



Efficiency of Neuromuscular Electrical Stimulation (NMES) in Improving the Pharyngeal Phase of Swallowing in Adult Patients with Dysphagia: A Review Article

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ABSTRACT

Background: Dysphagia is a symptom of a neurological or psychological disorder, considered as a serious social health problem which has gained a lot of attention in the last decade due to its high prevalence and intense consequences. Currently, at the side of completely different treatments, NMES has been accepted and used as a therapeutic intervention for the swallowing disorder since 2001. However, due to the deficiency of the clear and supporting data on NMES, its efficacy is still debatable in some specific areas.

Objective: To analytically review the evidence based literature examining the effects of neuromuscular electrical stimulation (NMES) on the pharyngeal phase of swallowing in adult patients with dysphagia. The main purpose of conducting this study is to find out whether NMES alone is sufficient for treating dysphagia caused by multiply etiologies, does the effectiveness of NMES varies across the severity scale of dysphagia (in terms of mild, moderate and severe), and how much does it contribute in the removal of tube feeding in dysphagia patients.

Method: A systematic exploration was conducted through various databases like PubMed and Scihub to detect the most relevant studies about the impact of NMES published in different journals from 2001 to 2018. The similar and deviated findings of all the related articles were compared and analyzed.

Conclusion: This literature review revealed that NMES alone is not a sufficient treatment approach for patients with dysphagia, instead it works effectively only when combined with any other treatment method (TDT, TTS, effortful swallowing), the efficacy of NMES is restricted till mild-moderate dysphagia only. It was found to be most effective with stroke patients in terms of the removal of tube feeding as limited studies were present on non-stroke patients.

Keywords: neuromuscular electrical stimulation, deglutition, dysphagia, pharyngeal phase, Vital Stim Therapy.

I. INTRODUCTION

Swallowing is a complex function of motor process initiated by the cerebral cortex that has generally been portrayed as comprising of 4 stages: oral preparatory, oral, pharyngeal and esophageal phases and effected by the brainstem swallowing center. (Logemann J. 1983). In continuation to this, Dysphagia is a conventional term used to define the problems that can take place in any of the 4 stages of swallowing. (Todd HT, 2013). An estimated 15 million adults in the United States are affected by dysphagia (Freed ML, 2001; Emily Dowdy, 2007).

The normal pattern of swallowing encompasses elevation and anterior excursion of the hyolaryngeal complex within the pharyngeal phase, which aids laryngeal vestibule closure and serves to avoid aspiration into the respiratory tract. (HY Lee, JS.Hong, 2015). The pharyngeal phase is the reflexive action of the transportation of the bolus through pharynx which is initiated by the posterior movement of the tongue base and the anterior movement of the posterior pharyngeal wall. Furthermore, the strong contraction of suprahyoid muscles, superior, middle, inferior pharyngeal constrictors and the anterior and superior movement of the hyoid bone play a vital role as this movement trigger the epiglottis to invert and hence close the laryngeal vestibule with transient termination of the respiration along with the opening of the upper esophageal sphincter. (Ertekin C, 2003; Lang IM; 2009; J.S PARK, 2016). Above 80% of the swallowing mechanism happens during exhalation with an apneal phase ranging from 1 – 1.5 seconds which occurs pre and during pharyngeal phase. (Logemann, 1997). However, it is essential to note that the normal pharyngeal swallow triggering in healthy adults above 60 years has been observed to be delayed when the food/liquid crosses the faucial arches to almost the center of the base of tongue. (Freed, 2001; Carnaby-Mann 2007).

It can be very well understood from the above description that any weakness of suprahyoid muscles will result in deviation of the hyoid bone which in turn cause incomplete opening of upper esophageal sphincter, resulting in aspiration/penetration. (Logemann JA, 1992). Reduced or delayed laryngeal elevation is believed to be the foremost communal explanation and reason for dysphagia and aspiration (Burnett TA, Mann EA, 2003). Along with this, it has been asserted that it is common to develop pharyngeal sensory impairment post stroke and that such condition is directly proportional to the risk of developing aspiration. (Kidd D, Lawson J, Kil- Byung Lim 2009).

Dysphagia prompts an expanded danger of lack of healthy sustenance, dehydration, aspiration pneumonia, and even death. (Holas MA, 1994; Yi- Wen Chen, 2015)

Beside the physical complications of aspiration, patients typically suffer severe depression due to the loss of the swallow function and the interruption of regular daily living activities. (Leonard A Freed 2001). In the initial acute phase of CVA (cerebral vascular accident) and TBI (traumatic brain injury), the patient usually presents with oropharyngeal dysphagia and the incidence ranges from 22% to 70% in patients with CVA, 38-65% in TBI (Terre R, Mearin F. 2009; 2015).

The type and severity of dysphagia must be determine with the help of an instrumental assessment(MBS, FEES) so that the therapist can obtain a clear view of the swallowing mechanism in terms of its anatomical structures and physiology. On the basis of the clinical findings the therapist then plans the treatment accordingly (Freed, 2001; Carnaby-Mann 20017). FEES is a safe, reliable and valid assessment tool which helps to detect the aspiration/penetration via passing a thin flexible fiber optic tube into the larynx. It is highly helpful in the most appropriate diagnosis and management of the pharyngeal phase of dysphagia. (Langmore SE, 2001, Shu-Fen Sun et al 2013). Whereas a Modified Barium Swallow test is another instrumental procedure which enables to identify the swallowing problems through barium which is a radioactive solution mixed with liquid or food consistency. It is helpful for the therapist to make correct decisions according to the pathological disruption seen in any of the 3 phases of deglutition. It is also used to rule out aspiration and make clinical judgements in terms of the selection of best consistency along with the posture for the dysphagia patients. (Logemann, 1991).

The main aim of dysphagia management is to achieve an increase in safe and appropriate intake of oral nutrition (liquids and solids). Prevailing ways of dysphagia intervention which comprises of traditional methods namely oro-motor exercises, thermal tactile stimulation, alteration in diet, adequate postures and maneuvers, are considered as the basis of dysphagia therapy to date. (Geeganage C et al 2012; Shu-Fen Sun et al 2013).

Traditional dysphagia therapy, in collaboration with dietary modifications has been shown to be an efficient tool in dysphagia treatment and management, however results are not fulfilling and rewarding in all patients (Freed et al 2001; Michael Jungheim 2014) the management of dysphagia in stroke patients has been focused, since decades on behavioral compensatory strategies. These strategies were found to be helpful in safe swallow but unfortunately were not effective in impaired swallow mechanics and were also not helpful in recovery of damaged neural system of swallowing. (Speyer R, 2010; L. ROFES, 2013). Such findings raised the need of some other treatment that could work on the stimulation of impaired muscles and neural networks. The only answer that the researcher could get at that time was the implementation of NMES which was already been used by the physiotherapists for the muscle stimulation of the upper and lower limbs.

The NMES was accepted and permitted by the US Food and Drug Administration in 2001 for the management of dysphagia after submitting the data on more than 800 patients who received Vital Stim therapy. (Bulow M, Speyer R, 2008; Gary Shaw, 2015). It is to be noted that in most of the oropharyngeal dysphagia caused by stroke, NMES was found to be a useful tool with no side effects. (Rosa Terre et.al 2012). The belief behind the usage of NMES in dysphagia rehabilitation is to support the swallowing process and to avoid aspiration by supporting the preventive mechanism of the larynx. (Shaw GY 2007). The purpose of NMES is to give electrical stimulation on the anterior surface of the throat which increases the rate and strength of the muscular contractions. This procedure indirectly contributes in the decrease of the muscle atrophy, thereby helping neuromuscular training and re-education. (Ludlow CL, Humbert, 2007; Suiter DM, 2006; J.S. PARK, 2016). NMES is utilized on innervated muscle that recruits a lot of motor units than voluntary contraction and will manufacture bigger improvements in strengthening the muscles than exercise in isolation. (Sun SF, Hsu CW, Lin HS, 2013).

Compared with the other treatment options which comprise pharyngeal electrical stimulation, repetitive transcranial magnetic stimulation and transcranial direct current stimulation, neuromuscular electrical stimulation is the cheapest and easiest to supply. (Kwang-Hwa Chang, 2016). NMES can be effectively applied in light of the fact that it includes utilization of protected and convenient gadget and is non-obtrusive. (Carnaby- Mann, 2007). Considering hyoid bone as a landmark, the NMES device makers have suggested many ways of placing two sets of surface electrodes on the frontal part of neck muscles superior and inferior to it i.e. suprahyoid and infrahyoid muscles. (Ding R, Larson CR, 2002; J.S. PARK, 2016). In Vital Stim therapy electrodes are simultaneously activated over the submental and laryngeal regions on the throat, with the goal of creating a synchronous contraction of the mylohyoid in the submental region and thyrohyoid in the neck. (Freed ML, 2001). During the application of NMES, the current intensity level is increased until the patient reports the sensation of 'muscles grabbing', referred to as 'motor levels' of stimulation. The trigger at that point stays on, cycling off for 1s every minute throughout 1 hour of therapy while the patient is encouraged to consecutively 'swallow hard.' The creators of this device guarantees that most patients ought to exhibit expanded increased laryngeal elevation with stimulation during first session. (Wijting Y and Freed ML, 2003).

One of the primary issues concerning the utilization of NMES in dysphagia treatment, and a conceivable clarification for conflicting outcomes, lies in the poor comprehension of the physiological procedures happening because of NMES. (Low J, Reed A. 2006; Alexander Matthias Jansen, 2014).

II. DISCUSSION

With the advent of Vital Stim therapy, its inventor claims that no more feeding tube is required and it is considerably better than prevailing therapies with around 97% success rate after testing it upon under a 1000 patients. However, a further detailed analysis by the researchers on a diverse group of total 18 patients having undergone NMES revealed somewhat contrasting results as 12 of them (66%) still required a feeding tube for proper nutrition, and only 6 (33%) did not. Those particular studies indicate that NMES in isolation is not an effective treatment for majority of the patients with dysphagia and dependence on other approaches is still necessary. The very same analysis revealed that few patients classified as having severe dysphagia, only 30% revealed signs of recovery. While those with mild and moderate dysphagia, 60% reported some recovery and only 20% showed considerable recovery. Vital Stim treatment appears to help those with mild to moderate

dysphagia. But the patients with the most extreme dysphagia in the investigation didn't pick up freedom from their tubes. The Vital-Stim treatment unmistakably has a spot in the curing of dysphagia, however that the most seriously affected are not likely to have drastic recovery.

In the year 2006, a case control study was performed on the patients having dysphagia due to different causes. The cases were given the NMES whereas the control group was intervened through traditional swallow therapy to find out the pattern of recovery in those patients. The outcomes were measured through FEES to compare the status pre and post therapy. The findings of the study suggested that insignificant variance was observed in both the groups. There were a lot of factors that contributed in these results such as the difference in the frequency of sessions given to both the groups, deviation in the time period of treatment as control group were mediated right after the date of onset, but interestingly in this study they realized that the control group had larger gains in terms of their dysphagia improvement than the cases.

Two different studies were conducted in the year 2008 and 2009 respectively, in which a comparative treatment was provided to two groups in which NMES and TTS were given separately and then collectively to the CVA patients for 15 sessions that were able to swallow and were without feeding tubes. The results of these studies exhibited negligible difference in the outcome of both treatment methods separately when instrumentally assessed. However, the significant finding of the study was that NMES and TT when given together were found effective only with mild-moderate dysphagia. The drawback of these studies was that a short sample size was enrolled and follow up could not be maintained after the period of 2 years.

Most of the prevailing treatments of dysphagia have been found to be unproductive with only thermal tactile stimulation (TTS) somewhat productive but that also in mild to moderate dysphagia cases taking lengthy periods in recovery. In order to find a solution to this problem a study was performed with NMES and TS applied on similar demographics dysphagia patients except the fact that NMES patients had a history of longer treatment period of failed therapies post their stroke. Despite that NMES patients held a higher position showed comparatively more improved swallow scores with 98% patients showing some recovery as compared to just 62% success rate of TTS. Also, NMES tests showed that patients with mild to moderate severity and not on a feeding tube witnessed around 50% improvement in swallowing. NMES patients with more than 6 on the SFSS (swallow function scoring system) changes recovered from severe dysphagia to normal swallow while those with plus 5 changes recovered from tolerates saliva only to being completely normal.

In a similar study like above 92 tube dependent IPD patients were recruited, amongst which 65 patients were given NMES with TDT/PRT (traditional dysphagia therapy/ progressive resistance training) and the remaining 27 were provided with TDT/PRT only. This particular study suggested that the group which was given NMES with TDT/PRT exhibited remarkable improvement in their dysphagia. The speedy recovery of the patients in the NMES group displayed a slightly deviated finding than previous studies as severe to profound cases were also benefited from it. On the basis of these findings the most highlighted point would be that, the NMES has the potential to facilitate recovery in the initial stages of stroke with patients having severe dysphagia. The emphasis could be made that NMES can reduce the natural recovery period of 60 weeks after stroke if given intensively with other techniques as well. However, the limitations of that study included randomization error and selection biasness.

In the following year one more case control study was carried out which provided NMES with TDT to 31 ischemic stroke patients and TDT only to 26 patients immediately after their stroke. The baseline of swallowing mechanism was assessed after 3, 6 and 12 weeks of therapy. The functional oral intake scale (FOIS) exhibited an improvement in the scores of patients receiving NMES with TDT in terms of progression towards the oral diet. The results of this study advocated and emphasized on the early intervention of dysphagia through NMES in patients having acute or sub-acute stroke. In terms of diet intake 5 patients were still dependent on tube feeding as they had been diagnosed with severe dysphagia. So the inference perceived could be that early application of NMES would be highly beneficial for patients having mild-moderate dysphagia only.

In the year 2016 a randomized controlled trial was conducted to identify the implication of a novel dysphagia training program which comprised of NMES in combination with effortful swallowing for 6 weeks in CVA patients with mild-moderate dysphagia.

An experiment was performed in which a strong, high-degree stimulus was given to the patients, acting as a training force to initiate voluntary contraction which in turn reinforce the patient to swallow with great effort combating with in and trying to overcome the resistance produced. Significant improvement in the anterior-superior movement of the hyoid bone was observed, enhancing the positive outcome in the pharyngeal phase of swallowing. The interpretation achieved was that NMES when combined with effortful swallow was confirmed to be effective. However, the results should be viewed with caution as the numbers of participants were limited and only patients with mild-moderate dysphagia were included.

In another prospective study conducted in the year 2013, conventional treatment was provided to the patients with aspiration. Out of 8 patients only 1 patient was fed through tube after the study and the remaining were progressed on the oral diet without any complications. This study highlighted the safety and usefulness of NMES with tube feeding patients.

An article review on 7 articles was formulated in the year 2013 on the role of NMES compared to other treatments (TT, TTS) in non-stroke patients (dementia, cancer) with dysphagia, analyzed that NMES was much more effective and non-complicated with various etiologies than TT. According to them, there is no harm in using NMES with non-stroke patients in fact it was proven to be beneficial for them as it improve the pharyngeal phase of swallowing. However, the results should be viewed carefully as it had a variety of limitations, due to which it is doubtful to state that NMES has been proven to be superior than any other treatment approach.

In a meta-analysis published in the year 2015, the comparison was made between dysphagia treatments with NMES vs treatment without NMES after reviewing eight studies. The data suggested that the NMES for dysphagia after stroke in the short term period produced better results than treatment without NMES; however it was not proven whether NMES alone could be considered as the leading approach in dysphagia management due to the insufficient evidence. In continuation with this, one more study was conducted in the same year to compare the results of NMES and conventional swallowing therapy (CST) vs sham electrical stimulation (SEM) and (CST) in patients with acquired brain injury during the period of 20 sessions. Their conclusion proposed that the group given NMES/CST exhibited remarkable rapid recovery as the latency period was much more reduced than the other group, as till 1 month not much progress was seen in the other group. Though the pharyngeal muscles' contraction was very much intact prior to the therapy but still a lot more increment was observed post therapy.

In addition to the previous researches, a comparative study between NMES and traditional therapy versus traditional therapy was conducted in the year 2018 in patients with long lasting dysphagia. The results of that study added a strong evidence by unfolding the major finding which revealed that NMES with the combination of traditional therapy helped in upgrading texture consistencies and patient reported results in subjects with long-standing dysphagia of neurological cause who have otherwise failed to respond to traditional swallowing therapy. Those outcomes are very promising and are consistent with those from former studies which exhibited that an amalgamation of conventional therapy and NMES improved swallowing performance. Moreover, nine of the ten subjects sensed their quality of life had improved after NMES.

In a systematic review of randomized controlled trial, published in the year 2020 the result of NMES on swallowing functions was assessed. Ten out of eleven studies have confirmed that NMES assists to improve swallowing function in dysphagia patients post stroke. A study piloted by Lee 2014, established a notion that NMES exhibited a substantial enhancement on the FOIS (Functional Oral Intake Scale) after management. Both groups presented with a substantial enhancement on the swallowing function subsequent to treatment on acute/sub-acute dysphagia stroke patients. A study by Park et al (2016) confirmed that NMES joined with effortful swallowing was effective in improving the pharyngeal phase of swallowing, and hyoid movement in stroke patients with dysphagia compared to effortful swallowing groups.

In the mid of this year 2022 an article review was published about the efficacy of NMES in the management of dysphagia. Approximately, 14 studies were included in that review which established their results on instrumental and objective examination methods, twelve studies testified (inadequate) positive results for dysphagia when treated with NMES in combination with TDT and/or effortful swallowing. Ten out of

twelve studies used a comparison group treated by TDT and, therefore, showed benefits of the combined dysphagia therapy with NMES. Advantages of the combined treatment were supplemented with i.e.: an enhancement of the oral and the pharyngeal transit time an improved hyoid bone movement a decrease of aspiration and an improvement in oral feeding. The remaining four studies based their findings on clinical assessments or screenings. Three of these stated extra affirmative outcomes for dysphagia when treated with NMES. All twelve studies which explored this group of patients described post-treatment benefits in relation with NMES.

Few more studies were conducted which argued on the point that NMES still doesn't seem to be effective in comparison to the other muscles of the body. But keeping in consideration all the factors that have been discussed in this study NMES role in the dysphagia management could not be disregarded.

III. CONCLUSION

This systematic review's objective was to assess current research on the potential efficacy of NMES as a treatment for pharyngeal dysphagia while taking various factors into account. Overall, it can be said that a substantial number of studies point to NMES as a successful therapy option when used in conjunction with TDT for individuals with dysphagia especially following stroke, Parkinson's disease, or other types of brain lesions leading to dysphagia.

Even though it is believed that appropriate protocols have a significant role in the efficacy of NMES therapy, too far, not a single study has looked into or better defined the most effective NMES and therapeutic parameters. Clarification of the stimulation protocols, parameters, and therapy settings that are most advantageous for various patient populations and levels of impairment requires additional investigation.

However, the efficacy of NMES can be well defined in terms of, that it works more efficiently and productively only when accompanied with any other treatment approach in the management of mild-moderate dysphagia, which further contributes in the removal of the tube feeding. NMES reliability in isolation is still under debate as it has not been proven to be producing any fruitful results, due to which the traditional approach still holds a prestigious position to date. Also, NMES importance could not be neglected as it has been observed as the better treatment approach in combination with any other modality for the rapid progress in the acute/chronic post stroke patients and non-stroke patients.

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