

## THE EFFECTIVENESS OF NEUROMUSCULA ELECTRICAL STIMULATION THERAPY COMBINED WITH SWALLOWING EXERCISES FOR PATIENTS WITH DYSPHAGIA FOLLOWING TRAUMATIC BRAIN INJURY

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### ABSTRACT

**Introduction:** Dysphagia is a common complication following traumatic brain injury (TBI). Early detection and treatment of dysphagia are essential. Swallowing exercises combined with neuromuscular electrical stimulation (NMES) are used in TBI patients with dysphagia. This study aims to evaluate the effectiveness of swallowing exercises combined with NMES in patients with dysphagia due to TBI.

**Methods:** This study is a pre- and post-intervention study on a series of first-time TBI cases with dysphagia. A total of 30 TBI patients with dysphagia were randomly selected. The patient group received treatment with swallowing exercises combined with NMES for 15 days. Demographic characteristics, time since TBI, incidence of post-TBI pneumonia, clinical symptoms of dysphagia, and GUSS scores were recorded on day 1 and day 15 post-treatment.

**Results:** After the intervention period, the clinical symptoms of dysphagia in the patient group showed significant improvement, with a decrease in the percentage of dysphagia symptoms after 15 days. Before treatment, patients presented moderate (46.7%) to mild dysphagia (53.3%), with no patients experiencing severe dysphagia. Following treatment, the levels of dysphagia and risk of aspiration decreased, reflected by moderate dysphagia at 33.3% and mild dysphagia at 40%.

**Conclusion:** Swallowing exercises combined with NMES are a safe and effective treatment method for patients with dysphagia following traumatic brain injury.

**Keywords:** Traumatic brain injury, dysphagia, neuromuscular electrical stimulation, swallowing exercises, GUSS.

### I. INTRODUCTION

Traumatic brain injury has a high mortality rate and often results in severe long-term complications [1, 2]. Dysphagia is one of the potential consequences following traumatic brain injury, occurring in 27-30% of TBI patients. Dysphagia is defined as an impaired ability to swallow, resulting in the abnormal transport of a bolus of liquid or solid from the oral cavity to the stomach. Aspiration is defined

as the entry of saliva, liquids, or food into the lower respiratory tract, below the vocal cords. Dysphagia is characterized by changes in the swallowing process, leading to consequences such as aspiration, pneumonia, respiratory failure, worsening of the patient's clinical condition, or death.

It has been found that the lack of early diagnosis and treatment of dysphagia symptoms in patients leads to adverse complications following traumatic

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Received: 14/4/2025. Revised: 16/7/2025. Accepted: 08/7/2025.

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brain injury. Early detection and treatment of swallowing difficulties not only reduce the risk of pneumonia but also minimize the risk of malnutrition, dehydration, prolonged hospital stays, and mortality. Treatment methods for dysphagia have been proposed, including compensatory strategies, rehabilitation techniques, invasive interventions, and surgical management.

Swallowing is a complex sequence of movements that transports food from the mouth to the stomach. A normal swallowing process involves multiple reflex pathways, including the cortex, subcortex, brainstem, and peripheral nervous system, specifically the cranial nerves. These factors coordinate the activity of over 30 muscles located in the oral cavity, pharynx, larynx, and esophagus. Among these, the hyoid bone and the muscles attached to it, including the mylohyoid, geniohyoid, digastric, stylohyoid, infrahyoid, and thyrohyoid muscles, play a crucial role in opening the upper esophageal sphincter (UES), allowing the food bolus to enter the esophagus. These muscles may become weakened or experience impaired movement due to damage to the neural control areas following traumatic brain injury, leading to disturbances in the transport of saliva, liquids, and food within the mouth, pharynx, and esophagus. One of the goals of dysphagia rehabilitation is to restore the movement of these muscle groups.

There are several methods used to treat dysphagia following central nervous system injuries in general and traumatic brain injuries in particular. Swallowing exercises have been proven effective in improving the weakness and paralysis of swallowing muscles. Neuromuscular electrical stimulation (NMES) is also a commonly chosen treatment for dysphagia. Some studies have shown that NMES can improve swallowing function by strengthening muscles, enhancing sensation in the oral and pharyngeal regions, and increasing muscle contraction sensitivity. The combination of both swallowing exercises and NMES enhances the effectiveness of improving the swallowing process.

In Kun Ling Huang's study involving three groups of patients with dysphagia, one group underwent only swallowing rehabilitation exercises, another used only NMES, and a third group received both interventions. The results showed improvements across all three patient groups, with some metrics indicating better outcomes in the group that received both swallowing exercises and NMES [3].

This study was conducted to observe and evaluate the effectiveness of combining swallowing exercises with NMES in patients with traumatic brain injury suffering from dysphagia

## **II. MATERIALS AND METHODS**

This study is a pre- and post-intervention investigation of a series of first-time traumatic brain injury cases with dysphagia. The study was approved by the Medical Council of Hanoi Medical University, No. 3317/QĐ-ĐHYHN. All participants were informed about the study and provided their consent.

The study was conducted at Hanoi Rehabilitation Hospital over a period of 15 months. It involved 30 first-time traumatic brain injury patients who had completed the acute phase of treatment in the neurosurgery and ICU departments before being transferred to Hanoi Rehabilitation Hospital.

Patient selection criteria: Patients had to be in a stable overall condition and able to cooperate with medical staff. They needed a Glasgow Coma Scale score of  $\geq 13$ . Patients were identified based on clinical symptoms suggestive of swallowing disorders and underwent screening for dysphagia

Exclusion criteria: Traumatic brain injury patients with respiratory failure, consciousness disorders, coma, gastric tube placement, endotracheal intubation, epilepsy, esophageal or pyloric stenosis, and dysphagia due to other causes such as brain tumors, brain infections, encephalitis, or meningitis.

All patients were examined and assessed using the same procedure on the first and last days. Variables were collected, and symptoms of dysphagia were evaluated, including the GUSS scale score. The GUSS assessment was performed

## *The effectiveness of neuromuscular electrical stimulation therapy combined...*

by a physical therapy technician. This technique was carried out according to the provided guidelines [4]. The rehabilitation program was developed based on clinical assessments.

Neuromuscular electrical stimulation (NMES) was applied using the Vocastim system (Physiomed Elektromedizin, Germany). The NMES used was an alternating current with a frequency of 20-80Hz, pulse duration of 300 microseconds, and intensity adjusted to achieve maximum muscle contraction without causing pain to the patient. The rest period

was selected as 1:1 or 2:1, depending on the patient's comfort. Electrical pulses were applied through two electrodes, each measuring 3×4 cm, placed on the left and right sides of the midline of the thyroid cartilage [5]. This setup stimulates both sides of the pharyngeal muscles. The electrodes were covered with a layer of wet viscose to improve electrical conductivity. The treatment duration was 20 minutes per session, once a day for 14 days (Figure 1). Patients were monitored throughout the treatment process.



**Figure 1:** Electrode placement for treating dysphagia using NMES therapy

The swallowing exercises included: eating and drinking positions to facilitate the swallowing process, increasing sensory awareness, oral motor exercises, and exercises to strengthen the respiratory muscles [6-8]. The exercises used included: oral, jaw, and tongue exercises, effortful swallowing, the Mendelsohn maneuver, supraglottic swallowing, the Masako maneuver, and Shaker exercises. The total treatment duration was 30 minutes per day for 14 days. Patients were considered for oral feeding when they were conscious, had normal vital signs, stable respiratory condition, and a GUSS score above 15.

**Assessment tool:** The GUSS scale was used to evaluate the degree of swallowing disorders and the risk of aspiration. The GUSS was developed by Michaela Trapl and colleagues and published in October 2007 [9]. The GUSS assessment consists of two parts: indirect and direct evaluation.

**Indirect assessment of swallowing ability:** The maximum score is 5, and the minimum score is 0.

**Direct assessment of swallowing ability:** The maximum score is 15, and the minimum score is 0.

**The total score for both parts of the test:** The maximum score is 20, and the minimum score is 0.

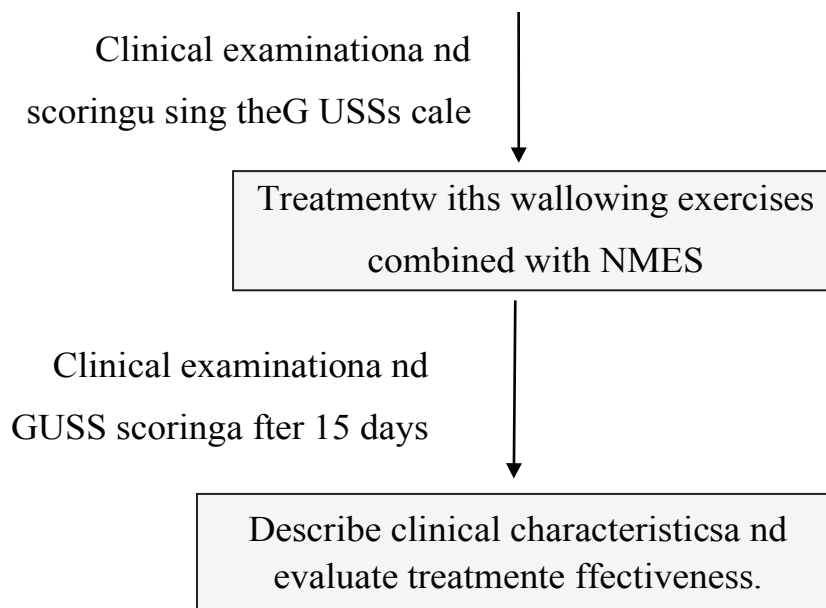
- Semisolid/ liquid and solid texture successful has a GUSS score of 20, with a dysphagia level and aspiration risk classified as Slight/ No dysphagia minimal risk of aspiration.

- Semisolid and liquid texture successful and solid unsuccessful has a GUSS score of 15 to 19, with a dysphagia level and aspiration risk classified as Slight dysphagia with a low risk of aspiration.

- Semisolid swallow successful and liquids unsuccessful has a GUSS score of 10 to 14, with a dysphagia level and aspiration risk classified as Moderate dysphagia with a risk of aspiration

- Preliminary investigation unsuccessful or semisolid swallow unsuccessful has a GUSS score of 0 to 9, with a dysphagia level and aspiration risk classified as Severe dysphagia with a high risk of aspiration

The flowchart of the study design was shown in Figure 2



**Figure 2:** Flowchart of the study design

The data were analyzed using SPSS 16.0. Frequencies, percentages, and means were calculated to demonstrate the distribution of demographic variables, severity of dysphagia, risk of aspiration, and treatment outcomes. Chi - square test and The McNemar statistical test was used for analysis. A p-value of  $< 0.05$  was considered to indicate a statistically significant difference.

### III. RESULTS

The characteristics and swallowing status of the traumatic brain injury patient group are presented in Table 1. A total of 30 traumatic brain injury patients were randomly selected for the study. There were twenty - four male patients, six female patients, and 86.7% of patients were aged 15 - 60 years, while 13.3% of patients were over 60 years old. Among the thirty patients, as of the time of intervention, 28% (6 patients) had pneumonia following traumatic brain injury.

**Table 1:** Characteristics of the Study Group

| Number of patients (n=30)                                                         |    | Degree |
|-----------------------------------------------------------------------------------|----|--------|
| Age range (year)                                                                  |    |        |
| 0 - 14                                                                            | 0  | 0      |
| 15 - 60                                                                           | 26 | 86.7   |
| > 60                                                                              | 4  | 13.3   |
| Gender distribution                                                               |    |        |
| Male                                                                              | 24 | 80     |
| Female                                                                            | 6  | 20     |
| Time of initiation of dysphagia treatment from the time of traumatic brain injury |    |        |
| Under 3 months                                                                    | 19 | 63.3   |
| Over 3 months                                                                     | 11 | 36.7   |

| Number of patients (n=30)                                             |    | Degree |
|-----------------------------------------------------------------------|----|--------|
| Post-traumatic brain injury pneumonia                                 |    |        |
| Yes                                                                   | 6  | 28     |
| No                                                                    | 24 | 72     |
| Dysphagia symptoms.                                                   |    |        |
| Spontaneous drooling                                                  | 0  | 0      |
| Drooling after swallowing                                             | 23 | 76.7   |
| Food residue in the mouth                                             | 25 | 83.3   |
| Coughing/choking while/ after swallowing                              | 26 | 86.6   |
| Voice changes after swallowing                                        | 28 | 93.3   |
| The sensation of food being stuck in the throat/difficulty swallowing | 24 | 80     |
| Changes in breathing during and after swallowing                      | 20 | 66.7   |

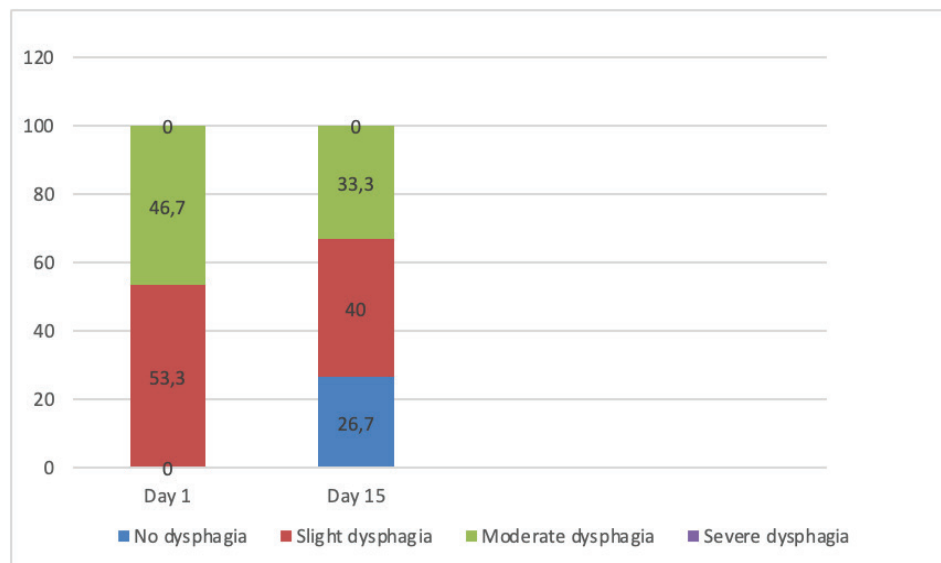
In our study, the time reference was set at 3 months after traumatic brain injury. The results obtained after 15 days of treatment are as follows: in the group without swallowing disorders, 100% of patients received treatment within 3 months. In the group with mild swallowing disorders, 81.8% of patients were treated within 3 months, and 18.2% were treated after 3 months. In the group with moderate swallowing disorders, 18.2% of patients were treated within 3 months, and 81.8% were treated after 3 months. The Chi-square test showed a p-value =  $0 < 0.05$ , indicating a significant correlation between the timing of treatment and the severity of swallowing disorders after treatment (Table 2).

**Table 2:** Relationship between the timing of treatment and the severity of swallowing difficulties after treatment

| Severity code      | Over 3 months |       | Under 3 months |       | Chi - square Tests<br>P = 0 |
|--------------------|---------------|-------|----------------|-------|-----------------------------|
|                    | N             | %     | N              | %     |                             |
| No dysphagia       | 8             | 100%  | 0              | 0%    |                             |
| Slight dysphagia   | 9             | 81.8% | 2              | 18.2% |                             |
| Moderate dysphagia | 2             | 18.2% | 9              | 81.8% |                             |
| Total              | 19            | 63.3% | 11             | 36.7% |                             |

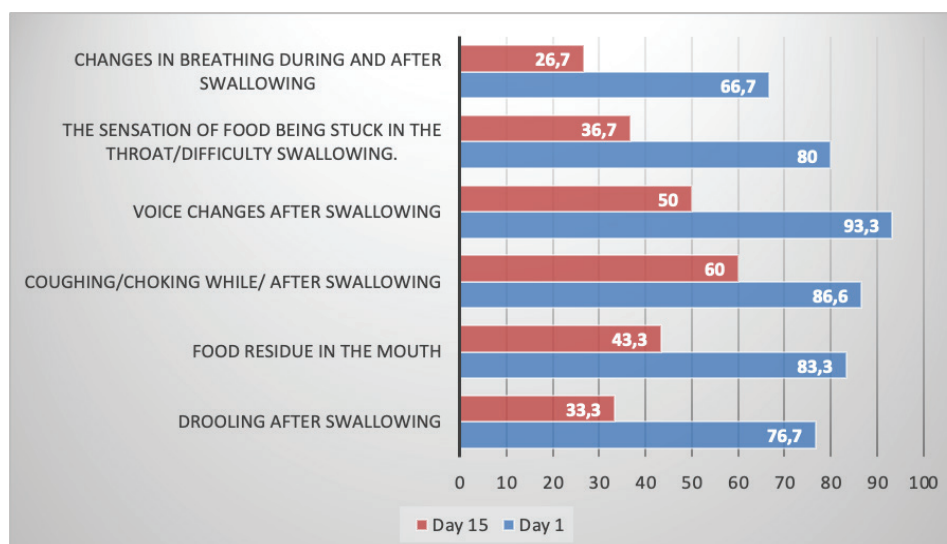
As show in Figure 3, before treatment, 100% of the patients had dysphagia, and after treatment, 26.7% of the patients showed no signs of dysphagia. Patients experienced dysphagia ranging from moderate (46.7%) to mild (53.3%) levels, with no cases of severe dysphagia. After treatment, both the severity of dysphagia and the risk of aspiration significantly decreased, as shown by the moderate dysphagia rate, which was 46.7% before treatment and decreased to 33.3% after treatment. The mild dysphagia rate was 53.3% before treatment and decreased to 40% after treatment. McNemar's test revealed a significant difference in the proportion of patients with dysphagia before and after treatment ( $p = 0.008 < 0.05$ ).





**Figure 3:** Percentage of dysphagia severity before and after treatment

According to Figure 4, the most common symptoms included voice changes after swallowing (93.3%), coughing during and after swallowing (86.6%), and symptoms like drooling after swallowing, food residue in the mouth, and changes in breathing rhythm during and after swallowing, with food residue in the mouth present at rates ranging from 66.7% to 83.3%. The symptom of spontaneous drooling was not observed in the intervention group. The intervention was performed as early as possible, with 63.3% (19 patients) receiving treatment within 3 months after the traumatic brain injury. From the time of the traumatic brain injury to the emphasize e intervention, 28% (6 patients) developed pneumonia. No cases of pneumonia were reported after the intervention. Following the intervention, the clinical dysphagia symptoms in the patient group showed significant changes. The drooling after swallowing decreased from 76.7% to 33.3%, the sensation of food residue in the throat/difficulty swallowing decreased from 80% to 36.7%, and voice changes after swallowing decreased from 93.3% to 50% ( $p < 0.05$ ).



**Figure 4:** Percentage of changes in dysphagia symptoms after treatment

#### IV. DISCUSSION

In our study, with 30 patients during the initial examination, the clinical symptoms suggesting dysphagia included: voice changes after swallowing (93.3%), coughing/choking during/after swallowing (86.6%), food residue in the mouth (83.3%), sensation of food residue in the throat/difficulty swallowing (80%), drooling after swallowing (76.7%), and changes in breathing rhythm during and after swallowing (66.7%). It was observed that voice changes after swallowing occurred in the majority of patients. According to several authors, coughing and voice changes after swallowing are considered important clinical signs of dysphagia, suggesting the possibility of aspiration, which results from liquids or viscous substances entering the larynx.

On the first day, the clinical signs of dysphagia were as follows: drooling after swallowing (76.7%), food residue in the oral cavity (83.3%), coughing/choking during or after swallowing (86.6%), voice changes after swallowing (93.3%), the sensation of food remaining in the throat or difficulty swallowing (80%), and changes in breathing patterns during or after swallowing (66.7%). After 15 days, all clinical symptoms of dysphagia showed improvement: drooling after swallowing (33.3%), food residue in the oral cavity (43.3%), coughing/choking during or after swallowing (60%), voice changes after swallowing (50%), the sensation of food remaining in the throat or difficulty swallowing (36.7%), and changes in breathing patterns during or after swallowing (26.7%).

The timing of dysphagia intervention varies widely among different authors. The intervention period ranges from the first day, 7 days, to 6 months, or even 1-2 years after traumatic brain injury. However, it is certain that screening and early intervention will improve swallowing disorders, reduce the risk of aspiration, and significantly decrease the incidence of pneumonia [10]

According to Kwakkel, within the first 6 months after a neurological injury, the patient's potential for recovery is the greatest. In a retrospective study by Douglas I and colleagues, which assessed 116 patients to predict the recovery time of motor function after traumatic brain injury, the patients

showed the greatest recovery potential within the first 3 months after the injury. In our study, the time reference was set at 3 months after traumatic brain injury. The earlier intervention, the better the prognosis for the patient's swallowing recovery. Therefore, the timing of intervention is one of the prognostic factors for the patient. Traumatic brain injury patients should be screened for swallowing disorders and have a treatment plan in place as soon as they are in the ICU.

In studies by various authors, such as Marilia S and colleagues, who assessed the effectiveness of swallowing therapy combined with NMES for stroke patients, or Kyung R K, who evaluated the effectiveness of swallowing therapy combined with NMES for traumatic brain injury patients, both concluded that the method of swallowing therapy combined with NMES results in a greater reduction in swallowing difficulties than using swallowing exercises alone [11, 12].

Assessment of patients before treatment using the GUSS score revealed that 46.7% of patients were at a moderate level, 53.3% at a mild level, and 0% had no swallowing disorders. All patients showed signs of swallowing disorders, but none had severe swallowing disorders. The reason we did not select these patients is that those with severe swallowing disorders are indicated for feeding through a tube. The study group was treated for swallowing disorders using conventional swallowing exercises and compensatory postures combined with NMES. Conventional swallowing exercises have been shown to be effective for swallowing disorders. Shaker demonstrated this on two patient groups: 7 patients received placebo exercises, and 11 patients performed the actual exercises. The results showed that there was no change in swallowing function in the placebo group, while in the actual exercise group, there was a significant improvement in the opening of the upper esophageal sphincter, allowing patients to resume eating. Masako Fujiu's tongue-holding exercise is effective in closing the base of the tongue and the posterior pharyngeal wall. Mendelsohn's exercise was demonstrated by Karen M to significantly improve the trajectory and duration of the hyoid bone movement. According to Mariana S, compensatory postures are beneficial

for patients with prolonged pharyngeal phases, poor laryngeal mobility, and difficulty swallowing liquids[13].

When conventional swallowing exercises are combined with NMES, they yield better results than conventional swallowing exercises alone. In a study by Kyung R K comparing two groups of traumatic brain injury patients with swallowing disorders, 12 patients received conventional swallowing exercises combined with NMES, while 6 patients only received conventional swallowing exercises. The results showed that the group combining NMES had better improvement in the pharyngeal phase on VFSS [14].

Our research group found that on the first day of treatment, 100% of patients had swallowing difficulties. After 15 days, 26.7% of patients no longer had swallowing disorders, moderate swallowing difficulties decreased from 46.7% to 33.3%, and mild swallowing difficulties decreased from 53.3% to 40%. Thus, the intervention process was effective in improving swallowing difficulties. Clinically, swallowing exercises combined with NMES should be used for traumatic brain injury patients with swallowing difficulties to provide benefits for the patients

Our research group found that on the first day of treatment, 100% of patients had swallowing difficulties. After 15 days, 6.7% of patients no longer had swallowing disorders, moderate swallowing difficulties decreased from 6.7% to 3.3%, and mild swallowing difficulties decreased from 3.3% to 4%. The McNemar test showed a statistically significant difference in the rate of swallowing difficulties before and after treatment, with a p-value of  $0.008 < 0.05$ . Thus, the intervention process was effective in improving swallowing difficulties. Clinically, swallowing exercises combined with NMES should be used for traumatic brain injury patients with swallowing difficulties to provide benefits for the patients.

Although we observed good improvement results in the study group, this evaluation has some limitations. First, for ethical treatment reasons, we only intervened and described the results of the group treated with swallowing exercises combined with NMES. We did not select and compare the

group receiving only swallowing exercises, the group using only NMES, the group with swallowing exercises combined with NMES, and the group that did not receive any intervention. Second, this study only used the GUSS score to assess dysphagia. Third, the sample size was small, and the number of patients involved was limited. This may affect the generalizability and reliability of the findings.

## V. CONCLUSION

Based on the results of this study, early intervention plays a crucial role in the recovery of swallowing function among patients with traumatic brain injury (TBI) who experience swallowing difficulties. The combination of swallowing exercises and neuromuscular electrical stimulation was shown to significantly alleviate the severity of dysphagia and improve all associated symptoms. Importantly, NMES proved to be a safe therapeutic option that can be implemented early in the course of treatment, even in cases where patients are not yet able to actively participate in swallowing exercises.

## Conflict of interest

The authors have no conflicts of interest to declare.

## REFERENCES

1. Capizzi A, Woo J, Verduzco-Gutierrez M. Traumatic Brain Injury: An Overview of Epidemiology, Pathophysiology, and Medical Management. *Med Clin North Am.* 2020; 104(2): 213-238.
2. Mandaville A, Ray A, Robertson H, Foster C, Jesser C. A retrospective review of swallow dysfunction in patients with severe traumatic brain injury. *Dysphagia.* 2014; 29(3): 310-8.
3. Huang K-L, Liu T-Y, Huang Y-C, Leong C-P, Lin W-C, Pong Y-P. Functional Outcome in Acute Stroke Patients with Oropharyngeal Dysphagia after Swallowing Therapy. *Journal of Stroke and Cerebrovascular Diseases.* 2014; 23(10): 2547-2553.
4. Trapl M, Enderle P, Nowotny M, Teuschl Y, Matz K, Dachenhausen A, et al. Dysphagia Bedside Screening for Acute-Stroke Patients. *Stroke.* 2007; 38(11): 2948-2952.
5. Huh JW PE, Min YS, Kim AR, Yang WJ, Oh HM, Nam TW, Jung TD. Optimal placement of electrodes for treatment of post-stroke dysphagia by neuromuscular electrical stimulation combined with effortful swallowing.



## *The effectiveness of neuromuscular electrical stimulation therapy combined...*

- Singapore Med J. 2020 Sep;61(9):487-491. doi: 10.11622/smedj.2019135. Epub 2019 Nov 4. PMID: 31680183; PMCID: PMC7927170.
6. Krekeler BN RL, Connor NP. Dose in Exercise-Based Dysphagia Therapies: A Scoping Review. *Dysphagia* 2021; 36(1): 1.
7. Kagaya H IY, Okada S, Saitoh E. Body Positions and Functional Training to Reduce Aspiration in Patients with Dysphagia. *JMAJ* 2011; 54(1): 35–38.
8. Banerjee S. Dysphagia Rehabilitation Management Course. Plus.
9. Troll C T-GM, Teuschl Y, Cerrito A, Compte MG, Siegemund M. A bedside swallowing screen for the identification of post-extubation dysphagia on the intensive care unit - validation of the Gugging Swallowing Screen (GUSS)-ICU. *BMC Anesthesiol.* 2023 Apr 13;23(1):122. doi: 10.1186/s12871-023-02072-6. PMID: 37055724; PMCID: PMC10099025.
10. Geeganage C, Beavan J, Ellender S, Bath PM. Interventions for dysphagia and nutritional support in acute and subacute stroke. *Cochrane Database Syst Rev.* 2012; 10: Cd000323.
11. Simonelli M, Ruoppolo G, Iosa M, Morone G, Fusco A, Grasso MG, et al. 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(1): 103-110.
12. Ko KR, Park HJ. Effect of Laryngopharyngeal Neuromuscular Electrical Stimulation on Dysphonia Accompanied by Dysphagia in Post-stroke and Traumatic Brain Injury Patients: A Pilot Study. 2016; 40(4): 600-10.
13. Saconato M, Chiari BM, Lederman HM, Gonçalves MIR. Effectiveness of Chin-tuck Maneuver to Facilitate Swallowing in Neurologic Dysphagia. *Int Arch Otorhinolaryngol.* 2016; 20(01): 013-017.
14. Ko KR, Park HJ, Hyun JK, Seo IH, Kim TU. Effect of Laryngopharyngeal Neuromuscular Electrical Stimulation on Dysphonia Accompanied by Dysphagia in Post-stroke and Traumatic Brain Injury Patients: A Pilot Study. *Ann Rehabil Med.* 2016; 40(4): 600-10.