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ORIGINAL RESEARCH

Effectiveness of Neuromuscular Electrical Stimulation on Patients With Dysphagia With Medullary Infarction

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Abstract

Objective: To evaluate and compare the effects of neuromuscular electrical stimulation (NMES) acting on the sensory input or motor muscle in treating patients with dysphagia with medullary infarction.

Design: Prospective randomized controlled study.

Setting: Department of physical medicine and rehabilitation.

Participants: Patients with dysphagia with medullary infarction (N = 82).

Interventions: Participants were randomized over 3 intervention groups: traditional swallowing therapy, sensory approach combined with traditional swallowing therapy, and motor approach combined with traditional swallowing therapy. Electrical stimulation sessions were for 20 minutes, twice a day, for 5d/wk, over a 4-week period.

Main Outcome Measures: Swallowing function was evaluated by the water swallow test and Standardized Swallowing Assessment, oral intake was evaluated by the Functional Oral Intake Scale, quality of life was evaluated by the Swallowing-Related Quality of Life (SWAL-QOL) Scale, and cognition was evaluated by the Mini-Mental State Examination (MMSE).

Results: There were no statistically significant differences between the groups in age, sex, duration, MMSE score, or severity of the swallowing disorder ($P > .05$). All groups showed improved swallowing function ($P \leq .01$); the sensory approach combined with traditional swallowing therapy group showed significantly greater improvement than the other 2 groups, and the motor approach combined with traditional swallowing therapy group showed greater improvement than the traditional swallowing therapy group ($P < .05$). SWAL-QOL Scale scores increased more significantly in the sensory approach combined with traditional swallowing therapy and motor approach combined with traditional swallowing therapy groups than in the traditional swallowing therapy group, and the sensory approach combined with traditional swallowing therapy and motor approach combined with traditional swallowing therapy groups showed statistically significant differences ($P = .04$).

Conclusions: NMES that targets either sensory input or motor muscle coupled with traditional therapy is conducive to recovery from dysphagia and improves quality of life for patients with dysphagia with medullary infarction. A sensory approach appears to be better than a motor approach.

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Dysphagia is common in patients with stroke and is an independent predictor of outcome.[1,2] It typically refers to difficulty in eating as a result of disruption in the swallowing process and shows an increased risk of complications (eg, malnutrition, aspiration pneumonia).[1-4] This may increase mortality and length of hospital stay.[5,6] Dysphagia caused by brainstem stroke has a greater occurrence than that caused by hemispheric stroke and shows signs of the most severe form.[7]

It has been well established that the sequential and rhythmic patterns of swallowing are produced and organized by a central pattern generator (CPG)[8-10] located in the lower brainstem

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(medulla oblongata)[11,12] and that this includes 2 main groups of neurons (nucleus tractus solitarius and nucleus ambiguous). In animal experiments, these neurons can be excited by the repetitive stimulation of the superior laryngeal nerve.[13,14] Once the sequential and rhythmic patterns of swallowing have been initiated, an irreversible motor event is observed in the pharyngeal phase of swallowing.[11,12]

Recently, neuromuscular electrical stimulation (NMES) has been widely studied in the clinical setting and shown to be an effective and safe treatment for dysphagia.[15-19] It has been assumed that the electrical stimulation assists swallowing either by eliciting muscle contractions[20-24] or by increasing the sensory input to the central nervous system.[25,26] Most of the randomized controlled studies[20-23] applied NMES at a frequency of 80Hz for 60m/d for 5d/wk. Kushner et al[19] administered NMES at fixed pulse rates in the range of 5 to 120Hz (mean, 80Hz), with a pulse duration of 100 to 300μs. They adjusted the frequency to <80Hz (range, 5−80Hz) to minimize fatigue, and the frequency of high voltage treatment was set at up to 120Hz. They reported that NMES with traditional dysphagia therapy was significantly more effective than traditional therapy alone in reducing feeding tube-dependent dysphagia in patients with acute stroke.[19] A supraliminal stimulus has been used to elicit muscle contractions, which may improve and enhance laryngeal elevation[19,27] and may also protect the muscles from atrophy.[28] It is believed that the sensory approach may stimulate the sensory pathways and that the sensory stimulation may have a long-term effect in reorganization of the cortex.[29-31] Power et al[26] applied faucial pillar stimulation on 10 healthy subjects at 3 frequencies (0.2, 1, and 5Hz); they found stimulation at 5Hz lengthened swallow response time and inhibited the corticobulbar projection, stimulation at 0.2Hz did not enhance swallowing behavior but facilitated the corticobulbar projection, and stimulation at 1Hz had no effect on swallow response time or corticobulbar projection.[26] Fraser et al[32] discovered electrical stimulation at 1 or 5Hz increased cortical excitability as determined by the greater response amplitude of pharyngeal electromyography, whereas stimulation at 10, 20, and 40Hz suppressed the excitability.[32] Wang et al[33] administered NMES to patients with severe dysphagia caused by lower brainstem infarction at a frequency of 0.25Hz for 20 minutes per session, twice a day, for 5d/wk; the authors indicated that this schedule could facilitate the recovery of the swallow function and that this may be because of involvement with the sensory input, particularly the integration of signals at the nucleus tractus solitarius.[33] These results suggest that the treatment effect is frequency-related for neurogenic swallowing dysfunction.

In this article we selected 0.25Hz for sensory approach and 120Hz for motor approach. We then evaluated and compared the effects of NMES in 2 different modes, acting on the sensory input or the motor muscle, in treating patients with dysphagia with medullary infarction.

List of abbreviations:

CPG	**central pattern generator**
FOIS	**Functional Oral Intake Scale**
MMSE	**Mini-Mental State Examination**
NMES	**neuromuscular electrical stimulation**
SSA	**Standardized Swallowing Assessment**
SWAL-QOL	**Swallowing-Related Quality of Life**
WST	**water swallow test**

Methods

Ethics statement

The study protocol was approved by the Ethics Committee of Zibo Central Hospital. After all the procedures in this study were explained, written informed consent was obtained from each patient.

Participants

Study participants were recruited from Zibo Central Hospital. Between January 2012 and January 2015, 97 participants with dysphagia who had been diagnosed with medullary infarction within 1 month and who had no muscular disorders or contraindications to the electrical stimulation were assessed for inclusion. Five participants were excluded, and 2 declined to participate; 8 participants dropped out for personal reasons unrelated to the intervention. Therefore, there were 82 participants (fig 1). Participants were randomized over 3 intervention groups: traditional swallowing therapy, a sensory approach combined with traditional swallowing therapy, and a motor approach combined with traditional swallowing therapy. The participants were assigned sequentially to the groups, including the first to the traditional swallowing therapy group, the second to the sensory approach combined with traditional swallowing therapy, the third to the motor approach combined with traditional swallowing therapy group, the fourth to the traditional swallowing therapy group, and so forth.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) a primary diagnosis of medullary infarction with brain computed tomography or magnetic resonance imaging; (2) disease onset <1 month previously; (3) presence of oropharyngeal dysphagia confirmed by videofluoroscopic swallowing study, including different levels of water choke to cough, choking, prolonged eating time, difficulty with swallowing, and nasal regurgitation after swallowing[34]; (4) age within the range of 40 to 80 years; (5) no severe cognitive degeneration that could restrict cooperation with the checks and treatment, with a Mini-Mental State Examination (MMSE) score ≥21; and (6) 30-mL water swallow test (WST) level of 3, 4, or 5.

The exclusion criteria were as follows: (1) unstable vital signs caused by highly inflammatory, severe cardiopulmonary disease or carotid sinus syndrome (ie, temperature >38.5°C or <35.5°C, systolic blood pressure >180 or <90mmHg, diastolic blood pressure >110 or <60mmHg, heart rate >100 or <60 times per min, respiratory rate >25 or <12 times per min); (2) a cardiac pacemaker or other electrically sensitive implanted stimulator; (3) dysphagia caused by structural lesions (eg, radiotherapy, extensive surgery of the head and neck region); (4) skin lesions of the area to be treated or implants containing metal parts within the area of treatment; (5) a history of epilepsy, malignancies, or other neurologic disease; (6) pregnancy; or (7) spastic paralysis.

Equipment and interventions

All treatments were performed by an occupational therapist. Traditional swallowing therapy involves compensation strategies to augment the impaired aspects of oropharyngeal swallowing