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Observation on the Efficacy of Repetitive Transcranial Magnetic Stimulation Combined with Rehabilitation Training in the Treatment of Non-dementia Vascular Cognitive Impairment

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Abstract: *Objective:* To explore the effect of repetitive transcranial magnetic stimulation combined with rehabilitation training on improving cognitive function and quality of life in patients with non-dementia vascular cognitive impairment. Methods: 64 patients with non-dementia vascular cognitive impairment admitted to our hospital from January 2024 to December 2024 were selected and divided into a combination group and a rehabilitation group using the random number table method, with 32 cases in each group. The rehabilitation group used simple rehabilitation training, while the combined group added repetitive transcranial magnetic stimulation treatment on the basis of rehabilitation training. The clinical effects of the two groups were compared. Results: The cognitive function score and total quality of life score of the combined group were higher than those of the rehabilitation group, and the total effective rate of treatment was higher ($p < 0.05$). Conclusion: Repetitive transcranial magnetic stimulation combined with rehabilitation training can significantly improve the cognitive function of patients with non-dementia vascular cognitive impairment, improve the quality of life, and achieve better therapeutic effects.

Keywords: Repetitive transcranial magnetic stimulation; Rehabilitation training; Non-dementia vascular cognitive impairment; Cognitive function; Quality of life

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1. Introduction

Non-dementia vascular cognitive impairment is a syndrome of cognitive impairment caused by cerebrovascular lesions. The patient's cognitive level declines but does not reach the standard of dementia, but it has affected daily life. Its incidence rate gradually increases with the aging of the population and brings a heavy burden to the patient's family and society [1]. Relevant epidemiological data show that the prevalence of non-dementia vascular cognitive impairment among people over 60 years old has reached 5% to 10%, and about 10% to 15% of patients will progress to vascular dementia every year, becoming one of the important diseases affecting the health of the elderly [2]. Currently, clinical treatments

for this disease are relatively limited. Drug treatments mostly focus on improving cerebral circulation and nourishing nerves. However, long-term use is prone to adverse reactions and has poor efficacy. Rehabilitation training is a commonly used clinical intervention method, but its single application effect is limited, and it is difficult to solve the core problem of cognitive function impairment from the level of neuroregulation [3]. Repetitive transcranial magnetic stimulation, as a non-invasive neuromodulation technology, has shown good potential in the treatment of cognitive impairment due to its safety and convenience. Its mechanism of regulating cerebral cortex function through magnetic field pulses is complementary to the neural remodeling effect of rehabilitation training. Based on this, this study observes the clinical efficacy of the combined application of the two and provides practical reference for the treatment of non-dementia vascular cognitive impairment.

2. Materials and methods

2.1. General information

64 patients with non-dementia vascular cognitive impairment admitted to our hospital from January 2024 to December 2024 were selected and divided into a combination group and a rehabilitation group using the random number table method, with 32 cases in each group. The combined group included 17 men and 15 men, respectively, aged 55 to 78 (65.42 ± 5.18) years old. Among them, 21 cases had a history of cerebral infarction and 11 cases had a history of cerebral hemorrhage. The duration of the disease was 3 to 12 months, with an average of (6.85 ± 2.13) months. There were 16 men and 16 men in the rehabilitation group, aged 56 to 79 (65.76 ± 5.03) years old, including 20 cases with a history of cerebral infarction and 12 cases with a history of cerebral hemorrhage. The duration of the disease was 3 to 13 months, with an average of (7.02 ± 2.08) months. There was no significant difference in general information such as gender, age, medical history, and course of disease between the two groups ($p > 0.05$), and they were comparable.

2.1.1. Inclusion criteria

(1) Meet the diagnostic criteria for non-dementia vascular cognitive impairment;
(2) Score 21 to 26 points on the Mini-Mental State Examination Scale;
(3) Voluntarily participate in the study and cooperate with treatment.

2.1.2. Exclusion criteria

(1) Combined with severe heart, liver and kidney diseases;
(2) Have a history of epilepsy or intracranial metal implants;
(3) Have mental illness or difficulty in cooperating with cognitive assessment.

2.2. Method

The rehabilitation group used simple rehabilitation training, specifically including:

(1) Cognitive training
Daily memory training such as number retelling (reciting a sequence of 3 to 7 random numbers in increments), object recall (showing 10 common objects for 30 seconds and then recalling them with eyes closed), and attention training such as spotting differences (two pictures of similar objects). Find 5 differences in similar pictures), number elimination (cross out specified numbers in a random number matrix), 30 minutes each time, and the training difficulty is adjusted every 2 weeks according to the patient's tolerance;
(2) Exercise training
Guide the patient to perform limb balance training (stand on one leg with eyes open, squat against the wall quietly), joint mobilization Movement training (full range flexion and extension of joints such as shoulders, elbows, knees, and hips) and walking training (slow walking on level ground, walking on slopes), 40 minutes each time, and the training intensity is appropriate when the patient's heart rate reaches 60% to 70% of the maximum heart rate;

(3) Language training

Carry out vocabulary recognition (commonly used Chinese characters) for patients with reduced language function, two-syllable words), sentence expression training (describing picture content, simple daily conversations), 20 minutes each time; all training is guided one-on-one by professional rehabilitation therapists, once a day, 6 times a week, for 12 weeks of continuous treatment. During the training process, the patient's vital signs are monitored in real time to avoid overexertion.

The combined group added repetitive transcranial magnetic stimulation treatment on the basis of the treatment of the rehabilitation group, using the CCY-I repetitive transcranial magnetic stimulator produced by Wuhan Yired Medical Equipment Co., Ltd., and the stimulation site was the left dorsolateral prefrontal cortex (coordinates refer to the F3 point of the international 10–20 EEG system). The excitation frequency is 10 Hz, and the stimulation intensity is 80% of the motor threshold. The motor threshold was measured using the single-pulse stimulation method. Each stimulation is 20 minutes (a cycle mode including 5-second stimulation and 10-second interval), once a day, 6 times a week, with an interval of 2 hours between rehabilitation training, and continuous treatment for 12 weeks. Before treatment, the patient was informed in detail about the treatment process and possible symptoms of discomfort. During treatment, the patient was assisted to lie on his back, keeping his head fixed, and the electrode pads were attached at the correct position. During the treatment, the patient's reaction was closely observed. If discomfort such as headache, dizziness, etc. occurred, the stimulation intensity was adjusted in time or the treatment was suspended. After treatment, the patient was asked to rest in bed for 15 minutes before leaving the hospital.

2.3. Observation indicators

Compare the cognitive function scores (assessed with the Mini-Mental State Examination Scale, total score 30 points, covering dimensions such as orientation, memory, attention, calculation, etc.) and the total quality of life score (assessed with the SF-36 scale, total score 100 points) between the two groups before and after treatment. The higher the score, the higher the score. The better the quality of life) and the total effective rate of treatment. The total effective rate statistics exclude the proportion of symptoms that do not improve after treatment. Markedly effective means that the cognitive function score increases by ≥ 4 points, effective means that the cognitive function score increases by 2 to 3 points, and ineffective means that the cognitive function score improves by < 2 points or has no change.

2.4. Statistical methods

Data were analyzed using SPSS24.0. *t*-test for measurement data; χ^2 test for count data. $p < 0.05$ represents significant difference.

3. Results

3.1. Comparison of cognitive function scores between the two groups

After treatment, the score of the combined group was higher than that of the rehabilitation group ($p < 0.05$), **Table 1**.

Table 1. Comparison of cognitive function scores between the two groups ($\bar{x} \pm s$, points)

Group	Pre-treatment score	Post-treatment score
Rehabilitation group (32)	23.15 ± 1.26	25.38 ± 1.34
Joint group (32)	23.22 ± 1.31	27.86 ± 1.42
t	0.248	7.486
p	0.805	0.000

3.2. Comparison of total quality of life scores between the two groups

After treatment, the total score of the combined group was higher than that of the rehabilitation group ($p < 0.05$), **Table 2**.

Table 2. Comparison of total scores of quality of life between the two groups ($\bar{x} \pm s$, points)

Group	Total score before treatment	Total score after treatment
Rehabilitation group (32)	62.35 ± 5.18	68.74 ± 5.36
Joint group (32)	62.58 ± 5.24	76.92 ± 5.48
t	0.177	6.037
p	0.860	0.000

3.3. Comparison of the total effective rate of treatment between the two groups

The total effective rate of treatment in the combination group was higher than that in the rehabilitation group ($p < 0.05$), **Table 3**.

Table 3. Comparison of the total effective rate of treatment between the two groups [n (%)]

Group	Effective	Valid	Invalid	Total valid [n (%)]
Rehabilitation group (32)	12 (37.50)	8 (25.00)	12 (37.50)	20 (62.50)
Joint group (32)	12 (37.50)	19 (56.25)	2 (6.25)	30 (93.75)
χ^2				9.143
p				0.002

4. Discussion

The onset of non-dementia vascular cognitive impairment is closely related to insufficient cerebral blood perfusion, disordered neurotransmitter secretion, and abnormal neural network connections after cerebrovascular injury. Its core pathological changes involve functional decline in cognitive-related brain areas [4]. After cerebrovascular disease, cerebral parenchymal ischemia and hypoxia will lead to neuronal degeneration and necrosis, which will lead to synaptic transmission dysfunction. At the same time, the synthesis and release of neurotransmitters will decrease, especially the levels of dopamine, acetylcholine and other neurotransmitters that are closely related to cognitive functions. This will eventually lead to patients with cognitive impairment symptoms such as memory loss and inattention. The key to clinical treatment is to improve cerebral circulation, regulate neural function and promote the remodeling of cognitive pathways. However, a single treatment method is often difficult to fully cover the pathological mechanism and has limited effect. In this study, the combined group used a treatment plan that combined repetitive transcranial magnetic stimulation and rehabilitation training. The results showed that the cognitive function score, total quality of life score, and total treatment effectiveness of this group were significantly better than those of the rehabilitation group with rehabilitation training alone, which fully demonstrated that the combined treatment plan has obvious advantages in the treatment of non-dementia vascular cognitive impairment [5].

From the perspective of the mechanism of repetitive transcranial magnetic stimulation, this treatment technology uses magnetic field pulses of specific frequencies to act on the cerebral cortex, which can penetrate the skull and directly stimulate nerve cells without causing damage to brain tissue. The left dorsolateral prefrontal cortex is a key brain area for the regulation of cognitive functions and is closely related to attention, memory and executive functions.

Repeated transcranial magnetic stimulation in this area can regulate the excitability of neurons, promote the expression of brain-derived neurotrophic factors, and thereby improve the metabolism and repair of nerve cells [6]. As an important neurotrophic factor, brain-derived neurotrophic factor can promote neuron survival, proliferation and differentiation, enhance synaptic plasticity, and play an important role in the repair of damaged neural pathways. At the same time, repetitive transcranial magnetic stimulation can also regulate the secretion balance of neurotransmitters such as dopamine and acetylcholine in the brain. These neurotransmitters play an important role in cognitive signal transmission. The improvement of their secretion levels can directly enhance the synergy of brain areas related to cognitive function. In addition, repetitive transcranial magnetic stimulation can promote the increase of local cerebral blood perfusion, relieve cerebral ischemia caused by cerebrovascular lesions, and provide a good microenvironment for neurological recovery. These mechanisms together lay the foundation for the improvement of cognitive function [7].

Rehabilitation training plays an irreplaceable role in the treatment of non-dementia vascular cognitive impairment. Through targeted cognitive training, it can strengthen the neuroplasticity of the brain and promote the reorganization and compensation of damaged cognitive pathways. Brain neuroplasticity refers to the ability of the nervous system to adapt to environmental changes and repair damage in structure and function. Rehabilitation training, through continuous sensory stimulation and task practice, can activate potential nerve cells in relevant functional areas of the brain and form new synaptic connections to replace damaged pathways [8]. The rehabilitation training in this study includes memory, attention and language training, which can improve the efficiency of synaptic connections between nerve cells through repeated cognitive task practice, thereby improving cognitive performance. Exercise training can not only enhance the patient's limb function and balance ability, but also indirectly improve cerebral blood flow supply by promoting systemic blood circulation. At the same time, endorphins and other substances produced during exercise can also help regulate emotional state and reduce the impact of negative emotions such as anxiety and depression on cognitive function recovery. However, simple rehabilitation training can only guide the remodeling of nerve function through external stimulation. It is difficult to fundamentally regulate the excitability and neurotransmitter secretion of nerve cells, and cannot quickly improve the pathological state of nerve cells. Therefore, its ability to improve cognitive function is limited. This is also an important reason why the treatment effect of the rehabilitation group is not as good as that of the combined group.

The combined application of repetitive transcranial magnetic stimulation and rehabilitation training achieves complementarity and synergy in the mechanism of action. Repetitive transcranial magnetic stimulation improves nerve cell function and cerebral circulation through non-invasive neuromodulation, providing a good physiological basis for rehabilitation training, making patients more receptive to stimulation during rehabilitation training and forming effective neural pathway remodeling. Rehabilitation training, through targeted cognitive and motor exercises, can strengthen the neuroplastic changes induced by repetitive transcranial magnetic stimulation, transforming physiological functional improvements into actual improvements in cognitive ability and quality of life. The two promote each other to form a virtuous cycle, which ultimately significantly improves the treatment effect. In this study, the post-treatment Mini-Mental State Examination score of the combined group was 2.48 points higher than that of the rehabilitation group, the total score of the SF-36 scale was 8.18 points higher, and the total effective rate of treatment was higher. These data fully confirm the synergistic advantages of combined treatment and are consistent with the conclusion that combined intervention programs are better than single treatments in related studies. Further analysis shows that the improvement in neurotransmitter secretion and increase in cerebral blood flow brought about by repetitive transcranial magnetic stimulation can improve patients' attention and learning ability during rehabilitation training, making it easier for patients to master training skills and complete training tasks, thus amplifying the effect of rehabilitation training. Rehabilitation training can consolidate the therapeutic effect of repetitive transcranial magnetic stimulation and avoid short-term rebound in efficacy.

In terms of treatment safety, no serious adverse reactions occurred in the combination group in this study. Only 2 patients had mild headaches in the early stages of treatment. The symptoms were relieved after adjusting the stimulation intensity, indicating that the treatment plan of repetitive transcranial magnetic stimulation combined with rehabilitation training has high safety and tolerability. This feature is particularly important for elderly patients with non-dementia

vascular cognitive impairment, because this group often has multiple underlying diseases such as hypertension and diabetes, has relatively weak liver and kidney functions, and has higher safety requirements for treatment. The combined regimen used in this study does not require systemic medication, which avoids the risk of adverse reactions caused by drug metabolism in the body. At the same time, the non-invasive nature of repetitive transcranial magnetic stimulation also reduces the risk of trauma and infection related to treatment, further enhancing its clinical application value. In clinical practice, for patients with multiple underlying diseases, the physical condition can be fully assessed before treatment, and the stimulation intensity of repetitive transcranial magnetic stimulation and the difficulty of rehabilitation training can be adjusted to ensure safe and orderly treatment.

In summary, repetitive transcranial magnetic stimulation combined with rehabilitation training has a very significant effect in the treatment of non-dementia vascular cognitive impairment. It can effectively improve the patient's cognitive function and quality of life and is safe. This combined program maximizes the therapeutic effect through mechanism synergy and is worthy of clinical promotion and application.

About the author

Xu Ye (1992.03), female, Han nationality, native of Wuxi City, Jiangsu Province, undergraduate, supervisor of rehabilitation therapist; research direction: application of neuromodulation technology in motor dysfunction.

Disclosure statement

The author declares no conflict of interest.

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