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EFFICACY OF MASTICATORY MUSCLES ELECTRIC STIMULATION IN IMPROVING SWALLOWING IN SPASTIC DIPLEGIC CP

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A B S T R A C T

Objectives: The aim of this work was to investigate the efficacy of masticatory muscles electric stimulation in improving swallowing in spastic diplegic CP.**Method**: Thirty children were enrolled in this study and randomly assigned into two groups; group A received masticatory muscles electrical stimulation plus traditional physiotherapy program), and group B (traditional physiotherapy program only). (FOIS) was used to evaluate and follow feeding level progress.. This measurement was taken before treatment and after 12 weeks of treatment for all patients. The children parents in both groups A and B were instructed to complete 3 hours of home routine program. **Results:** Data analysis were available on the 30 spastic diplegic cerebral palsy children participated in the study. No significant difference was recorded between the mean values of all parameter of the two groups before treatment. By comparison of the two groups results after treatment there was significant improvement in (FOIS) in favor of the study group. **Conclusion:** According the results of this study supported by the relevant literature it can be concluded that the combined effect of physiotherapy training program in addition to masticatory muscles electrical stimulation can be recommended in improvement of feeding level progress in spastic diplegic cerebral palsy children.

INTRODUCTION

Children with cerebral palsy (CP) are at risk for aspiration with oral feeding with potential pulmonary consequences, and commonly have reduced nutrition/hydration status and prolonged stressful meal times. There is considerable variability in the nature and severity of swallowing problems in these children whose needs change over time. Children with generalized severe motor impairment (for example, spastic quadriplegia) are likely to experience greater swallowing deficits than those with diplegia, but oropharyngeal dysphagia is prevalent even in children with mild CP[1].

Feeding disorders may present as inadequate growth, prolonged feeding times, delayed progression of oral feeding skills and/or recurrent respiratory disease. Children with CP have dysphagia caused by a central nervous system disorder in which passive tone is variable (hypertonia common with spastic CP), and primitive reflexes may be strong and persistent. Although children with neurological-based dysphagia may not produce a gag upon stimulation, they may be appropriate for oral feeding. There is no direct relationship between gag and swallowing ability[2].

Children with spastic Cerebral Palsy are especially vulnerable to dysphagia because spasticity can cause contractions of the esophagus that are uncontrolled.Children with dysphagia endure a number of different symptoms of the condition, depending on the nature, and severity of their Cerebral Palsy. Some of these related symptoms are inconvenient or uncomfortable, but others are severe and must be monitored by caretakers and parents. Sometimes, dysphagia can cause problems unrelated to feeding; children with severe cases have difficulty speaking because their muscles cannot adequately control their vocal chords[3]

Swallowing is a complex act involving five nerves and 25 muscles. It serves two main purposes. The first and most obvious is to maintain nutrition and hydration. The second is an airway protection reflex. It empties the pharyngeal airway and prevents inappropriate material entering the larynx, trachea, and lungs. A swallow consists of forming a bolus, closing off the airway, and moving the bolus into the throat and then into the esophagus A normal swallow is a swallow that is not followed by a cough or aspiration. An abnormal swallow followed by aspiration can lead to pneumonia, in which aspiration pneumonia can potentionally lead to death[4].
Application of electrical stimulation to muscles associated with swallowing links swallowing therapy with general physical therapy. A fundamental principle of physical therapy is that disuse of a striated muscle leads to atrophy of that muscle and direct effect on the associated nerves. When attempts at exercise alone fail to result in contraction of an atrophied muscle, electrical stimulation may enhance tone to the point where exercise may again strengthen the muscle[5].

The clinical objectives in electrical stimulation with CP include: (1) reduction of stiffness and exaggerated reflexes(spasticity); (2) reduction of co-activation (co-contraction) of antagonistic muscles; (3) increasing the ROM; (4) facilitation of muscle contraction to fill the gap that

patients experience as an inability to fully activate their muscles (poor percentage recruitment of muscle fibers); (5) improving the timing of coordinated movement and (6) Recently, there has been increased interest in the use of NMES for the treatment of swallowing disorders (dysphagia). (7)The oxygen levels of tissues increased (8) increased cortical intensity in the somatosensory cortex.[6]

MATERIAL AND METHODS

Subjects

Thirty children from both sexes with spastic diplegic cerebral palsy children were enrolled for this study, aged 2 to 5 years at time of recruitment because the children in this age are able to participate in graduations tests of (FOIS), children were restricted single consistency diet at level 4. Children who otherwise met the inclusion criteria were excluded.

Children randomized to the experimental group (A) received masticatory muscles electrical stimulation plus traditional physiotherapy program. Children randomized to the control group (B) received traditional physiotherapy program only. The individual-based masticatory muscles electrical stimulation treatment sessions of 30 minutes were conducted three times weekly for 12 weeks in physiotherapy treatment room after the traditional physiotherapy session for group (A). In addition, children in the experimental group were exposed to home routine program 3 hours daily for the 12 weeks treatment period. Control group (B) received a traditional physiotherapy program only.

Outcome measurements

Functional oral intake scale for dysphagia(FOIS)

Level 1*:* nothing by mouth;
Level 2: tube dependent with minimal attempts of food or liquid;
Level 3: tube dependent with consistent oral intake of food or liquid;
Level 4: total oral diet of a single consistency;
Level 5: total oral diet with multiple consistencies, but requiring special preparation or compensations;
Level 6: total oral diet with multiple consistencies without special preparation, but with specific food limitation;
Level 7*:* total oral diet with no restrictions.

A clinical assessment before and after treatment using the functional oral intake scale(FOIS) for dysphagia After therapy the scale showed changes in feeding. The scale showed improvement in feeding progressed from a restricted single consistency diet to a full oral diet.

The spastic diplegic cerebral palsy children could receive a maximum of 36 sessions; if the spastic diplegic cerebral palsy children reached a level 6 on the FOIS before all 36 sessions were completed, then treatment could be terminated. 10 spastic diplegic cerebral palsy children raised their score by at least 2 points on the FOIS and the majority progressed from a restricted single consistency diet to a full oral diet[7]

Oral motor function test(for oral motor skills)

1. Open and close the mouth.
2. Blow up the cheeks while the mouth is closed. Then press a finger against the left cheek and the right cheek a couple of times, while keeping the mouth closed. (No air may leak out of the mouth.)
3. Stretch out the tongue as far as possible.
4. Open the mouth and move the tongue as far as possible to the right
5. Open the mouth and move the tongue as far as possible to the left.
6. While the tip of the tongue pushes into the left cheek, press a finger against the tongue. (If there is normal tongue strength it should be possible to resist mild finger pressure.)
7. While the tip of the tongue pushes into the right cheek, press a finger against the tongue. (If there is normal tongue strength it should be possible to resist mild finger pressure.)

The test should be evaluated according to the scale below.
Scale

- 0Normal
- Mild dysfunction
- Moderate dysfunction
- Severe dysfunction
- Impossible to perform[7]

Swallowing duration: measured by stopwatch the more decrease of swallowing duration the more improvement of swallowing function.

According to medical research, as many as 90 percent of children with Cerebral Palsy may show symptoms of dysphagia. it's highly recommended that the child be evaluated for oral-motor dysfunction. To a child or adult with dysphagia, it feels as though food is lodged in the esophagus before it either moves into the stomach, or is regurgitated. Some disclose that it feels as if the muscles of the neck and face work in the opposite direction than they are supposed to – effectively making the food move back up the system instead of down. For this reason, feeding time can become quite scary for a child, as they fear they cannot breathe and swallow at the same time.

Children with CP frequently need more time to complete feeding tasks, but caution is urged as fatigue may become a factor, as well as reduced attention to the task. Meal times longer than 30 min, on a regular basis, often signal a feeding/swallowing problem**.**[7]

Intervention

For all children, the programs were conducted three times weekly, for a period of 12 weeks. Each session lasted for 45 to 60 minutes in a physical therapy room, in addition to 3 hours of home program, 7 days a week during the treatment period.

Both groups (A and B) received a traditional treatment for dysphagia, as the following

Change in food or liquid consistency – Sometimes, if foods are too solid, or if liquids are too thin, this can aggravate a child's ability to swallow successfully. When this occurs, a physician may direct parents or caretakers to puree solid foods, or cut foods into smaller pieces to change its texture. Also, it may be recommended that children drink thicker (or thickened) liquids, which are generally easier to control once they're in the mouth.

Chin tucking – Sometimes, positioning helps a child to control mechanisms that affect swallowing. A tucked chin, for example, may be of helpful. This action prevents the likelihood that food will enter the trachea while swallowing.

Encouraging chewing – Sometimes, children have a tendency to insufficiently chew their foods. When a child is undergoing speech and language, or occupational therapy, this topic may be covered.

Muscle exercises – Specific exercises usually prescribed to strengthen the muscles used in swallowing in order to improve strength and coordination.

Thermal tactile stimulation- also, known as thermal application is one type of therapy used for the treatment of swallowing disorders. This method involves stroking or rubbing the anterior faucial pillars with a cold probe prior to having the patient swallow. It is hypothesized that the touch and cold stimulation increases oral awareness and provides "an alerting sensory stimulus to the cortex and brainstem such that, when the patient initiates the oral stage of swallow, the pharyngeal swallow will trigger more rapidly". In individuals with reduced oral sensation or poor initiation of oral bolus transport, a cold stimulus seems to facilitate more rapid posterior tongue movement and pharyngeal swallow elicitation.

Physical problems managment-postural correction, rib cage or spinal mobility, muscle imbalance or respiratory issues. Treatment can include rib cage and spinal mobilization, muscle stretching, and therapeutic exercises. Families are encouraged to take part in this therapy and to continue it in the home.

Oral-Motor Skills training-Inefficient movement of the muscles of the mouth or other difficulties with fine or gross motor skills can sometimes affect feeding and swallowing. suggestions and therapies to maximize the child's oral-motor skills to facilitate improved feeding and swallowing[8].

The experimental group (group A) received specialized training program as the following

Decreased masticatory function caused by paralysis also decreases the thickness of the MM(masticatory muscles) fibers furthermore, the extent of decrease in MM thickness is greater indication to NMES

Swallowing electrical stimulation system (SESS):

The SESS is a four-channel swallowing electrotherapy system designed for neuromuscular rehabilitation. It consists of a power source, a stimulus generator, a user interface, and (4) electrodes. Electrical stimulation mimics the temporal sequence of swallowing events during oropharyngeal swallowing, especially in cases requiring the activation of muscles paralyzed after a stroke. Four sets of electrodes were placed on the left and right mandibular ramus and suprahyoid area, targeting the masseter on the left (channel 1) and right (channel 2) and digastric muscles on the left (channel 3) and right (channel 4)

The stimulation potential was transmitted through a pair of square silicone rubber electrodes (5 cm × 4 cm) placed on the skin overlying both sides of the masseter and digastric muscles. The stimulation voltage was delivered as an asymmetric biphasic pulse at a frequency of 60 Hz.

Treatment began within 24 h of the initial evaluationin all cases. Patients were treated three times per week for 30 min per treatment. If a patient became fatigued, treatment was continued later in the day as often as was required to obtain the full 30min. Treatment was continued for 12 weeks in total. Four sets of electrodes were placed in the left and right mandibular ramus and suprahyoid areas, targeting the masseter and digastrics muscles, and were repositioned until muscle fasciculations occurred or the strongest contraction was observed during the swallow response.

The frequency and pulse width were fixed at 60Hz and 230μs, respectively. The current intensity was set according to the patient's tolerance and comfort level. Most patients first experienced a very slight "tugging" sensation. As the intensity was increased the patient perceived a strong vibration or a sensation that the electrodes were coming loose from the cheek. Most individuals accommodated rapidly enough to the sensations that the intensity could be increased continuously until contractions were consistently visible (designated as the therapy current level). When electrical stimulation was successful in obtaining a voluntary swallow response, the patient was asked to attempt a swallow with a specific oral consistency.

Stimulation appears to be safe and effective in post-stroke dysphagia patients and is as effective as physical therapy. This technique is widely used in North America, and appears to give satisfactory training effect results when used for restoring associated with swallowing function .A swallowing electrical stimulation system (SESS) with four-channel swallowing electrotherapy modules was designed specifically for the treatment of post-stroke dysphagia. Our study was based on the concept of neuromodulation, induced by peripheral electrical stimulation, and was performed to show that SESS could be used in clinical swallowing rehabilitation and could improve oropharyngeal dysphagia in spastic diplegic C.P [9].

Central pattern electrical stimulation

Stimulates the central pattern generators associated with swallowing. In this regard, it will be appreciated that the cranial roots of the accessory nerve (XI) convey most of the fibers from the recurrent laryngeal nerve to the vagus nerve (X), which provides most of the motor fibers distributed in the pharyngeal and recurrent laryngeal branches of the vagus nerve. The activation and sequencing of these nerves are under the control of the swallowing central pattern generator associated with swallowing. The cranial root of the accessory nerve (XI) can be accessed in the posterior neck region between the C1-C4 cervical vertebrae and in the trapezius muscle (which is innervated by the spinal branch of the accessory nerve) using the relative negative electrode

placement of one electrode at the posterior neck region or posterior thoracic region of the patient and placement of another electrode near the buccinator, orbicularis oris, masseter, pterygoids, tongue, trapezius, median nerve, and/or first dorsal interosseous muscles of the patient will reeducate the central pattern generator associated with the various stages and related muscles involved in swallowing. The relative positive and negative electrodes contain both phases of the current and, thus, the electrode placement is generally determined by the sensitivity of the neural structures and the proximity of the nerve to the superficial tissue. Thus, the

relative negative electrode is generally placed paraspinally over the accessory and spinal nerves, which are deeper and more difficult to activate than, for example, the motor points of the buccinator, orbicularis oris, masseter, pterygoids, tongue, trapezius, median nerve, and/or first dorsal interosseous muscles

In another aspect, stimulation of the cervical paraspinal muscles with the relative negative electrode and stimulation of the motor point of the right and/or left masseter muscle and/or pterygoid muscle with the relative positive electrode has been shown to improve swallowing during the oral phase, especially that involving chewing.

Stimulation of the cervical paraspinal muscles with the relative negative electrode and stimulation of the motor point of the tongue with the relative positive electrode has been shown to improve the oral and oropharyngeal phases of swallowing associated with multidimensional movement of the bolus to the pharynx by the tongue

Stimulation of the cervical paraspinal muscles with the relative negative electrode and stimulation of the left and/or right median nerves in the vicinity of the anterior surface of the wrist and/or stimulation of the motor point of the left and/or right first dorsal interosseous muscle with the relative positive electrode has been shown to improve the oropharyngeal and esophageal phases of swallowing. This stimulation is thought to modulate the gag reflex in patients who may have hypersensitivity or neurologic inhibition of the gag reflex due to central pattern generator damage in which case the stimulation reeducates the correct pattern for the reflexhas been shown to improve the oropharyngeal and esophageal phases.

Neuromuscular electrical stimulation (NMES) is a rehabilitation tool that involves coursing an electrical current to cause a muscular contraction by depolarizing the nerves that are responsible for motor innervation to a particular muscle or muscle group .The rehabilitative functions and prerequisites are necessary to benefit from NMES. intact motor nerve is required for eliciting muscle contractions with this tool. Surface NMES involves passing an electric current from electrodes placed on the skin. physiologic alterations as a result of applying NMES to weak muscle, including improved blood flow and movment force. Traditional treatments for dysphagia have attempted to improve residual musculature function through diet modifications, compensation strategies, direct swallowing exercises or maneuvers, or a combination of these[9].

RESULTS

Patients characteristics

Table 1 shows the demographic and clinical characteristics of all patients. There were 11 boys (36.66%) and19 girls (63.33%). and in term of Right hand dominance reported in 16 patients (53.33%), and also14 patients (46.66%) were left hand dominance. There was no significant difference between the two groups in terms of age (p=0.7394), in term of sex (p=0.2712) and in term of hand dominances (p=0.1534).

Table 1 Patients' characteristics

Variables	Study group N=15	Control groupN=15	P-value
Age	3.67±1.11	3.53±1.06	0.7394
Sex N%			
Boys	4(26.66%)	7(46.66%)	0.2712
Girls	11(73.33%)	8(53.33%)	
Hand dominanceN%			
Right	6(40%)	10(66.66%)	0.1534
Left	9(60%)	5(33.33%)	

Changes in feeding level

Mean test scores and standard deviations for both groups are shown in the table 2. The mean value of feeding level in both groups (assessed by FOIS) at baseline measurement (pre-treatment) was insignificant (p>0.05). while both groups had a significant improvement in feeding level post-treatment (p<.05). The average improvement of feeding level tended to being highly significant in the study group (1.33±0.49 versus 1.80±0.68, p=0.0035) than in the control group (1.40±0.51versus 1.67±0.72, p=0.0406). The percentage of improvement of feeding level was (35.34%%) in the study group compared to the (19.28%) in control group.

Table 2 The average test of feeding level in both groups

Feeding level	Study group Mean±SD	Control group Mean±SD	P-value (within groups)
Pre-treatment	1.33±0.49	1.40±0.51	0.7165
Post-treatment	1.80±0.68	1.67±0.72	0.6062
Improvment%	35.34%	19.28%	0.8708
P-value (within groups)	0.0035	0.0406	

DISCUSSION

After surface electrical stimulation combined with traditional treatment for dysphagia of Post-treatment swallowing evaluations revealed significant improvements in swallowing function, characterized by 1-an improvement the reflexive and automatic movements during the swallowing act appeared, based on an increase of contractile qualities and muscle force through (FOIS). 2-decreases in swallowing duration. Subjects improved the timing and magnitude of muscle activity, which led to improvements in swallowing ability. The longer the period after the stroke, the less success is typically expected with dysphagia treatment.

Characteristics of CP include: (1) stiff or tight muscles, and an associated increase in tonic stretch reflex (spasticity); (2) lack of muscle coordination when executing voluntary movement (ataxia); (3) walking with one foot or leg dragging; (4) walking on the toes; (5) a crouched gait or 'scissored' gait; (6) muscle tone that is either too stiff or too flaccid; (7) difficulty articulating speech (dysarthria); and (8) difficulty in swallowing (dysphagia)[10].

Oropharyngeal dysphagia may be characterized by problems in any or all phases of swallowing. The types of oral and pharyngeal problems that children with CP have include reduced lip closure, poor tongue function, tongue thrust, exaggerated bite reflex, tactile hypersensitivity, delayed swallow initiation, reduced pharyngeal motility and drooling. Impaired oral sensori-motor function can result in drooling that in turn results in impaired hydration. Problems with liquids are common and usually relate to a timing deficit with delayed pharyngeal swallow initiation. Problems with thick

smooth, lumpy or mashed foods relate to residue in the pharynx when pharyngeal motility is reduced. Residue can spill into the open airway after swallows[10].

Dysphagia is the medical term for difficult swallowing. Typically, if a person has the condition, it's because the esophagus cannot move food and liquids from the back of a child's mouth to the stomach. The muscle coordination in the face and neck is a complex and intricate set of movements that allow a person to breath, swallow and talk. A person with Cerebral Palsy is prone to muscle impairment, even in the face and neck region. Dysphagia can happen to anyone, but it's a fairly common condition among children with Cerebral Palsy or other conditions that affect the central nervous system, or those that have endured brain injury Dysphagia is generally defined as difficulty in swallowing. For example, dysphagia may occur when one cannot create a good lip seal/closure (which results in the leaking of the mouth contents) or ineffective tongue plunger action. Also, poor cheek tensing may result in the pocketing of food between the teeth and cheek. The patient may sometimes be unable to complete chewing due to muscle fatigue of the tongue and the muscles involved in mastication[10]

The muscles involved in swallowing were presumed to be atrophied because of disuse due to loss of voluntary control. So there is a bad need for using NMES. When using NMES alone there is a synchronous activation pattern of muscle fibers whereas a volitional contraction tends to result in asynchronous motor unit recruitment. Thus, recruitment patterns of muscle fibers when using NMES differs from those of volitional contractions which highlights the need to pair use of NMES with a functional movement to approximate a volitional contraction**.** NMES such stimulation aims to improve function by enhancement the swallowing musculature contraction or by stimulating the sensory pathways relevant to swallowing or both. To facilitate this enhancement, muscle contractions elicited via NMES generally recruit larger and more motor units than voluntary contractions, causing metabolic responses within the muscle tissue that ultimately lead to increase efficiency of muscle contraction[11]

The potential therapeutic effects of ES have both peripheral and central components. Peripherally, ES acts to facilitate muscles contraction, reduce spasticity of the antagonist muscle via reciprocal inhibition, reduce co-contraction, create soft-tissue changes that allow increased range of motion (ROM) and increase of clenching ability. Centrally, stimulation enhances reorganization in the motor regions of the brain by an effect known as plasticity. To promote central mechanisms of central nervous system (CNS) plasticity, stimulation should be: (1) highly repetitive; (2) task-specific (physiologically relevant); (3) cognitively oriented; (4) novel (i.e. the individual cannot do it alone); (5) at the limit of performance; and (6) combined with feedback of performance[11].

changes occurred at the level of the motor unit or neuromuscular junction. This claim is made because physiologic changes to musculature are known to take weeks to months of exercise to occur, though rapid functional gains are often attributed to changes in innervation and changes at the level of the nerve. muscle hypertrophy becomes a dominant factor around three to five weeks of training Based on the presented literature, there are well documented improvements in functional mechanisms following NMES training, Neuromuscular Electrical Stimulation Alterations to Muscle Physiology improvements may either be made at the level of the muscle fibers (i.e., muscle isoform shifts) or at the level of the nerve including the neuromuscular junction[11].

Physiologic changes to musculature have been known to take weeks to months of exercise to occur, though rapid functional gains are often attributed to changes in innervation and changes at the level of the nerve. Furthermore, it has been shown that type II fibers are preferentially activated by NMES before type I fibers, which is contrary to the pattern of a volitional contraction. NMES induced rapid and prolonged improvements in fatigue resistance. NMES induced atypical adaptations in muscle phenotype that are characteristic of both resistance (i.e., strength gains) and endurance (i.e., fast-to-slow twitch conversion) training[11].

Stroke, may block the primary neural pathway for swallowing. There are fewer myofibrils per motor unit of the digastric muscles relative to larger muscles (4-6 vs.4000), and numerous small muscles of this type participate in the oropharyngeal phase of swallowing. In addition, the motor units within each digastric muscle tend to fire asynchronously during a normal swallow, in contrast with the more synchronous firing of larger muscles designed for strength. Given this model, even a few days without the typical 600-2400 normal swallows per day could lead to long-term dysphagia. Although this characteristic of small muscles may make them more susceptible to failure from lack of use, it is also possible that they may respond more fully to electrical stimulation. This may be why electrical stimulation restored effective swallowing with fewer treatments than typically required for restoration of appropriate function by electrical stimulation of other muscles in the body[12].

Oral, pharyngeal, and esophageal swallowing are sequential events that transport saliva, ingested solids, and fluid from the mouth to the stomach, and protect the airways during swallowing. Pharyngeal function involves numerous interacting control mechanisms that ultimately link pharyngeal contraction patterns to the adjacent oral cavity and esophagus. Because the act of swallowing is voluntary, its individual steps must be planned. Food must be chewed thoroughly to prepare to be swallowed and digested. All edibles must be transferred from the mouth, through the larynx and into the esophagus. Ensuring all of this occurs in a coordinated fashion is considered one of the body's most intricate processes. From a functional viewpoint, the pharynx can be divided into two parts, namely muscles and nerves. The contraction of swallowing muscles occurs as a result of depolarization after acetylcholine release at the endplates. However, muscle contraction can also occur after direct electrical stimulation. NMES is used to re-educate patients to use the masticatory muscles for patterned activity to initiate swallowing. Spontaneous improvement in swallowing may occur in certain acute diseases that cause mild dysphagia[12].

Mastication, which is controlled by the nervous system, is closely related to quality of life. The sensory, motor, and pre-motor cortexes and the cerebellum of the brain are activated during the clenching action. Mastication movements are under highly accurate control of the nervous system. The complex control of mastication is disrupted by a neurological injury

that prohibits the interactions of the central and peripheral mechanisms. The bite force of the masticatory muscles in the affected and the unaffected side in stroke patients, as compared to that in healthy individuals, decreases an approximately 20–30%. Moreover, in stroke patients, the masticatory muscles are asymmetrically stimulated, resulting in the thickening of the muscles in one side. Consequently, masticatory function is impaired. Therefore, a longer oral phase and a greater number of chews are required in stroke patients than in healthy individuals.Swallowing is a complicated action whereby food is moved from the mouth through the pharynx and esophagus to the stomach. The swallowing act is usually divided into several stages that require the integrated action of the respiratory center and motor functions of multiple cranial and cervical nerves, as well as the coordination of the autonomic system. The swallowing mechanism by which food is transmitted to the stomach is a complex action involving 25 muscles and 5 cranial nerves[12]

The first stage (commonly referred to as the oral stage) involves mastication, bolus formation and bolus transfer. The food, which has been brought to the mouth, is chewed and combined with saliva to form a bolus that is moved to the back of the oral cavity and prepared for swallowing. The performance of the oral phase requires proper lip closure, cheek tensing, multidimensional tongue movement and chewing.

The second stage (commonly referred to as the oropharyngeal stage) involves the coordinated contractions of several muscles of the tongue, pharynx and larynx, whereby the bolus is moved to the back of the throat and into the esophagus. The tongue propels the bolus to the posterior mouth into the pharynx. The bolus passes through the pharynx, which involves relaxation and constriction of the walls of the pharynx, backward bending of the epiglottis, and an upward and forward movement of the larynx and trachea. The bolus is prevented from entering the nasal cavity by elevation of the soft palate and from entering the larynx by closure of the glottis and backward inclination of the epiglottis. During the oropharyngeal stage, respiratory movements are inhibited by reflex

The third stage (commonly referred to as the esophageal stage) involves the movement of the bolus down the esophagus and into the stomach. This movement is accomplished by momentum from the prior stage, peristaltic contractions and gravity[12].

There are two categories of dysphagia. They include:

- **Oropharyngeal dysphagia** – This form of dysphagia is the result of abnormalities in the muscles and nerves of the oral cavity, pharynx and esophageal sphincter. Oropharyngeal dysphagia is most often related to nerve and muscle malfunctions that weaken the throat muscles, thereby making it difficult to move food from the mouth to the throat.
- **Esophageal dysphagia** – This form of dysphagia is the result of the muscle malformations, or a malfunction of the lower esophageal sphincter,When this occurs it can cause motility issues; a feeling as though food is stuck in the esophagus.

Untreated dysphagia can lead to

- **Achalasia** – This is a systematic narrowing of the esophagus due to the destruction of parasympathetic ganglia of the esophagus, causing inability of the lower esophageal sphincter to relax, open and pass food into the stomach.
- **Aspiration or respiratory issues** – Among the most serious concerns a parent will have for a child with Cerebral Palsy, aspiration occurs when fluids enter the lungs, leading to infection. This can cause a person to choke, or close off an airway. Any of these situations can be life-threatening for a child, especially one that is medically vulnerable.
- **Dehydration** – This condition persists when a person does not receive enough liquids to sustain life – they lose more fluids than they retain. If prolonged, dehydration can lead to a number of severe problems, including swelling of the brain, low blood volume shock, kidney failure, coma and, in severe cases, death.
- **Malnutrition** – If a child is experiencing swallowing issues, the symptoms cause so much pain and discomfort that a child may not want to eat food. This can be particularly troublesome for infants, who may not take a bottle or food because of how it makes them feel. As a child grows, it may be difficult to maintain a normal body weight or thrive because of the lack of nutrients consumed.
- **Pneumonia** – Chronic aspiration can lead to pneumonia, a severe infection of and inflammation to one or both lungs[13].

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