The Effect of Neuromuscular Electrical Stimulation on Dysphagia in Stroke Patients

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Introduction

Dysphagia is an abnormal swallowing pattern where there is a disruption of bolus flow through the mouth and pharynx leading into the esophagus. The bolus may get stuck in between the mouth and pharynx or get stuck within the pharynx. This can lead to very dangerous consequences because when food is left behind in the pharynx, an individual may breathe in the leftover food causing it to travel into the airway. Some signs of a person having dysphagia include "repetitive swallowing, throat clearing, hoarse voice, recurrent pneumonia, deglutitive cough, weight loss, or choking" (8). However, having some of these symptoms does not necessarily mean that a person has dysphagia. For instance, if an individual clears their throat after swallowing this does not automatically equate to dysphagia. If dysphagia is left untreated, dehydration, malnutrition, infection, or aspiration pneumonia can occur. Aspiration pneumonia is an infection that occurs when food or liquid is aspirated into the lungs. If the food or liquid is not removed, it can collect bacteria within the lung causing an infection. Aspiration pneumonia is the third-highest cause of death during the first month following a stroke and has resulted in over 50,000 deaths per year in the United States. Aspiration pneumonia is the cause of death in 34 percent of people who suffered a stroke. Also, 30 percent of all stroke patients require tube-feeding for one year after their stroke has occurred, which can lead to nutritional deficiencies and increased mortality and morbidity. The estimated cost of feed-tubing a patient for a year is approximately $30,000 and the mortality rate can be as high as 36 percent following the two years after a stroke (3). Early diagnosis of dysphagia is important so that an individual will be at a reduced risk of developing any of these complications. The most commonly used way to diagnose dysphagia in a patient is through a video fluoroscope examination. This test is administered by having the patients swallow foods of different consistencies that are mixed with

radio-opaque barium. The clinician can then follow the bolus as it travels through the mouth and down into the esophagus, noting an abnormalities in the physiology of swallowing or if any barium ended up in the airway which would be reflective of aspiration. If the food becomes stuck in the pathway from the mouth to the esophagus, or if any food enters into the airway, the patient is diagnosed with dysphagia. There are many causes of dysphagia including "central nervous deficits, muscular/neuromuscular disorders, and chronic obstructive pulmonary disease" (8) These disorders increase the chance of developing dysphagia due to damaged areas of the brain that function in swallowing and damages to the nerves and muscles that are a part of the swallowing mechanism.

Neuromuscular disorders are the most common cause of dysphagia (5). Of all of the neuromuscular disorders that can lead to dysphagia, stroke patients have the highest prevalence of developing dysphagia. There are approximately 800,000 acute strokes that occur in a year in the United States and the incidence of dysphagia in stroke patients has been found to be between 23-70 percent, with the majority of research presenting approximately 35 percent. Dysphagia can be caused by a stroke due to the potential damaging of the cortex and brain stem regions of the brain, or damage to the nerves and muscles that are used in swallowing. The cortex and brain stem are the primary areas of the brain responsible for the swallowing mechanism. Humans have three different types of swallowing that occur on a daily basis. The first type of swallowing is subconscious swallowing. This type of swallowing occurs instinctively to eliminate excess saliva in the mouth. The second type of swallowing is reflexive swallowing. This type of swallowing is an airway protective mechanism and occurs automatically when a stimulus is presented that could potentially enter into the airway and cause damage. The third type of swallowing is volitional swallowing, which occurs when an individual is eating. The volitional type of

swallowing is what is most affected when an individual has a stroke, and the resulting swallowing abnormalities lead to dysphagia. Volitional swallowing is controlled through the cerebral cortex of the brain and it has a network that uses the "insula, cingulate gyrus, prefrontal gyrus, somatosensory cortex, and precuncus regions" (8). The swallowing pattern involves approximately 55 muscles, 6 cranial nerves, and 2 cranial nerve roots. A stroke can cause damage to many of these areas, and when one of these areas is damaged it leads to an irregularity or discoordinated function in the swallowing network. This abnormality causes swallowing to become disrupted. The most common treatments for dysphagia in stroke patients include "thermal tactile stimulation, oral motor exercises, progressive resistance training, sensory stimulation, and compensatory swallowing strategies" (4). One type of treatment that has been rising in clinical practice is neuromuscular electrical stimulation.

Neuromuscular electrical stimulation has been used on a wide variety of injuries, but it has only recently been used on dysphagia patients. NMES uses electrodes that are placed on the surface of the skin and deliver an electrical stimulation to muscles causing a contraction by depolarizing the muscle fibers that are associated with the muscle and surrounding muscle that the electrodes were placed on. NMES was approved by the Food and Drug Administration to be used on patients with dysphagia in 2001, but was not recognized as a common clinical use by speech pathologists until 2005. Electrical stimulation can help "enhance sensory feedback from the oropharynx to the central pattern generator, strengthening the disused oropharyngeal musculature, and preventing atrophy and reduced motor output" (2). Atrophy of the oropharyngeal muscles has been shown to occur after just four days of having abnormal swallowing patterns. Type II fibers are the first fibers to atrophy and NMES causes these fibers to contract more forcefully, which could help regenerate these fibers. This type of treatment also

allows sensory feedback to be sent to the cortex, brainstem, and the swallowing centers to enhance brain plasticity of proper swallowing mechanisms. Stimulating these areas causes excitability in the brain areas that control swallowing, and when using NMES the excitability period could last longer than the stimulation period causing plastic changes in the brain. There have been several research studies published to determine the efficacy of using NMES to improve swallow function in patients that have developed dysphagia from a stroke.

Literature Review

One research article that evaluated the efficacy of neuromuscular electrical stimulation on dysphagia in stroke patients combined the use of electrical stimulation with thermal-tactile stimulation (6). Thermal tactile stimulation is one of the most common forms of treatment in patients who have been diagnosed with dysphagia. The method involves rubbing the anterior faucial pillars with a cold stimulus before the swallowing mechanism occurs. This method has been used because it is believed that applying a cold probe will trigger the pharyngeal swallowing mechanism more rapidly due to the cold stimulus being sent to the cortex and brainstem. TTS was used for the control group, while NMES and TTS were both used for the experimental group. There were 28 subjects in this study who were diagnosed with an acute stroke either through an MRI or CT scan. The experimental group contained 16 subjects and the control group contained 12 subjects. The "affected hemisphere, stroke type, location of lesion, and previous treatment history," were distributed equally among the two groups, and the degree of swallow function scores at initial evaluation were the same among the two groups (6). The experimental group received NMES for one hour with a frequency of five days a week and they also received TTS five days a week. The electrodes were placed in the exact same spot on each

subject in the experimental group, so that they could stimulate the muscles that are used for swallowing in all of the subjects. The control group only received the TTS five days a week. The study lasted for four weeks, and the experimental group had significantly higher scores in their swallow function scores than the control group in the final evaluation. The experimental group also had a lower amount of aspiration and a lower amount of subject who needed tube-feeding than the control group in the final evaluation. The results suggest that the combination of NMES and TTS have better outcomes for improving dysphagia than just TTS alone. Limitations of this article include the small amount of subject participation and a short-term final evaluation period (6).

Another study that was done combined NMES with progressive resistance training (PRT) with a larger amount of subjects who were in inpatient rehabilitation (4). This study contained 92 subjects who had acute stroke, relied on feed-tubes, and were diagnosed with severe dysphagia. The primary purpose of this study was to test the effectiveness of NMES on improved swallow function and not being dependent on tube-feeding. The experimental group contained 65 subjects that received both NMES and PRT. The PRT consisted of "lingual strengthening exercises, laryngeal adduction-elevation exercises," and different types of swallowing exercise/maneuvers. The PRT and NMES were administered for an hour a day during meal times for 18 days. The control group only received the PRT for the same duration. The two groups were similar in demographics and stroke location; however, the experimental group had significantly lower swallow function ability. After the final evaluation, the experimental group had 46 percent of the subject show minimal or no swallowing difficulties, while the control group had 26 percent. The results suggest that combining NMES with PRT can improve swallowing function in severe dysphagia patients. This study contrasts with other findings on NMES and severe dysphagia.

Many articles that researched the interaction between using NMES in severe dysphagia patients found little to no improvement in the scores of the swallow function. However, the authors of this article suggest that recovery must take place within 2 months of the onset of acute stroke to see significant results. This study implemented the treatment programs within seven days after the diagnoses of the acute stroke, which could account for why the results were contrasting from other studies. The limitations of this study include having almost three times as many subjects in the experimental group as in the control group, being a case-control instead of randomized study, and bias by having the same clinicians perform both the pretest and posttest assessments (4).

However, there are studies that show that NMES does not show any improvement in stroke patients with dysphagia. One study that contrasts the results of the previous studies includes comparing the effectiveness of NMES against traditional therapy techniques in patients with a chronic stroke (9). A chronic stroke is one characterized by three months after having a stroke. In this study, twenty-five patients were included and they were split into two groups. Twelve of the subjects were put in a group with NMES and traditional therapy, and thirteen patients were put into the group of just receiving traditional therapy. The results of the study showed improvement in both groups, but there was no significant difference in the amount of improvement between the two groups. These results suggest that the combination of NMES with traditional therapy was just as effective as treating chronic stroke patients with dysphagia using only traditional therapy techniques. Another study conducted with 18 patients who had a chronic stroke compared patients with mild to moderate dysphagia versus patients with severe dysphagia using NMES (7). Eleven patients had mild to moderate dysphagia, and all of the patients showed significant improvement in their swallow function with six of the patients being able to be taken off of feeding tubes. However, only one of the patients from the seven who had severe dysphagia

showed any sign of improvement. The conclusion of these two studies is that patients who have a chronic stroke or have severe dysphagia do not show any significant improvement in their dysphagia after being administered NMES compared to traditional therapy techniques.

Limitations

Using NMES to treat dysphagia patients is still a very new process, and the effectiveness of the process still needs to be researched further. Some methodological inconsistencies in the research that contribute to the topic still being controversial include crossover and differing study methods. The first question that is taken into account is whether the improved swallowing function produced from NMES can be transferred to an improved voluntary swallowing pattern. There are two purposes of NMES. The first is to increase the intensity of NMES until it causes a muscle contraction, and the purpose of these contractions is to help strengthen the associated muscles. Increased strength of the muscles in the swallowing mechanism is important to help initiate normal swallowing patterns and to protect food from going into airway. However, the muscle contractions and motor unit recruitment induced by NMES are different than voluntary contractions. In voluntary contractions, Type I muscle fibers are recruited first , while in NMES contractions Type II muscle fibers are recruited at a higher level and this causes a more forceful contraction and increases strength development. In some research articles, this concept is considered a positive advantage of using NMES, but in other research articles the authors argue that this discrepancy could cause the motor unit recruitment to not carry over into functional swallowing when the patient is taken off of NMES. The second aspect of why NMES still needs to be researched further for its effectiveness in treating dysphagia includes the inconsistencies of the procedures in previous research studies. Many of the studies used subjects with a stroke and

included subjects with other brain injuries within the same study. Using subjects with both stroke and differing brain injuries can reduce the validity of the effectiveness of using NMES to treat dysphagia in stroke patients because different brain injuries may affect the swallowing pattern different than a stroke will. In studies where only stroke patients were used there was very different inclusion criteria throughout the same studies. Many studies included both acute and chronic stroke patients without separating them into different groups, different swallowing dysfunction severities, intensity of NMES, and where the electrodes were placed on the patient. Having a combination of these four can cause the results of the effectiveness of NMES to improve swallow function to be skewed to a more positive or negative result. Another reason why NMES is still controversial in clinical practice is because most research studies have very short follow up periods for gathering data on their post-assessments. These short follow up periods call into question whether the improvement in the swallow function can be sustained after treatment is no longer being administered.

Conclusion

The results of research on the effectiveness of neuromuscular electrical stimulation in treating dysphagia in stroke patients can be interpreted that patients with acute stroke, mild to moderate dysphagia, and receiving treatment within two weeks of being diagnosed with stroke show the greatest improvement in their swallow function from NMES. Patients who have a chronic stroke, sever dysphagia, and receive treatment a month after being diagnosed with a stroke do not show as significant of an improvement in their swallow function after being administered NMES. Dysphagia is a common side-effect of having a stroke and further research containing standardized and randomized-controlled studies need to be investigated more to help

determine if neuromuscular electrical stimulation can help stroke patients with dysphagia reduce their risk of aspiration, malnutrition, and increase their overall quality of life.

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