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Original Article

Effect of neuromuscular electrical stimulation combined with swallowing rehabilitation training on the treatment efficacy and life quality of stroke patients with dysphagia

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Abstract: Purpose: To explore the therapeutic efficacy of neuromuscular electrical stimulation (NMES) combined with swallowing rehabilitation training on the healing effect and quality of life of stroke patients with dysphagia. Methods: The clinical data of 63 stroke patients admitted to the First Affiliated Hospital of Zhengzhou University from October 2019 to September 2020 were retrospectively analyzed. The included patients were divided into two groups according to different treatment plans: an observation group (n=33) treated with NMES combined with swallowing rehabilitation training, and a control group (n=30) treated by swallowing rehabilitation training alone. Before and after 2 courses of treatment, the Water swallow test, Functional Oral Intake Scale (FOIS), and MD Anderson Dysphagia Inventory (MDADI) were used to assess the swallowing function of patients in the two groups, and the National Institutes of Health Stroke Scale (NIHSS) was used to evaluate patients' neurological deficit; the SA7550 surface electromyogram (EMG) analysis system was applied to collect surface EMG, and the F113-5 medical X-ray TV system was used to detect the mobility of the hyoid-throat complex; the negative emotions of patients were assessed using the Hamilton Rating Scale for Depression (HAMD) before and after treatment, and the quality of life was evaluated by the Swallowing Quality of Life (SWAL-QOL) questionnaire; and the occurrence of adverse reactions during treatment was recorded and compared between the two groups. Results: There was no significant difference in swallowing function, duration of swallowing, maximum amplitude value, and hyoid-throat complex mobility between the two groups before treatment (P>0.05), nor were there any differences in the scores of FOIS, MDADI, NIHSS, HAMD, and SWAL-QOL before treatment (P>0.05). After treatment, however, the above indicators of both groups were significantly improved (P<0.05), and the improvements were more significant in the observation group compared with the control group (P<0.05). Moreover, the incidence of adverse reactions in both groups were relatively low without significant difference between groups (P>0.05). Conclusion: NMES combined with swallowing rehabilitation training is effective in the treatment of swallowing dysfunction following stroke. It can effectively improve patients' swallowing function and quality of life, and relieve their negative emotions, with a high safety profile, which is worthy of clinical promotion.

Keywords: Neuromuscular electrical stimulation, swallowing rehabilitation training, stroke, dysphagia, curative effect, quality of life

Introduction

As a cerebrovascular event, stroke is a disease with a high incidence among the elderly [1]. Once a stroke occurs in the elderly, it will lead to a longer recovery period, as well as varying degrees of limb dysfunction with a high disability rate, which has a serious negative impact on the quality of life of patients [2, 3]. Dysphagia is one of the main complications of stroke, which occurs in approximately half of stroke patients to varying degrees [4]. Dysphagia is an inability to properly swallow, with numerous manifestations and reasons for it. Without timely intervention, it can cause adverse symptoms such as coughing when drinking water, food entering the lungs, and even suffocation or death in severe cases [5, 6]. Therefore, how to quickly and effectively restore the swallowing function of patients and improve their quality of life is a clinical problem that needs to be urgently solved.

At present, there is no standard treatment plan for dysphagia after stroke, but instead, there are mainly rehabilitation therapies such as swallowing training, cold stimulation of the pharynx, and empty swallowing [6]. Swallowing rehabilitation training refers to the practice of normal swallowing patterns after regular training, so as to inhibit abnormal patterns, and form normal swallowing patterns as soon as possible, in order to maximize the recovery of swallowing function. Although it has favorable results, the effect of rehabilitation training is not yet ideal [7]. Neuromuscular Electrical Stimulation (NMES), on the other hand, is a safe, simple, and inexpensive treatment method, which refers to the use of electric current to stimulate the target area to promote the excitability of the target area and connect it to neural innervation and the brain [8]. In recent years, scholars have revealed that the intensity and frequency of NMES had different effects on the therapeutic effect and quality of life of patients with brain injury [9]. However, a certain treatment method alone has limited efficacy and it also has a longer course of treatment [10].

Therefore, this study analyzed the therapeutic efficacy of NMES combined with swallowing rehabilitation training on stroke patients suffering from dysphagia, hoping to provide reference data for the selection of treatment options for stroke patients with dysphagia.

Materials and methods

Clinical information

The clinical data of 63 stroke patients (male-to-female ratio: 34:29) admitted to the First Affiliated Hospital of Zhengzhou University from October 2019 to September 2020 were retrospectively analyzed. According to different treatment plans, the included patients were divided into the following two groups: an observation group (n=33) treated with NMES combined with swallowing rehabilitation training, and a control group (n=30) given swallowing rehabilitation training alone. All included patients met the diagnostic criteria for stroke [11] and dysphagia [12]. Exclusion criteria were as follows: (1) patients with conscious disorders; (2) patients with swallowing disorders caused by other injury; (3) patients with severe trauma; (4) patients with malignant tumors; (5) patients with damage to vital organs such as the liver and kidney other than the brain; (6) patients who were allergic to the electrode pads. All patients agreed to participate in the study with a signed written informed consent form. This experiment was approved by the hospital ethics committee and was conducted in strict accordance with the Declaration of Helsinki.

Treatment methods

Both groups of patients were given conventional treatments such as controlling brain edema, reducing intracranial pressure, nourishing brain nerve cells, and improving brain tissue circulation. On this basis, both groups received swallowing rehabilitation training with the specific methods as follows: (1) Neck activity training: patients were instructed to do related training such as left and right head rotation, forward neck bending, neck extension, and neck rotation in a small range, twice a day for 15 minutes each time; (2) Ice stimulation training: pinky-sized ice cubes were put on the tip of the tongue, the cheeks, and the root of the tongue twice a day for 5 minutes each time; (3) Breathing training: patients were instructed to do abdominal breathing, blow out candles or paper strips after deep inhalation, or whistle, many times until they felt tired; (4) Food intake training: before training, we prepared small recessed spoons, cutting cups, syringes and other feeding equipment; suction devices and other first-aid equipment; and paste food or a semi-liquid diet that were of even consistency. Patients were instructed to lie down in a semi-recumbent position with their head tilted forward. Patients started eating food with a small dose of 2 ml and increased to 15 ml depending on their individual situation, during which, they were instructed to eat slowly. The chewing and swallowing function exercise was conducted once a day, 20 min each time, for 2 weeks.

The observation group was treated with NMES based on swallowing rehabilitation training. The electrical stimulator used was a G111 Vagus nerve stimulator (Beijing Pinchi Medical Equipment Co., Ltd.) with a two-way square wave, an electrical stimulation intensity of 0-25 mA, a wave width of 700 ms, and a frequency of 80 Hz. The instrument has a total of 4 electrodes, of which two sets of electrode pads were placed on the suprahyoid area, 1 set on the movement points of the mandibular hyoid muscles on both sides, and 1 set on the movement points of the geniohyoid muscles on both sides. Each electrical stimulation application was performed 5 times/week, for 30 min each time. The intensity of electrical stimulation was determined according to the patient's tolerance, while ensuring that the targeted muscles could be contracted. Patients in both groups were treated for 2 courses, with 4 weeks as a course of treatment.

Outcome measures

Before and after 2 courses of treatment, the Water swallow test [13] was performed to observe the swallowing function of patients in both groups, specifically as follows: the patient sat in an instructed sitting position, and then drank 30 ml of warm water. The drinking time of each patient was recorded and the coughing during the drinking process was observed. Evaluation criteria: Level 1: being able to finish drinking 30 ml of warm water at one time without coughing; Level 2: being able to finish drinking 30 ml of warm water over several times with no coughing; Level 3: being able to finish drinking 30 ml of warm water at one time but with coughing; Level 4: failed to finish drinking 30 ml of warm water over two times and with coughing; Level 5: unable to finish drinking 30 ml of warm water smoothly and with frequent coughing. Among which, the recovery of swallowing function of patients referred to the success to reach level. (1) Improvement of symptoms referred to a reduction of ≥2 levels of the evaluation of Water swallow test with significantly relieved dysphagia; effective corresponded referred to a 1-level reduction of the Water swallow test; ineffective referred to no significant changes assessed before and after treatment. The total effective rate of swallowing function improvement = (number of cured cases + number of improved cases)/total number of cases ×100%. (2) The Functional Oral Intake Scale (FOIS) [14], with 1-7 levels corresponding to a score of 1-7 points, was used to evaluate the oral intake function of patients in the two groups: No oral intake (1 point); Tube dependent with minimal attempts of food or liquid (2 points); Tube dependent with consistent oral intake of food or liquid (3 points); Total oral diet of a single consistency (4 points); Total oral diet with multiple consistencies, but requiring special preparation or compensations (5 points); Total oral diet with multiple consistencies without special preparation, but with specific food limitations (6 points); Total oral diet with no restrictions (7 points). (3) The MD Anderson Dysphagia Inventory (MDADI) [15] was used to evaluate the swallowing function of patients before and after treatment, from global, emotional, functional, and physical subscales. Using Likert's 5-level score, 1 point indicates strongly agree, 5 points indicates strongly disagree. The global subscale 2 is scored separately, while the scores of other three subscales were added together to get the average value, which was multiplied by 20 for the total score of the scale, ranging from 0 to 100 points. Higher score means better swallowing function. (4) The National Institutes of Health Stroke Scale (NIHSS) [16] was used to assess the neurological deficit of patients before and after treatment. Higher scores suggest more severe neurological impairment. (5) The SA7550 surface electromyogram (EMG) analysis system (Shanghai Hanfei Medical Instrument Co., Ltd.) was used to collect the surface EMG of the two groups of patients: I cotton balls with alcohol were used to remove the patient's skin oil on the neck before the examination. Then we applied coupling agent, connected the left hand to the ground wire, and placed the four-channel synchronous motor on the left and right suprahyoid muscles (mentioglossus, digastric muscle, stylohyoid muscle, mandibular hyoid muscle), 2 cm above the hyoid bone on both sides of the midline, the subhyoid muscles (scapula hyoid muscle, sternohyoid muscle, thyrohyoid muscle, sternohyoid muscle), and 2 cm below the hyoid bone on both sides of the midline. Patients were asked to swallow 2 ml of water each time, and the surface EMG swallowing time and the maximum amplitude were collected simultaneously. The data were collected 3 times, and the average value was taken. (6) The F113-5 medical X-ray TV system (Shanghai Huanxi Medical Instruments Co., Ltd.) was used to check the hyoid-throat complex mobility of patients before and after treatment. The position of the hyoid bone and thyroid cartilage was recorded in a resting state using the patient's chin as a measuring ruler. After that, the patient was

Table 1. Comparison of general information between the two groups

Factor	Observation Group (n=33)	Control Group (n=30)	t/χ^2	P
Gender			0.009	0.923
Male	18 (54.55)	16 (53.33)		
Female	15 (45.45)	14 (46.67)		
Age (Y)			0.050	0.824
≤64	13 (39.39)	11 (36.67)		
>64	20 (60.61)	19 (63.33)		
BMI (kg/m^2)			0.021	0.885
≤23	17 (51.52)	16 (53.33)		
>23	16 (48.48)	14 (46.67)		
Course of disease (months)	3.41±0.23	3.43±0.21	0.359	0.721
Smoking history			0.088	0.767
YES	21 (63.64)	18 (60.00)		
NO	12 (36.36)	12 (40.00)		
Diabetes			0.077	0.782
YES	22 (66.67)	19 (63.33)		
NO	11 (33.33)	11 (36.67)		
Hypertension			0.057	0.811
YES	24 (72.73)	21 (70.00)		
NO	9 (27.27)	9 (30.00)		
Family history of stroke			0.029	0.66
YES	15 (45.45)	13 (43.33)		
NO	18 (54.55)	17 (56.67)		

Table 2. Comparison of therapeutic effects between the two groups

Therapeutic effect	Observation Group (n=33)	Control Group (n=30)	χ^2	P
Cured	20 (60.61)	13 (43.33)	-	-
Improved	10 (30.30)	7 (23.33)	-	-
Effective	2 (6.06)	7 (23.33)	-	-
Ineffective	1 (3.03)	3 (10.00)	-	-
Effective Rate	30 (90.91)	20 (66.67)	5.639	0.018

given 2 ml of liquid, semi-liquid, and mushy food, respectively, to record the position of the hyoid bone and thyroid cartilage during swallowing, and measure the distance of the hyoid bone, the hyoid bone, the thyroid cartilage, and the thyroid. (7) The Hamilton Rating Scale for Depression (HAMD) [17] was used to evaluate the negative emotions of patients before and after treatment. (8) The Swallowing Quality of Life (SWAL-QOL) questionnaire [18] was to assess the life quality of patients in the two groups before and after treatment. The total score of SWAL-QOL was 220 points, including 44 items and 11 dimensions. Higher scores indicated higher life quality, and vice versa. (9) Safety analysis. The adverse reactions of the two groups were recorded and analyzed, which included muscle pain, nausea and vomiting, arrhythmia, and aspiration pneumonia.

Statistical methods

Data analysis and image rendering were performed by SPSS 19.0 statistical software and GraphPad 7, respectively. Count data were expressed as number of cases and percentages (%), and the differences were analyzed by the χ^2 test. For measurement data, paired t test was used for comparison before and after treatment, and independent samples t test was used for comparison between groups. P<0.05 indicated a statistically significant difference.

Results

Comparison of general information between both groups

The two groups of patients were comparable since there were no significant differences in terms of gender, age, BMI and underlying diseases (P>0.05), see **Table 1**.

Comparison of water swallow test results between both groups

After treatment, the results of the water swallow test were compared between the two groups. The number of patients in the observation group who were cured, improved, effective and ineffective was 20, 10, 2 and 1 respectively with a treatment effective rate of 90.91%, while those in the control group were 13, 7, 7, and 3, respectively, and the treatment effective rate was 66.67%. This indicated that the treatment efficiency of the combined treatment was significantly higher than that of monotherapy (P<0.05), see **Table 2**.

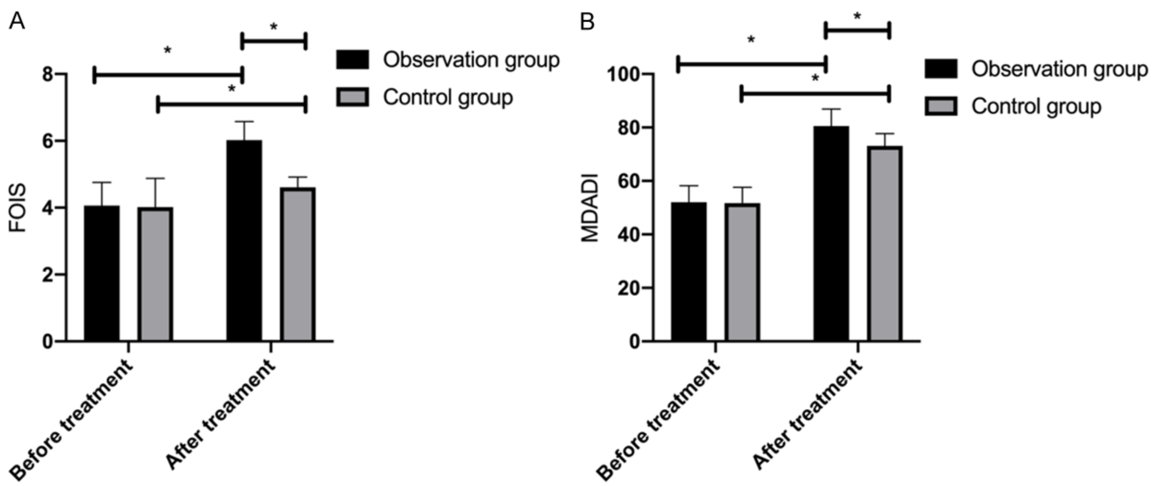

Figure 1. Comparison of FOIS and MDADI scores between the two groups before and after treatment. A: Comparison of FOIS scores between the two groups before and after treatment; B: Comparison of MDADI scores between the two groups before and after treatment. * indicates P<0.05.

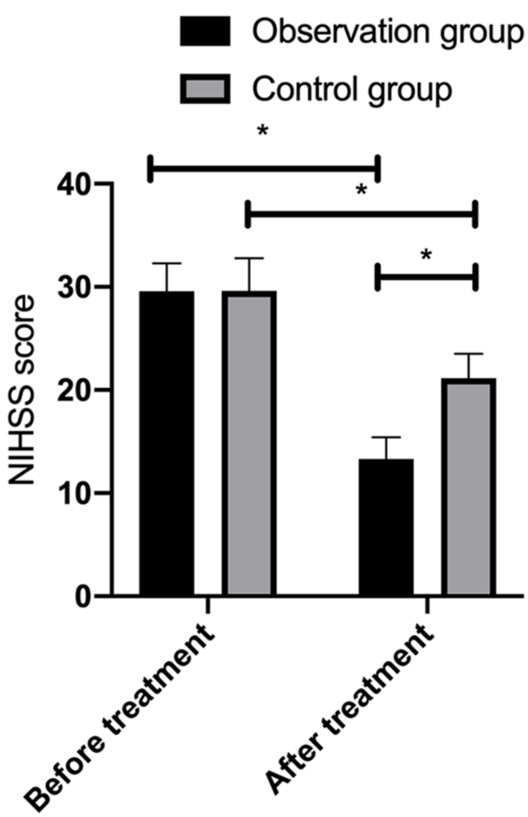

Figure 2. Comparison of NIHSS scores before and after treatment between two groups. * indicates P<0.05.

Comparison of FOIS and MDADI scores between both groups before and after treatment

No significant difference was found in the FOIS and MDADI scores between the two groups before treatment (P>0.05). After the intervention, the FOIS and MDADI scores of both groups improved significantly (P<0.05), and the improvements were more significant in the observation group compared with the control group (P<0.05), see **Figure 1**.

Comparison of NIHSS scores between two groups before and after treatment

There was no significant difference in the NIHSS score between the two groups before treatment (P>0.05). While after treatment, the NIHSS score decreased significantly in both groups after intervention (P<0.05), and was even lower in the observation group (P<0.05), see **Figure 2**.

Comparison of surface EMG indexes between both groups before and after treatment

Before treatment, no significant difference was observed in the duration of swallowing and maximum amplitude value between the two groups (P>0.05). While after two courses of treatment, both groups showed improvement in these two surface EMG indexes, among which the observation group performed better with shorter swallowing duration and higher maximum amplitude value (P<0.05), as shown in **Figure 3**.

Comparison of momentum indexes of hyoid-laryngeal complex between both groups before and after treatment

There were no significant differences in the distance of the hyoid bone upward movement and

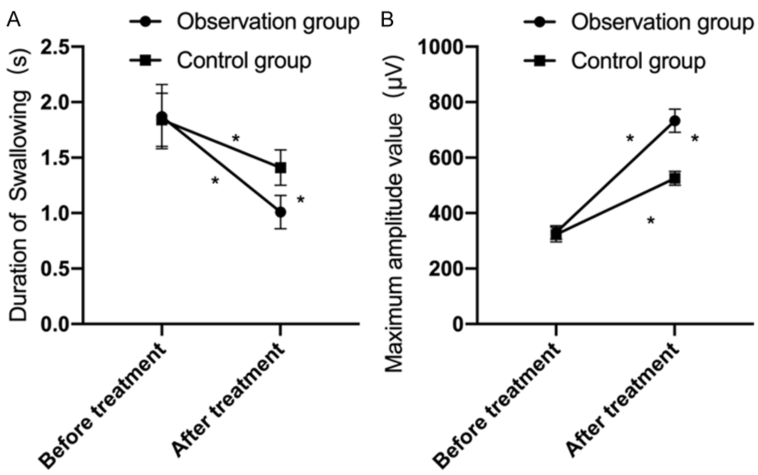

Figure 3. Comparison of surface EMG indexes between the two groups before and after treatment. A: Comparison of the duration of swallowing between the two groups before and after treatment; B: Comparison of the maximum amplitude value between the two groups before and after treatment. * indicates P<0.05.

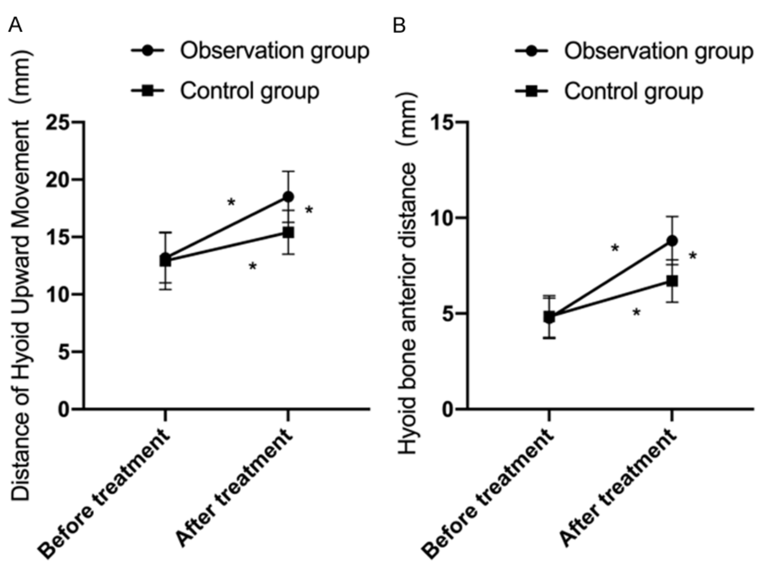

Figure 4. Comparison of the hyoid-throat complex mobility index between the two groups before and after treatment. A: Comparison of distance of the hyoid bone upward movement between the two groups before and after treatment; B: Comparison of the hyoid bone anterior distance between the two groups before and after treatment. * indicates P<0.05.

the distance of the hyoid bone anterior movement between the two groups before treatment (P>0.05). While after 2 courses of treatment, hyoid bone distance and hyoid bone advancement increased in both groups, with more significant increases in the observation group compared with the control group (P<0.05), as shown in **Figure 4**.

Comparison of HAMD and SWAL-QOL scores between both groups before and after treatment

HAMD and SWAL-QOL scores showed no significant difference between the two groups before treatment (P>0.05). After treatment, HAMD decreased and SWAL-QOL score increased in both groups after treatment (P<0.05), with more significant changes in the two scores in the observation group compared with the control group (P<0.05), see **Figure 5**.

Comparison of the incidence of adverse reactions between both groups

We recorded and compared the adverse reactions of the two groups during treatment. The results showed that the number of patients suffering from muscle pain, nausea and vomiting, arrhythmia, and aspiration pneumonia in the observation group were 2, 0, 1, and 0 respectively with an incidence of adverse reactions of 9.09%. While the corresponding data in the control group were 1, 0, 0, and 1 respectively with an incidence of adverse reactions of 6.67%. This indicated that there was no significant difference in the incidence of adverse reactions between two groups (P>0.05), see **Table 3**.

Discussion

With the acceleration of societal aging, the incidence of stroke has been on the rise in recent years. Stroke has a high disability and mortality rate, which poses a severe threat to the health and life of the elderly [19]. Although the success rate of stroke rescue has increased with the constant advancement of medical technology, a series of sequelae such as dys-

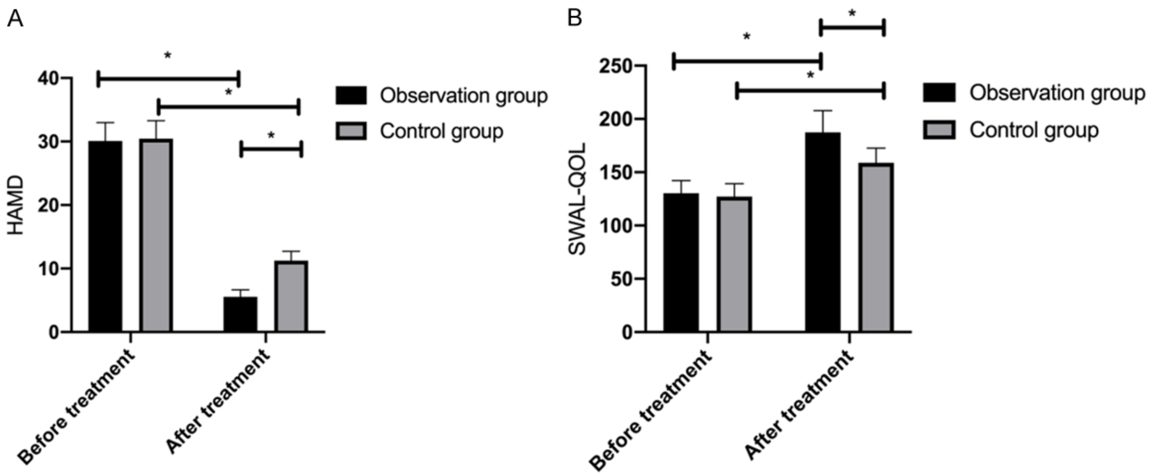

Figure 5. Comparison of the HAMD and SWAL-QOL scores between the two groups before and after treatment. A: Comparison of the HAMD scores between the two groups before and after treatment; B: Comparison of the SWAL-QOL scores between the two groups before and after treatment. * indicates P<0.05.

Table 3. Comparison of adverse reactions between the two groups

Factors	Observation Group (n=33)	Control Group (n=30)	χ^2	P
Muscle pain	2 (6.06)	1 (3.33)	-	-
Nausea and vomiting	0	0	-	-
Arrhythmia	1 (3.03)	0	-	-
Aspiration pneumonia	0	1 (3.33)	-	-
Adverse reaction	3 (9.09)	2 (6.67)	0.126	0.722

phagia caused by stroke still significantly compromised the quality of life of patients [20].

The mechanism of post-stroke dysphagia is complicated. Previous studies [21, 22] have suggested that the possible mechanism is that there is still some neurological damage in stroke patients after treatment, which may disrupt the innervation of swallowing function. Where these patients experience limited tongue motor function in the case of cranial nerve injury. During food intake, the body cannot generate enough power to transport food from the oral cavity to the next destination such as the esophagus and gastrointestinal tract, which causes the food to stay in the pharynx for a long time, resulting in dysphagia. Swallowing rehabilitation training refers to instructing patients to practice normal swallowing patterns to suppress abnormal patterns after routine training, so as to help patients form good muscle memory pattern as soon as possible, and to maximize the recovery of swallowing function [23]. NMES, on the other hand, is based on the high plasticity in the structure and function of the central nervous system by using low-frequency pulse currents to stimulate the depolarization of muscle groups and stimulate the neuromuscular junctions, thereby inducing the re-contraction of paralyzed muscles to simulate normal voluntary movement, and increase muscle strength [24, 25]. Although NMES is widely used in post-stroke rehabilitation treatment, few comprehensive reports are focused on its effects on swallowing function with surface EMG, and hyoid-laryngeal complex mobility in patients with dysphagia after stroke. Therefore, we carried out this comparative analysis to observe the clinical application value of NMES combined with swallowing rehabilitation training.

In this study, it was observed that compared with patients treated by swallowing rehabilitation training alone, the combined treatment of NMES and swallowing rehabilitation training could improve patients' swallowing function with a shorter duration, a higher maximum amplitude, and a more obvious improvement on the strength of the skeletal muscle group, showing that the combination treatment was beneficial and effective to help stroke patients with dysphagia to recover and regain swallowing function. Moreover, the scores of FOIS, MDADI and NIHSS were compared between the two groups. The results showed the above indicators were significantly improved in both groups, but with more significant improvements in the observation group. NMES can improve the swallowing function and relieve surface muscle atrophy. Through a stimulation program of certain intensity, the locally atrophic muscles can be repeatedly stimulated to make the muscles reflex after stimulation and restore their contraction function. Effective stimulation can also activate the nerves in the damaged area and spread to the brain motor central nerves, synchronize the central nerve with the pharyngeal motor nerve, and restore the nervous system function, thus restoring the swallowing ability [26, 27]. In addition, swallowing rehabilitation training can promote various contractions and reflexes of muscles and nerves through repeated chewing, which can exercise the patient's oral muscles, coordinate motor muscles and nerves, and help form new neuromuscular collateral pathways, thereby alleviating swallowing dysfunction and helping to restore oropharyngeal nerves function [28]. The combination of the two treatment types plays a synergistic effect to effectively promote the recovery of swallowing function and nerve function in stroke patients, which explains our results.

Subsequently, mental depression and life quality of two groups of patients were evaluated and compared. The results showed that both groups had obvious improvements in the two aspects mentioned above, especially in the observation group, suggesting that the combination of NMES and swallowing rehabilitation training can effectively mitigate patients' negative emotions, facilitate their recovery, and improve their quality of life. The reason behind this may be due to the fact that multiple modes of treatment can better promote the improvement of patients' symptoms, enable them to return to a normal diet as soon as possible, and gradually reduce the impact of the disease on patients, thereby improving their quality of life [29]. In addition, research has [30] indicated that the improvement of swallowing function and life quality can effectively alleviate patients' negative emotions, which is also consistent with our conclusions. Finally, the incidence of adverse reactions was compared, with no significant difference found between the two groups, indicating that the combination treatment of NMES and swallowing rehabilitation training was of great safety.

In summary, the combination treatment of NMES and swallowing rehabilitation training is effective in the treatment of post-stroke dysphagia. Thus it can significantly improve patients' swallowing dysfunction, relieve their negative emotions, and improve their life quality, with a high safety profile, which is worth promoting clinically. However, this study also has certain shortcomings due to its small sample size and limited observation time. Therefore, there is still room for improvement regarding the accuracy of the data, and corresponding conclusions need to be confirmed by further studies.

Disclosure of conflict of interest

None.

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References

[1] Kimura H. Stroke. Brain Nerve 2020; 72: 311-321.
[2] Boursin P, Paternotte S, Dercy B, Sabben C and Maier B. Semantics, epidemiology and semiology of stroke. Soins 2018; 63: 24-27.
[3] Doeltgen SH and Huckabee ML. Swallowing neurorehabilitation: from the research laboratory to routine clinical application. Arch Phys Med Rehabil 2012; 93: 207-213.
[4] Heijnen BJ, Speyer R, Baijens LW and Bogaardt HC. Neuromuscular electrical stimulation versus traditional therapy in patients with Parkinson's disease and oropharyngeal dysphagia: effects on quality of life. Dysphagia 2012; 27: 336-345.
[5] Hu R, Yan J and Li TL. Effect of electroacupuncture of different acupoints on plasma and cerebral endothelin and CGRP contents in acute cerebral ischemia rats. Zhen Ci Yan Jiu 2008; 33: 169-172.
[6] Carnaby GD, LaGorio L, Silliman S and Crary M. Exercise-based swallowing intervention (McNeill Dysphagia Therapy) with adjunctive NMES to treat dysphagia post-stroke: a double-blind placebo-controlled trial. J Oral Rehabil 2020; 47: 501-510.

[7] Park HS, Oh DH, Yoon T and Park JS. Effect of effortful swallowing training on tongue strength and oropharyngeal swallowing function in stroke patients with dysphagia: a double-blind, randomized controlled trial. Int J Lang Commun Disord 2019; 54: 479-484.
[8] Knutson JS, Fu MJ, Sheffler LR and Chae J. Neuromuscular electrical stimulation for motor restoration in hemiplegia. Phys Med Rehabil Clin N Am 2015; 26: 729-745.
[9] Salazar AP, Pagnussat AS, Pereira GA, Scopel G and Lukrafka JL. Neuromuscular electrical stimulation to improve gross motor function in children with cerebral palsy: a meta-analysis. Braz J Phys Ther 2019; 23: 378-386.
[10] Alamer A, Melese H and Nigussie F. Effectiveness of neuromuscular electrical stimulation on post-stroke dysphagia: a systematic review of randomized controlled trials. Clin Interv Aging 2020; 15: 1521-1531.
[11] Park JS, Oh DH, Hwang NK and Lee JH. Effects of neuromuscular electrical stimulation combined with effortful swallowing on post-stroke oropharyngeal dysphagia: a randomised controlled trial. J Oral Rehabil 2016; 43: 426-434.
[12] Meng P, Zhang S, Wang Q, Wang P, Han C, Gao J and Yue S. The effect of surface neuromuscular electrical stimulation on patients with post-stroke dysphagia. J Back Musculoskelet Rehabil 2018; 31: 363-370.
[13] Xie Y, Liu H and Zhou W. Effect of acupuncture on dysphagia of convalescent stroke patients. Zhongguo Zhong Xi Yi Jie He Za Zhi 2011; 31: 736-740.
[14] Chen HJ, Chen JL, Chen CY, Lee M, Chang WH and Huang TT. Effect of an oral health programme on oral health, oral intake, and nutrition in patients with stroke and dysphagia in Taiwan: a randomised controlled trial. Int J Environ Res Public Health 2019; 16: 2228.
[15] Montes-Jovellar L, Carrillo A, Muriel A, Barbera R, Sanchez F and Cobeta I. Translation and validation of the MD Anderson Dysphagia Inventory (MDADI) for Spanish-speaking patients. Head Neck 2019; 41: 122-129.
[16] Olivato S, Nizzoli S, Cavazzuti M, Casoni F, Nichelli PF and Zini A. e-NIHSS: an expanded national institutes of health stroke scale weighted for anterior and posterior circulation strokes. J Stroke Cerebrovasc Dis 2016; 25: 2953-2957.
[17] Williams JB, Kobak KA, Bech P, Engelhardt N, Evans K, Lipsitz J, Olin J, Pearson J and Kalali A. The GRID-HAMD: standardization of the Hamilton depression rating scale. Int Clin Psychopharmacol 2008; 23: 120-129.
[18] McHorney CA, Bricker DE, Robbins J, Kramer AE, Rosenbek JC and Chignell KA. The SWAL-QOL outcomes tool for oropharyngeal dysphagia in adults: II. Item reduction and preliminary scaling. Dysphagia 2000; 15: 122-133.
[19] Jordan LC and Beslow LA. Hard to swallow: dysphagia and feeding after ischemic stroke in children and neonates. Stroke 2021; 52: 1319-1321.
[20] Sungsinchai S, Niamnuy C, Wattanapan P, Charoenchaitrakool M and Devahastin S. Texture modification technologies and their opportunities for the production of dysphagia foods: a review. Compr Rev Food Sci Food Saf 2019; 18: 1898-1912.
[21] Cohen DL, Roffe C, Beavan J, Blackett B, Fairfield CA, Hamdy S, Havard D, McFarlane M, McLauglin C, Randall M, Robson K, Scutt P, Smith C, Smithard D, Sprigg N, Warusevitane A, Watkins C, Woodhouse L and Bath PM. Post-stroke dysphagia: a review and design considerations for future trials. Int J Stroke 2016; 11: 399-411.
[22] Hellden J, Bergstrom L and Karlsson S. Experiences of living with persisting post-stroke dysphagia and of dysphagia management-a qualitative study. Int J Qual Stud Health Well-being 2018; 13: 1522194.
[23] Lawlor CM and Choi S. Diagnosis and management of pediatric dysphagia: a review. JAMA Otolaryngol Head Neck Surg 2020; 146: 183-191.
[24] de Freitas GR, Szpoganicz C and Ilha J. Does neuromuscular electrical stimulation therapy increase voluntary muscle strength after spinal cord injury? A systematic review. Top Spinal Cord Inj Rehabil 2018; 24: 6-17.
[25] Harbo T, Markvardsen LK, Hellfritzsch MB, Severinsen K, Nielsen JF and Andersen H. Neuromuscular electrical stimulation in early rehabilitation of Guillain-Barre syndrome: a pilot study. Muscle Nerve 2019; 59: 481-484.
[26] Ravikumar R, Williams KJ, Babber A, Moore HM, Lane TR, Shalhoub J and Davies AH. Neuromuscular electrical stimulation for the prevention of venous thromboembolism. Phlebology 2018; 33: 367-378.
[27] Maffiuletti NA, Gondin J, Place N, Stevens-Lapsley J, Vivodtzev I and Minetto MA. Clinical use of neuromuscular electrical stimulation for neuromuscular rehabilitation: what are we overlooking? Arch Phys Med Rehabil 2018; 99: 806-812.
[28] Permsirivanich W, Tipchatyotin S, Wongchai M, Leelamanit V, Setthawatcharawanich S, Sathirapanya P, Phabphal K, Juntawises U and Boonmeeprakob A. Comparing the effects of rehabilitation swallowing therapy vs. neuromuscular electrical stimulation therapy among stroke patients with persistent pharyngeal dysphagia: a randomized controlled study. J Med Assoc Thai 2009; 92: 259-265.

[29] Simonelli M, Ruoppolo G, Iosa M, Morone G, Fusco A, Grasso MG, Gallo A and Paolucci S. A stimulus for eating. The use of neuromuscular transcutaneous electrical stimulation in patients affected by severe dysphagia after subacute stroke: a pilot randomized controlled trial. NeuroRehabilitation 2019; 44: 103-110.

[30] Mitchell AJ, Sheth B, Gill J, Yadegarfar M, Stubbs B, Yadegarfar M and Meader N. Prevalence and predictors of post-stroke mood disorders: a meta-analysis and meta-regression of depression, anxiety and adjustment disorder. Gen Hosp Psychiatry 2017; 47: 48-60.