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Clinical Observation of Manual Breathing Function Training Combined with Repetitive Transcranial Magnetic Stimulation in the Treatment of Post-stroke Dysphagia

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Keywords: Stroke; Dysphagia; Repetitive Transcranial Magnetic Stimulation (rTMS); Respiratory Function Training; Standard Swallowing Function Assessment; Aspiration

Abstract: To investigate the clinical efficacy of manual breathing training combined with repetitive transcranial magnetic stimulation (rTMS) in post-stroke dysphagia. A total of 90 patients with post-stroke dysphagia were randomly divided into three groups: respiratory training group, transcranial magnetic stimulation (TMS) group, and combined therapy group, with 30 cases in each group. All three groups received conventional swallowing rehabilitation therapy (including swallowing organ motor training, sensory stimulation, and low-frequency electrical stimulation). The respiratory training group additionally received manual breathing training, the TMS group received rTMS therapy, and the combined therapy group received both interventions simultaneously. After four weeks of treatment, the swallowing function of the three groups was evaluated using the Standard Swallowing Assessment (SSA). After treatment, the SSA scores of all three groups showed significant improvement compared to baseline ($P<0.01$). The combined therapy group demonstrated significantly better improvement in SSA scores than the respiratory training group and the TMS group ($P<0.01$), while no statistically significant difference was observed between the latter two groups ($P>0.05$). Manual breathing training combined with rTMS can significantly improve swallowing function in post-stroke dysphagia patients and reduce the risk of aspiration. Its therapeutic efficacy is superior to that of single interventions, demonstrating a synergistic promoting effect.

1. Introduction

Stroke is one of the leading causes of disability and mortality worldwide, with dysphagia as a common complication occurring in over 51% of cases [1,2]. Dysphagia not only predisposes patients to malnutrition, dehydration, and aspiration pneumonia but also significantly increases mortality risks and imposes substantial burdens on families and society. Consequently, exploring safe and effective rehabilitation strategies for swallowing function remains a key focus in neurorehabilitation. Current clinical interventions for dysphagia include physical therapy, compensatory strategies, neuromodulation techniques, and acupuncture [3]. Studies have demonstrated [4] that manual breathing training enhances respiratory muscle strength and improves

respiratory-swallowing coordination, thereby improving swallowing safety and reducing the risk of aspiration. Repetitive transcranial magnetic stimulation (rTMS), as a non-invasive neuromodulation technique, promotes the reorganization and functional compensation of swallowing-related neural networks by modulating cortical excitability [5,6]. In recent years, some researchers have attempted to combine breathing training with rTMS for the rehabilitation of dysphagia, showing preliminary potential for synergistic therapeutic effects. Based on this, the present study aims to systematically evaluate the impact of manual breathing training combined with rTMS on swallowing function in post-stroke dysphagia patients, providing a basis for optimizing clinical rehabilitation protocols.

2. Materials and Methods

2.1 General Information

A total of 90 patients with post-stroke dysphagia admitted to the Department of Rehabilitation Medicine and the Department of Neurology at Zhengzhou First People's Hospital from May 2024 to October 2025 were selected. All patients met the criteria of the "China Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke (2018 Edition)" and the "China Guidelines for the Diagnosis and Treatment of Intracerebral Hemorrhage".

The diagnosis was confirmed by cranial CT or MRI examination [7,8]. Patients were randomly assigned to the respiratory training group, transcranial magnetic stimulation (TMS) group, and combined therapy group using a random number table, with 30 cases in each group. No statistically significant differences were observed in gender, age, disease duration, height, weight, or stroke type among the three groups ($P>0.05$), indicating comparability.

2.2 Inclusion and Exclusion Criteria

Inclusion Criteria 1) Compliance with the aforementioned diagnostic criteria; 2) Age range of 40–75 years; 3) Disease duration of 2–8 weeks with stable condition and no contraindications to rehabilitation training; 4) Presence of dysphagia; 5) Ability to maintain assisted sitting position for over 30 minutes and cooperation in completing relevant assessments and training; 6) Informed consent signed by the patient or family member.

Exclusion Criteria 1) Swallowing disorders not caused by stroke (e.g., Parkinson's disease, traumatic brain injury, dementia, motor neuron disease, postoperative conditions of the oral and maxillofacial region, etc.); 2) Inability to cooperate with examinations or treatments such as swallowing studies (e.g., coma, severe cognitive impairment, aphasia, or psychiatric disorders); 3) Swallowing disorders caused by bilateral cerebral hemisphere stroke or simultaneous involvement of one cerebral hemisphere and brainstem; 4) Unstable vital signs or comorbidities with multiple severe underlying diseases; 5) Contraindications to rTMS (e.g., history of epilepsy, cardiac pacemaker, intracranial metal implants, etc.); 6) Patients with malignant tumors.

2.3 Treatment Methods

All three groups received conventional medical treatment and basic swallowing rehabilitation, including motor training of swallowing organs, sensory stimulation and low-frequency electrical stimulation.

The breathing training group received additional manual breathing exercises on top of standard therapy. The training methods included: (1) Auxiliary respiratory muscle relaxation: Sequentially massage and stretch the upper trapezius, sternocleidomastoid, and scalene muscles, maintaining the direction of muscle fibers for 15 seconds to relieve muscle tension and improve neck-shoulder

mobility, preparing for subsequent training. (2) Breathing pattern training: ① Abdominal breathing: Abdominal protrusion during nasal inhalation (count 1, 2), abdominal adduction during lip-sucking exhalation (whistling-like exhalation, count 1, 2, 3, 4), avoiding thoracic movement, repeated 8 times. ② Lip-sucking breathing: Nasal inhalation with lip-sucking exhalation, inhalation-exhalation ratio 1:2 or 1:3, coordinated with hand-lifting movements, repeated 8 times. Twice daily, 10-20 minutes per session. (3) Breathing exercises: ① Single-lift breathing: Deep inhalation with one hand, slow exhalation during lowering. ② Sky-lifting breathing: Rhythmic lifting and lowering of both hands, alternating with inhalation-exhalation. ③ Squat-standing breathing: Inhale while squatting, exhale while standing. 30 minutes per session, once daily, five days per week, for four weeks.

The transcranial magnetic stimulation (TMS) group received conventional treatment supplemented with repetitive TMS, with the stimulation point located at the motor cortex representative area of the supraglottic muscle group in the affected cerebral hemisphere [9]. First, the vertex Cz point was identified, then moved anteriorly by 2-4 cm and laterally by 4-6 cm to locate the maximal evoked potential (MEP) stimulation point. The motor threshold (MT) was measured, and a stimulation dose of 120%MT was selected at a frequency of 5 Hz. Each treatment session lasted 20 minutes, administered once daily for 5 weeks, totaling 4 weeks of therapy.

The combined therapy group received both manual breathing training and rTMS treatment as described above.

2.4 Observation Indicators

The standard swallowing assessment (SSA) [10] was performed before treatment and 4 weeks after treatment to evaluate efficacy. The assessment consists of three steps: (1) Preliminary evaluation, including level of consciousness, head and trunk control, lip control, breathing pattern, voice intensity, pharyngeal reflex, and spontaneous coughing, scored 8–23 points; (2) Drinking one spoonful of water (approximately 5 mL), repeated three times, to observe for corner of mouth drooling, laryngeal movement, repeated swallowing, coughing during swallowing, choking, and voice quality, scored 5–11 points. If ≥2 times were normal, proceed to the third step; (3) Drinking 60 mL of water, to observe whether it can be completely completed within 2 minutes, with coughing, choking, and voice quality, scored 5–12 points. The total score of this scale is 46 points, with higher scores indicating poorer swallowing function.

2.5 Statistical Methods

Statistical analysis was performed using SPSS 26.0 software. Measurement data were expressed as mean ± standard deviation ($X \pm s$). Comparisons of measurement data were conducted using t-tests, while comparisons of categorical data were performed using $\chi 2$ tests. A P-value <0.05 was considered statistically significant.

3. Results

Prior to treatment, there was no statistically significant difference in the SSA scores among the three groups ($P>0.05$). After four weeks of treatment, the SSA scores in all three groups showed significant improvement compared to baseline ($P<0.01$). The improvement in SSA scores was significantly greater in the combined therapy group than in the respiratory training group and the transcranial magnetic stimulation group ($P<0.01$), while no statistically significant difference was observed between the respiratory training group and the transcranial magnetic stimulation group

(P>0.05). (See Table 1 for details.)

Table 1: Comparison of SSA Scores before and after Treatment in Three Patient Groups ($\bar{X}\pm s$, n=30)

Group	Pretherapy	Post-treatment
Breathing Training Group	35.2±3.1	28.5±2.8*
Transcranial magnetic stimulation group	34.9±3.4	27.9±3.0*
Combination therapy group	35.5±3.0	23.3±2.5*▲

Note: Compared with pre-treatment, *P<0.01; compared with the respiratory training group and transcranial magnetic stimulation group, ▲P<0.01

4. Discussion

There exists a highly coordinated neurophysiological relationship between swallowing and respiration, both regulated by the same neural circuit in the medulla oblongata. The pharyngeal phase achieves airway protection through brief apnea, which is crucial for preventing aspiration [11]. Disruption of the respiratory-swallowing rhythm during feeding can easily lead to aspiration. For patients with weakened coughing ability, aspiration may result in aspiration pneumonia. Post-stroke, cortical or subcortical damage can impair respiratory-swallowing coordination, leading to respiratory muscle weakness and diminished cough reflex, thereby increasing the risk of aspiration and aspiration pneumonia. Respiratory training enhances respiratory muscle function and improves cough efficiency, contributing to the restoration of swallowing safety and coordination [12].

In the field of neurological rehabilitation, the recovery of post-stroke swallowing function primarily relies on two mechanisms [13]: functional compensation of the non-affected brain regions and activation of neural plasticity in the damaged regions. Studies have demonstrated that enhancing sensory input to the affected side and strengthening neural network connectivity are critical pathways for promoting the reorganization of swallowing function [14]. Repetitive transcranial magnetic stimulation (rTMS), as a non-invasive neuromodulation technique, can modulate cortical excitability through frequency-specific approaches: high-frequency stimulation (>1 Hz) increases cortical excitability, while low-frequency stimulation (≤1 Hz) tends to inhibit corresponding regions. This can facilitate the functional reorganization of swallowing-related neural networks by regulating synaptic transmission efficiency and optimizing inter-brain functional connectivity. Existing evidence [15] indicates that high-frequency rTMS is more effective than low-frequency rTMS in treating post-stroke dysphagia. Therefore, the high-frequency rTMS protocol selected in this trial is consistent with the supporting evidence reported in previous literature.

This study combined manual breathing training with repetitive transcranial magnetic stimulation (rTMS) to promote swallowing function recovery through a "peripheral-central" dual pathway: respiratory training improves respiratory muscle function and respiratory-swallowing coordination at the peripheral level, while rTMS modulates the excitability and neural connectivity of swallowing-related cortical areas at the central level. The results demonstrated that the combined intervention significantly outperformed single treatments in improving the Stroke-Specific Assessment (SSA) score, indicating a synergistic effect. This finding aligns with recent research trends on the application of "dual stimulation" modalities in swallowing rehabilitation [16,17], suggesting that the integration of peripheral functional training and central nervous system modulation can more comprehensively promote neural functional reorganization and motor output optimization. Therefore, both manual breathing training and rTMS are effective methods for

improving post-stroke swallowing dysfunction, and their combined application can exert synergistic effects, significantly enhancing swallowing function and reducing the risk of aspiration. This combined therapeutic approach demonstrates good clinical applicability and promotion value, contributing to improved patient quality of life and rehabilitation outcomes.

The limitations of this study include: relatively small sample size, short treatment duration, and failure to evaluate long-term efficacy; lack of subgroup analysis based on stroke location, nature, etc.; and room for optimization in the parameter settings (e.g., frequency, intensity, duration) of respiratory training and rTMS. Future studies could further investigate the effects of different stimulation parameters, training intensity, and duration on efficacy, and combine neuroimaging techniques (e.g., fNIRS, fMRI) to elucidate the central mechanisms of the combined therapy.

No conflict of interest

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