reaction
Group A	46	1 (2.17)	1 (2.17)	1 (2.17)	0 (0.00)	3 (6.51)
Group B	46	1 (2.17)	0 (0.00)	0 (0.00)	0 (0.00)	1 (2.17)
χ^2						0.261
p						0.609

4 Discussion

In order to improve the clinical efficacy of patients with dysphagia after stroke, this paper investigated the effect of bilateral rTMS assisted by swallowing respiratory guidance in the treatment of patients with dysphagia after stroke. Our results have uncovered that bilateral rTMS assisted by swallowing respiratory guidance may have a better efficacy in the treatment of this disease.

Cerebrovascular circulatory disorders after stroke can lead to damage to the swallowing cortical areas and nerve cells in the brain, which weakens the body's ability to control swallowing-related muscle groups, thus causing swallowing dysfunction [17]. In this study, the recovery of neurological function injury in the two groups was assessed by observing the following three indicators: NSE, VILIP-1 and NPY. Among them, NSE has high activity in brain tissue cells, and a high level of this index may indicate the presence of intracranial infection or cerebral hemorrhage [18]. VILIP-1 is a sensitive indicator reflecting neuronal damage [19]. NPY can act in the central nervous system, promoting platelet aggregation, leukocyte adherence, and macrophage activation [20]. A decrease in the above three indexes represents that patients' comprehensive degree of neurological damage has been alleviated compared with that before treatment [18-20]. According to the results of this study, the use of bilateral rTMS assisted

by swallowing respiratory guidance in the treatment of patients with dysphagia after stroke effectively improved neurological damage and dysphagia and was more effective than the use of rTMS alone. Bilateral rTMS can stimulate the current to the representative area of the swallowing cortex of the brain, which affects the stimulated area and the distal area related to swallowing function, thus activating the neuronal reorganization of the cerebral cortex to compensate, and improving the patient's neurological function, and then restoring the function related to swallowing [9,10]. In the study by León et al., rTMS has been revealed to be effective in reducing nerve damage and alleviating the symptoms of dysphagia in patients, which is consistent with the findings of Yin M [21,22]. Compared with these previous findings, our findings emphasized that the combination of bilateral rTMS and swallowing respiratory guidance is more effective than rTMS alone on treating neurological damage and dysphagia.

Swallowing respiratory guidance consists of swallowing breathing training and the six-letter word "Xu, He, Hu, Si, Chui, and Xi" [12]. Pronunciation of these six words by mouth, if simultaneously supplemented by the body guide and the idea of contemplation, can autonomously regulate the qi and blood flow of the internal organs and improve the body's swallowing function [12]. In the meantime, actions such as opening mouth, closing mouth, puffing cheeks, showing teeth, sticking out tongue, and retracting tongue in swallowing respiratory guidance can actively exercise the motor function of the patients' tongue and mouth, as well as improve their swallowing disorders [12]. In addition, the swallowing respiratory guidance organically combines body adjustment, qi adjustment, and spirit adjustment, and the breathing and rehabilitation actions are given equal importance, which plays a role in harmonizing yin and yang and cultivating both the spirit and the body, thereby stimulating the body's rehabilitation state and improving the therapeutic effect of bilateral rTMS on the patient's neurological injuries [23]. In our results, it can be seen that bilateral rTMS assisted by swallowing respiratory guidance can alleviate the symptoms of dysphagia in stroke patients and effectively reduce the neurological damage, thus obtaining a better therapeutic effect than the single use of rTMS, which was consistent with the description in previous literature.

Patients with dysphagia after stroke often have impaired respiratory function, which may be complicated by aspiration pneumonia in severe cases [24, 25]. In this study, three lung function indicators, FVC, MVV, and BF, were chosen to assess the overall function of the lungs and the respiratory system [26,27]. According to the results of this study, the use of bilateral rTMS assisted by swallowing respiratory guidance in the treatment of patients with dysphagia after stroke effectively improved their respiratory function and was more effective than the use of rTMS alone. Bilateral rTMS can improve patients' respiratory function by restoring their respiratory-related neural function, inducing respiratory excitability, and thus improving the function of their respiratory-related muscle groups [28]. Swallowing respiratory guidance can enhance the respiratory function of patients by exercising the strength of respiratory muscles, and the reflexive cough training after swallowing can effectively protect the airway of patients, which has been proved to be effective in improving the respiratory function of patients with dysphagia after stroke in many studies [29,30]. Therefore, the use of bilateral rTMS assisted by swallowing respiratory guidance in the treatment of patients with dysphagia after stroke not only better restored the patient's respiratory-related neurological function, but also improved the existing respiratory symptoms. At the same time, bilateral rTMS assisted by swallowing respiratory guidance is a more scientific

than rTMS alone in the treatment of specific symptoms of the disease.

The results of this study revealed that no serious adverse reaction occurred in both groups during the treatment, indicating that bilateral rTMS assisted by swallowing respiratory guidance had good safety in the treatment of patients with dysphagia after stroke.

5 Conclusions

Bilateral rTMS assisted by swallowing respiratory guidance is effective in the treatment of dysphagia after stroke, which can alleviate the symptoms of dysphagia, improve respiratory function, and effectively relieve nerve damage, with a higher safety. There are certain shortcomings in this study, such as the small number of included cases, single source of research subjects, and the limited representativeness, which need to be further addressed by expanding the sample size and sample randomness in the future, to provide more convincing evidence for bilateral rTMS assisted by swallowing respiratory guidance in the treatment of dysphagia after stroke.

Acknowledgements

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

Conceptualization: Wujie Zhai; Data curation: Wenjie Zhai; Formal analysis: Wujie Zhai; Methodology: Wenjie Zhai; Writing – original draft: Wujie Zhai; Writing – review and editing: Wenjie Zhai; All authors have read and agreed to the published version of manuscript.

Ethics Approval and Consent to Participate

This study was approved by Medical Ethics Committee, and patients were informed and agreed.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of Data and Materials

The analyzed data sets generated during the study are available from the corresponding author on reasonable request.

Supplementary Materials

Not applicable.

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