EFFECTIVENESS OF ELECTRICAL MUSCLE STIMULATION (EMS) ON DYSPHAGIA AMONG ACUTE-STROKE PATIENTS IN A TERTIARY HEALTH INSTITUTION IN BENIN CITY

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CERTIFICATION

This dissertation by Eluemunor Chinasia Rhema is accepted in its presented form as satisfying the dissertation requirement of the degree of Bachelor of Physiotherapy of the School of Basic Medical Sciences, College of Medical Sciences of the University of Benin.

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DEDICATION

This dissertation is dedicated to my mother, Joy Isitua who made this work a reality.

ABSTRACTS

Introduction: Dysphagia is a prevalent and life-threatening condition after an acute stroke. It causes under-nutrition, dehydration, and aspiration pneumonia. Besides, while swallowing therapy is conventional, other therapies such as electrical muscle stimulation (EMS) are being researched on how they can boost swallowing recovery.

Objective: The purpose of this study was to establish the impact of EMS in conjunction with swallowing therapy and routine swallowing therapy among patients with dysphagia who had undergone acute stroke.

Methods: This research involved a quasi-experimental study done at the University of Benin Teaching Hospital. Thirty-two patients who had undergone an acute stroke with dysphagia were chosen purposively into either the intervention group (n=22) or the control group (n=10). The intervention group underwent EMS treatment and routine swallowing therapy (swallowing exercises, positioning, and diet modification) for four weeks, while the control group had routine swallowing therapy alone. Evaluation of swallowing function before and at the end of four weeks was done using the Functional Oral Intake Scale (FOIS).

Results: Highly significant improvement was observed among the intervention group participants ($p < 0.001$) as compared to the improvement among the control group participants ($p = 0.011$). Nonetheless, the Mann-Whitney U-test indicated a statistical significance between the final FOIS scores of both groups ($U = 64.00$; $p = 0.043$). In terms of their final FOIS scores, the intervention group had a mean score of 5.55 ± 1.47 while the control group had a mean score of 3.80 ± 2.25.

Conclusion: From the results of this research, it can be concluded that routine swallow therapy is effective while the use of EMS yields significantly better results for swallowing function among patients with stroke-related dysphagia.

Key Words: Stroke, Dysphagia, EMS, Functional Oral Intake Scale (FOIS).

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

A stroke is considered an acquired condition that involves the sudden development of focal neurological signs caused by damage (either by infarction or hemorrhage) to the brain, retina, or spinal cord, which lasts for at least 24 hours. Acute stroke patients refer to those who suffer from a cerebrovascular accident, or stroke, usually within the first few hours, days, or weeks after its occurrence. The definition of the term "acute" may differ slightly across literature but is generally associated with the period when the neurological signs are at their peak and recovery takes place swiftly, usually within the first 1 to 4 weeks after a stroke (Chen et al., 2023; Zhang et al., 2024). Stroke continues to pose significant challenges to global health, being the second biggest killer and the leading cause of disabilities worldwide (Feigin et al., 2024). High morbidity, disability, and mortality rates make the magnitude of its effects evident (Adeloye et al., 2019). Dysphagia is one of the many complications that develop secondary to stroke. Affectation to swallowing muscles may result in dysphagia for patients with strokes. Stroke is considered one of the commonest neurological factors causing dysphagia. Stroke usually affects the oropharyngeal stage of swallowing. The condition may lead to oral dysphagia when there is insufficient manipulation of food, including both solids and liquids, owing to tongue dysfunction, muscle fatigue, inability to chew, as well as weak buccal and labial muscles. Nevertheless, pharyngeal dysphagia can cause food residue, airway leakage, and aspiration (Carbid et al., 2016).

One of the important complications resulting from stroke is dysphagia, which is characterized by swallowing difficulties (NHS, 2023). This condition occurs frequently among stroke patients, as it affects between 37% and 78% of individuals who experience a stroke (Arnold et al., 2016). Clinical presentations of dysphagia following stroke include impaired swallowing coordination, aspiration of liquids (evident from the presence of drinking coughs), and increased salivation (Rommel & Hamdy, 2016). Dysphagia involves swallowing dysfunction or abnormality during the transit of boluses from the mouth to the esophagus and can be a severe issue in several neurological diseases (Alamer et al., 2020). Dysphagia, a compound that combines the prefix "dys," meaning difficult, and "phagia," which means to eat, can be described as swallowing problems. Although the term originates from old language constructions, research in the area of swallowing disorders has come a long way throughout the years (NHS, 2023). The consequences of dysphagia go beyond merely being an annoyance. Apart from these symptoms, there are other serious complications related to dysphagia that severely compromise the health status of the individual affected. Most importantly, dysphagia is strongly linked to the following secondary complications: malnutrition, dehydration, weight loss, poor quality of life, and pulmonary infection, especially aspiration pneumonia, which may prove fatal, (Zuercher et al., 2019). Psychosocial implications, such as the fear of eating and social isolation, could also occur. Patients will frequently suffer from mental disturbances like anxiety and depression due to their swallowing problems (Philpott et al., 2017).

Swallowing therapy technique (TST) is considered to be the backbone of dysphagia treatment, including interventions such as behavioral treatment, pharmacological treatment, which aims at improving sensory input into the oropharynx from the central pattern generator, strengthening weak muscles of the disused or pharynx, avoiding atrophy of the muscles and low motor output

from the central pattern generator, reducing symptoms via compensatory postural maneuvers (Alamer et al., 2020), swallowing muscle strengthening exercises, coordination exercises, and diet modification (Newman et al., 2016). Nevertheless, there are significant limitations associated with using only TST in treating dysphagia. Firstly, long-term treatment is needed; secondly, non-compliance issues may arise; finally, poor effectiveness is seen, particularly when dealing with serious dysphagia cases (Park et al., 2020). Importantly, more than 10% of patients fail to recover from their dysphagia symptoms despite undergoing extended periods of TST (Carnaby-Mann and Crary, 2025). These recurrent problems indicate an imperative clinical need for the introduction of innovative and additional therapeutic approaches to aid in the improvement of swallowing ability, oral feeding, and minimize complications in such patients (Cichero et al., 2013). Currently, there are a number of supplementary therapeutic approaches which have received much attention, which may potentially contribute to the restoration of dysphagia. Such therapies are: repetitive transcranial magnetic stimulation and transcranial direct current stimulation, and electrical muscle stimulation (EMS).

In recent times, Neuromuscular Electrical Stimulation (NMES) therapy has been established as an effective and increasingly applied treatment option for dysphagia rehabilitation after a stroke (Youngs, 2015; Konecny & Elfmark, 2017). This treatment entails the administration of electrical currents into the skin over specific muscle groups or nerves responsible for swallowing (Alon et al., 2007). The central tenet of NMES treatment is its potential for improving the functionality of the swallowing mechanism by virtue of various mechanisms of action. It administers controlled electrical pulses aimed at stimulating peripheral nerves, hence causing contractions of the affected swallowing muscles (Alamer et al., 2020). In addition, NMES has been shown to foster neuroregeneration in the motor cortex and facilitate the

intrinsic motor learning abilities of the brain (Zhang et al., 2022; Liang et al., 2021; Tan et al., 2022). In this report, the underlying theoretical basis of NMES and the mechanism of its beneficial therapeutic action will be discussed in detail. Interest in the technique of electrical muscle stimulation to address dysphagia arose from the success achieved by physiotherapists in applying the technique as a form of intervention for other disorders such as foot drop and facial paralysis by stimulating the muscles to perform better and improve their functioning. There have been many studies supporting the theory of electrical muscle stimulation to enable muscle contraction and hence improve their performance, especially when it comes to the rehabilitation of muscle-related diseases like peripheral nerve injury and muscle weakness (Alon et al., 2007). The utilization of EMS as a technique to be used in conjunction with the existing rehabilitation techniques for dysphagia has become prominent in the 21st century. The logic behind applying EMS to treat dysphagia is that EMS would strengthen weak muscles responsible for swallowing through the elicitation of muscle contraction. Some researchers have proposed that EMS may even possess a sensory function, enhancing the recognition of bolus existence and facilitating the swallowing reflex (Humbert et al., 2006). Previous research on the effects of EMS on swallowing problems in patients who suffered from a stroke revealed that it provided positive outcomes for these individuals, often decreasing their risk of aspiration (Freeman et al., 2001).

This led to more research being conducted with the purpose of determining an effective protocol for stimulating the muscles, as well as finding other potential applications of this treatment approach.

1.2 Statement of the Problem

Swallowing difficulty known as dysphagia is a relatively common and incapacitating condition that affects many individuals poststroke. It poses a risk for complications such as aspiration pneumonia, malnutrition, dehydration, long-term hospitalization, and poor functional prognosis, which consequently decreases the quality of life of affected patients and imposes extra costs to the health care systems (Carnaby-Mann & Crary, 2025). The application of electrical muscles stimulation (EMS), which includes the stimulation of selected muscles with certain electrodes, has been proven helpful for overall functional rehabilitation and prevention of complications. Recently, some research has indicated that EMS can play a role in the improvement of swallowing ability by promoting neuroplasticity and strengthening breathing muscles (Park et al., 2020). Still, the exact effect of using standardized EMS on the prevalence and seriousness of dysphagia in acute stroke patients in the particular environment of tertiary hospitals in Nigeria, such as UBTH, Benin City, Edo State has yet to be determined. Differences in demographic characteristics, type of stroke, availability of specialized rehabilitation therapy, and use of EMS protocols could have an impact. Hence, there is a crucial need to conduct research on the effect of EMS on dysphagia within this particular setting. The effectiveness of EMS on dysphagia within our local context will yield important results for the development of targeted rehabilitation protocols and better treatment of acute stroke patients in Southern Nigeria.

1.3 Research Questions

Based on the problem statement, this study on the effectiveness of Electrical muscle stimulation (EMS) on dysphagia among patients with acute stroke in a tertiary health institution in Nigeria is likely to answer the following key questions:

i. What is the effect of Electrical Muscle Stimulation on swallowing function in acute stroke patients with dysphagia?

ii. Does the application of EMS lead to an increase in the recovery rate of acute-stroke patients with dysphagia?

iii. Are there specific patient characteristics that moderate the effect of EMS on the severity of dysphagia in this population at University of Benin Teaching Hospital, Benin City, Edo State (UBTH)?

1.4 Aim of the Study

The aim of this study is to determine the effectiveness of Electrical Muscle Stimulation (EMS) on dysphagia among patients with acute stroke in University of Benin Teaching Hospital, Benin City.

1.5 Specific Objectives

The specific objectives of this study are to:

i. Evaluate the effect EMS on dysphagia among acute stroke patients in UBTH.

ii. Assess the length of hospital stay between acute stroke patients with dysphagia who receive the EMS treatment and those receiving usual care at UBTH.

iii. assess whether the application of EMS leads to a significant reduction in the severity of dysphagia at discharge at UBTH

1.6 Hypotheses

1.6.1 Main Hypotheses

There would be no significant effect of EMS on dysphagia among acute stroke patients.

1.6.2 Sub Hypotheses

i. There would be no significant difference in the swallowing function between acute-stroke patients with dysphagia on EMS and those receiving the usual care.

ii. There would be no significant difference in the recovery rate between acute-stroke patients with dysphagia on EMS and those that received usual care.

iii. There would be no significant difference in the improvement of acute-stroke patients with dysphagia on EMS and those undergoing standard care.

1.7 Significance of the Study

i. Evidence-Based Practice and Enhancement of Clinical Care through Evidences: This research provides valuable evidence-based knowledge on the efficacy of electrical muscle stimulation (EMS) therapy in managing dysphagia in acute stroke patients. Therefore, this information would help the doctors decide when to use EMS therapy in their practice to treat dysphagic acute stroke patients in Nigerian hospitals.

Benefiting Patients: This research can benefit acute stroke patients by improving the quality of their care and health. If this study finds out that electrical muscle stimulation therapy is efficacious in improving dysphagia in stroke patients, the therapy would be used on such patients. The results would mean that the patients would regain their normal swallowing function much earlier, which is associated with reduced risks of developing problems like aspiration pneumonia, malnutrition, and dehydration. Improved swallowing function allows patients to have better nutritional value from eating food, which eliminates the need to use feeding tubes to nourish them. Consequently, patients would have a shorter duration in the hospital, incur less cost for treatment and have improved quality of life.

i. The Improvement of the Nigerian Health Care System and Research Capacity: The research will fill one of the existing gaps within the scope of medical research in Nigeria. Since the research will be conducted at a particular tertiary health care facility in Benin City, the findings can be used for practical application in such hospitals across Nigeria. It will help the government and health care policy makers develop a strategy for implementing EMS within hospitals. The implementation can affect the training of medical practitioners and allocation of rehabilitation facilities.

1.8 Scope and Delimitation

This study is delimited to patients with acute stroke suffering from dysphagia in UBTH, Benin City, Edo state, Nigeria.

1.8.1 Limitation of the Study

The study is limited by preexisting health conditions that influences swallowing function and recovery.

1.9 Definition of Terms

i. Dysphagia: Dysphagia is the difficulty swallowing food. It results from an issue with the nerves and muscles that are responsible for controlling the swallowing process.

ii. Electrical Muscle Stimulation: This is a form of electrotherapy that causes muscle contraction by stimulating electrical impulses. It aims at strengthening the muscle.

iii. Neuromuscular Electrical Simulation (NMES): It involves the use of high-intensity electricity to cause the excitation of peripheral nerves, thereby causing muscle contraction.

iv. Stroke: Sudden signs or symptoms of brain function disturbances caused by focal (or global) cerebral dysfunction persisting for more than 24 hours.

v. Acute Stroke: Stroke that occurs between 1 – 3 months.

1.10 List of Abbreviations

EMS	Electrical Muscle Stimulation
FOIS	Functional Oral Intake Scale
NMES	Neuromuscular Electrical Stimulation
TST	Traditional Swallowing Therapy
UBTH	University of Benin Teaching Hospital

CHAPTER TWO

LITERATURE REVIEW

CONCEPTUAL FRAMEWORK

The study is built around the principle of muscle strength training and re-education.

Principle of Muscle Strength Training and Muscle Re-education: This principle provides an understanding of how muscles react to exercise and stimulation. This principle is based on the principle of overload (which means that the muscles have to be stressed to grow) and specificity (the results of exercises depend on the muscles involved). In case of dysphagia, usually there is some kind of discoordination or muscle weakness that affects the muscles responsible for swallowing. The regular treatment approach includes such exercises to increase the strength of these muscles. EMS stimulates the muscles by delivering electrical currents, which leads to contraction of the muscles. This could result in the following:

Increase in Muscle Strength: Electrically induced contractions may cause hypertrophy and muscle strength gain.

Increase Muscle Endurance: Continuous or repetitive use of EMS can help increase the endurance of these muscles.

Re-educate Muscles: In cases where the muscles are extremely weak or paralyzed, EMS can be used to activate the muscles again to start working. Therefore, EMS will serve as an effective way to re-educate muscles to enable voluntary contraction.

2.1. Definition

To reflect the occurrence of dysphagia in the history of western medicine, the word "dysphagy" came into existence from ancient Greek terms proposed by Nicolatopoulous in 1907 (Megna et al., 2012). The oldest documentation that refers to dysphagia has been identified from the anatomy and physiology of larynx by Galenos (129–199) (Feldmann, 2001). When compared to the western history of medicine, the history of standardized Chinese medicine has recorded its documentation related to dysphagia for over thousand years, starting with Yellow Emperor's Internal Classic, the earliest documentation of China. Nonetheless, the documentation on dysphagia has not been popular among international researchers because of the challenges that are faced in deciphering ancient Chinese language (Liu and Wang, 2020). Radiology was introduced at the beginning of the 20th century and transformed the diagnostic process for dysphagia. Dysphagia entails any form of dysfunction during the swallowing process. This involves the complex neuromuscular process which involves more than 30 muscles along with several cranial nerves such as CN V, VII, IX, X, and XII and spans three stages: the oral, pharynx, and esophagus stage (Ertekin & Aydogdu, 2003). Dysphagia can result from various impairments in the swallowing process resulting from structural, neuromuscular, or functional problems during the normal process of food or fluid consumption. Dysphagia is common after a cerebrovascular accident and referred to as post-stroke dysphagia (PSD). Dysphagia develops in 78% of stroke patients within the acute period and

approximately 50% in subacute periods (Arnold et al., 2016; Martino et al., 2005). Stroke interrupts the central and peripheral mechanisms of control of swallowing as a result of lesions in the cerebral cortex, brainstem, or corticobulbar tract, leading to poor neuromuscular coordination, impaired sensory feedback, and delayed initiation of the swallow reflex (Hamdy et al., 1998). Stroke-induced dysphagia is mostly neurogenic and dependent on the type of brain lesion, being more severe in the case of brainstem lesions, especially involving the medulla oblongata, which leads to disruption of the swallowing CPG. However, stroke in the cerebral cortex and subcortical regions (insula, anterior cingulate cortex, or basal ganglia), as opposed to the brainstem region, can lead to more subtle dysfunctions, such as difficulty with voluntary swallowing or coordination (Daniels & Foundas, 2001; Singh & Hamdy, 2006). Dysphagia after stroke is not merely an inconvenience but also carries numerous clinical implications. Dysphagia is associated with an increased risk of complications such as aspiration pneumonia, nutritional deficiency, dehydration, longer hospitalization, and increased morbidity (Zuercher et al., 2019). Psychological issues (withdrawal, anxiety, depression) are known to affect patients with dysphagia, and the resulting negative impact on their quality of life should not be underestimated (Philpott et al., 2017; Takizawa et al., 2016).

2.2 Epidemiology

Dysphagia, which is defined as a condition characterized by difficulty swallowing, is not a disease but a symptom that emerges from an underlying medical problem; therefore, its prevalence is dependent on the population under study.

According to previous research, dysphagia is common in about 15% of the older population and 60% of nursing home patients (Cichero et al., 2013). Moreover, dysphagia is a common

complication of stroke, where about 25%-80% of patients exhibit the condition (Martino et al., 2005). Neurological conditions, including Parkinson's disease, multiple sclerosis, and ALS (amyotrophic lateral sclerosis), have been associated with dysphagia in many cases (Logemann, 1998). There is also variation in reported percentages of dysphagia among stroke patients, ranging from 8.1% to 45%, which is attributable to the sensitivity of the diagnostic techniques employed (D'Netto et al., 2023). However, it is evident that there is a substantial percentage of dysphagia patients among those who suffer from stroke (Arnold et al., 2016). At least one out of five patients with stroke suffers from dysphagia after hospitalization, and almost half of them still have the symptoms at the time of discharge. (Feigin et al., 2024).

Stroke is one of the most common causes of neurological hospitalization, constituting up to 65% of admissions in Nigeria (Ekenze et al., 2010). The estimated prevalence of stroke among Nigerians is approximately 6.7% per 100,000 (Adeloye et al., 2019).

There are also differences in the incidence of dysphagia in relation to the setting. Among hospitalized patients, it ranges between 14% and 18%. However, in nursing homes, the proportion is significantly higher at 30% to 60% of residents having symptoms of dysphagia. Additionally, the incidence of post-extubation dysphagia (PED) in patients treated in ICUs has been assessed, showing the wide variation of 3% to 62% (Skoretz et al., 2010). One study conducted in ICUs found an even higher incidence of PED at 84% (Macht et al., 2011).

In addition, the prevalence of dysphagia is related to its cause. Indeed, the frequency of swallowing disorders in stroke patients differs widely, from 19% to 81%. It is essential to timely diagnose dysphagia in such patients since it will help prevent complications in the lungs and reduce the time of hospitalization. The risk of developing dysphagia as a result of the presence of a disease increases significantly after suffering from a brain stem stroke or bilateral

hemispheric stroke. In addition, there might be a relationship between the development of dysphagia and age. The prevalence rate of dysphagia among Americans aged 50 and more is 10% to 22% (Howden, 2004), increasing up to 40% in those older than 60 years old (Ney et al., 2009). Notably, one study demonstrated that 63% of seniors who reported no problems with swallowing had abnormalities according to their radiological examination ([10]). Idiopathic achalasia, which affects men and women equally and is often diagnosed at age 50, has an average incidence rate of 0.3 to 1.6 per 100,000 adults annually (Becker et al., 2016; Sadowski et al., 2010; Gennaro et al., 2011). However, the prevalence rises sharply to 17 cases per 100,000 people annually among those above 80 years old (Farrukh et al., 2008). Stroke patients experiencing dysphagia have also been shown to suffer longer hospitalizations and an increased risk of being discharged to nursing facilities. One of the significant consequences of post-stroke dysphagia is aspiration and aspiration pneumonia. The occurrence of aspiration pneumonia among stroke patients has been documented between 43% and 50% with a one-year mortality rate of 45%. Shockingly, 40% to 70% of aspiration incidences occur silently or asymptomatically. Aspiration pneumonia eventually leads to additional disabilities and a lower quality of life. Importantly, recent research has demonstrated that the early identification of dysphagia not only prevents pulmonary complications but also decreases hospitalization and healthcare expenses for acute stroke patients. Furthermore, patient awareness of their impairment, including dysphagia after stroke, plays a crucial role in rehabilitation; lower awareness is linked to a higher risk of complications caused by dysphagia.

2.3 Anatomy and Physiology of Swallowing Function

There are several procedures involved in swallowing which include the movement of food from the mouth into the stomach after ingestion. Transit of food from the mouth all the way to

the stomach via the throat and esophagus is a reflex action which is brought about by the contracting of the muscles present in the throat. Several body systems are involved in swallowing such as the muscular, neuromuscular and respiratory systems. Effective swallowing involves the functioning of more than thirty muscles (Umay et al., 2023), the brain, and five cranial nerves (Arvedson et al., 2020).

Swallowing is composed of four phases:

Preparatory phase: the preparatory phase includes the mastication of a bolus and its mixing with saliva. The bolus is shaped, sized, and positioned in the tongue for swallowing. In the preparatory phase of the bolus, the oral liquid bolus is normally positioned on the dorsal surface of the tongue, with the tongue tip being held against the posterior border of the maxillary incisors on the maxillary alveolar ridge. The back end of the tongue elevates towards the soft palate that presses down so as not to allow the escape of the bolus from the mouth with premature entry of the bolus into the pharynx.

Oral stage: the bolus travels from the mouth to the pharynx during the oral stage. The posterior portion of the tongue, the hyoid bone, and the larynx move upward and forward, expanding the sagittal dimension of the pharynx. This way, the bolus travels down along the sloping tongue that extends itself forward. Besides, shortening the pharyngeal elevators (such as stylopharyngeus muscle) causes expansion of the pharyngeal transverse dimension.

Pharyngeal stage: In the pharyngeal stage, after the bolus reaches the oropharynx, it is pushed backward by the rapid movement of the posterior part of the tongue acting like a piston. The pharynx becomes firm as all three constrictor muscles of the posterior part of the pharynx contract successively (superior, middle, and inferior pharyngeal constrictors). Hence, passage

of the bolus from the oropharynx to the hypopharynx occurs through the movement backward of the tongue, as well as through the coordinated squeeze of the pharyngeal muscles. Normally, the oral and pharyngeal stages of swallowing are well-coordinated such that the former stage seamlessly passes into the latter. While some researchers believe that the oral stage stimulates the onset of the pharyngeal stage by either making the posterior portion of the tongue touch the tonsillar pillars or pushing the bolus into the oropharynx, others contend that the swallowing center in the brainstem is responsible for regulating the coordination between the two stages. A typical pharyngeal swallow entails: (1) the elevation of the velum so that it closes the nasal cavity, (2) the transit of the bolus down the pharynx, (3) the closure of the vocal cords to ensure that food does not enter the respiratory tract during swallowing (i.e., aspiration), and (4) the opening of the upper esophageal sphincter to facilitate the passage of the bolus into the esophagus. The primary functions of the pharyngeal stage include conveying the swallowed food along the throat and protecting the airways. Various measures help protect the airways during the pharyngeal stage of swallowing.

Esophageal Stage: The esophageal stage of swallowing refers to an involuntary process whereby a food bolus travels from the pharynx to the stomach through the esophagus, which is a tube that measures 25 centimeters in length, with an average diameter of 2 centimeters. In its relaxed position, the upper segment of the esophagus is usually closed off, while the lower segment is more relaxed. The esophagus has three regions of constrictions at the upper esophageal sphincter (consisting of the cricopharyngeus and surrounding muscles), where it crosses the aorta and bronchus in the thoracic cavity, and the diaphragm, at the esophageal hiatus. Muscle fibers in the esophagus transition from being predominantly striated to smooth along the length of the tube (Chaudhry & Bordoni, 2023). This stage is characterized by the

opening of the upper esophageal sphincter when the pharyngeal stage is initiated, thus facilitating the transfer of the bolus into the esophagus (Belafsky & Lintzenich, 2013). It is essential that the cricopharyngeus muscle relax properly because difficulties associated with such relaxation may hinder the process of swallowing and cause dysphagia. In the following stage, the bolus passes through the esophagus due to a series of muscle contractions, which is referred to as peristalsis. The final stage involves the opening of the lower esophageal sphincter and its subsequent contraction.

2.3.1 Muscles of Swallowing

Swallowing, also referred to as Deglutition, is an act that involves more than thirty (30) muscles (Umay et al., 2023) from the mouth cavity, pharynx, larynx, and esophagus.

2.3.1.1 The Mouth Cavity

The mouth cavity, also referred to as the buccal cavity, is the first segment of the digestive system involved in the initial processes of deglutition, articulation, and breathing. Its complex nature enables the movement of food particles and sound articulation through its complex muscle systems.

Mouth Cavity Structure

The mouth cavity runs from the lips anteriorly to the palatoglossal folds (faucial pillars) posteriorly. Its boundaries include:

Anteriorly: The lips (labia) that constitute the mouth opening.

Laterally: The cheeks (buccae) that make up the side walls.

Superiorly: The palate, which partitions the mouth cavity from the nose cavity. It is divided into:

Hard Palate: The anterior, bony part.

Soft Palate (Velum): The posterior, fleshy part that may be raised to separate the nasopharynx during swallowing.

Inferiorly: The floor of the mouth made of muscles (mylohyoid, geniohyoid muscles) and includes the tongue.

Contents: The mouth contains the teeth that are fixed in the gums (gingiva) and the highly mobile tongue. Saliva produced by the salivary glands (parotid, submandibular, and sublingual) enters the oral cavity, helping with lubrication and primary digestion.

i. Oral Muscles and Their Nerve Supply

Several muscle groups perform different functions in the mouth, especially during swallowing. Each muscle group receives innervation from various cranial nerves.

Muscles of Mastication

Four strong muscles perform the actions of chewing and grinding food. All the muscles receive innervations from the mandibular branch of the trigeminal nerve (V3).

Masseter: Raises and protrudes the mandible (jaw closure).

Temporalis: Elevates and pulls back the mandible.

Medial pterygoid: Lifts and protrudes the mandible; also performs lateral movements.

Lateral pterygoid: Protrudes and lowers the mandible (jaw opening); also performs lateral movements.

Muscles of the Tongue

The tongue is a complicated muscle tissue responsible for the actions of forming a bolus, manipulating, and moving the bolus. These muscles are classified as intrinsic and extrinsic.

Intrinsic Muscles (Superior Longitudinal, Inferior Longitudinal, Transverse, Vertical): These muscles have both their origins and insertion sites in the tongue itself. They are involved in altering the shape of the tongue such as curling, flattening, narrowing, and elongating to modify the shape of the bolus of food.

Extrinsic Muscles (Genioglossus, Hyoglossus, Styloglossus, Palatoglossus): These muscles originate from outside the tongue and insert into it for gross tongue movement such as protrusion, retrusion, elevation, and depression.

Genioglossus: Tongue protrusion and depression.

Hyoglossus: Tongue depression and retrusion.

Styloglossus: Tongue retrusion and elevation.

Palatoglossus: Elevation of the posterior part of the tongue and tongue depression. Also helps in elevating the soft palate to form the palatoglossal arch. The only tongue muscle that does not receive innervation from CN XII but instead from the vagus nerve (CN X) through the pharyngeal plexus.

Muscles of the Lips and Cheeks

These muscles help in oral proficiency and bolus management.

Orbicularis Oris (Lips): A sphincter muscle responsible for closing and protruding the lips. It is important in ensuring that the food is contained within the mouth cavity and helps form the anterior seal. Innervated by the facial nerve (CN VII).

Buccinator (Cheeks): Helps compress the cheeks against the teeth so that food does not get trapped inside the buccal sulci. Innervated by the facial nerve (CN VII).

Soft Palate Muscles

The soft palate is vital in helping separate the oral and nasal cavities.

Tensor Veli Palatini: Tensions the soft palate. Innervated by the mandibular branch of the trigeminal nerve (CN V3).

Levator Veli Palatini: Lifts the soft palate to create a seal within the nasopharynx. Innervated by the vagus nerve (CN X) through the pharyngeal plexus.

Musculus Uvulae: Contracts and raises the uvula. Innervated by the vagus nerve (CN X) through the pharyngeal plexus.

Palatoglossus: (Also listed under tongue muscles) Raises the back of the tongue and lowers the soft palate. Innervated by the vagus nerve (CN X) through the pharyngeal plexus.

Palatopharyngeus: Lowers the soft palate and raises the throat and voice box. Innervated by the vagus nerve (CN X) through the pharyngeal plexus.

Mouth Floor Muscles (Suprahyoid Muscles that affect the oral phase)

These muscles elevate the hyoid bone and mouth floor, aiding tongue movement and the commencement of larynx elevation.

Mylohyoid: Elevation of hyoid bone and mouth floor. Controlled by the mandibular branch of the trigeminal nerve (CN V3).

Geniohyoid: Elevation and anteroinward pulling of the hyoid bone. Controlled by C1 via the hypoglossal nerve (CN XII).

Digastric Muscle (anterior head): Depression of the mandible and elevation of the hyoid bone. Controlled by the mandibular branch of the trigeminal nerve (CN V3).

Digastric Muscle (posterior head): Elevation of the hyoid bone. Controlled by the facial nerve (CN VII).

Stylohyoid: Elevation and retraction of the hyoid bone. Controlled by the facial nerve (CN VII).

Nerve Supply

Various cranial nerves coordinate the intricate processes performed in the oral cavity:

Trigeminal Nerve (CN V): Sensory innervation to the face and mouth, motor innervation to the chewing muscles (V3). Innervates mylohyoid and anterior head of digastric muscles.

Facial Nerve (CN VII): Controls motor movements of muscles involved in facial expressions, including the lips and cheeks, and provides sensation for the posterior belly of digastric and stylohyoid muscle.

Glossopharyngeal Nerve (CN IX): Supplies sensation to the posterior part of tongue and pharynx, and taste sensation. It also makes up the pharyngeal plexus.

Vagus Nerve (CN X): Involved in controlling motor movements of most muscles of the soft palate, pharynx, and larynx (pharyngeal plexus and recurrent laryngeal nerve). Sensory innervation to the pharynx and larynx.

Hypoglossal Nerve (CN XII): Involved in motor innervation of muscles of tongue.

2.3.1.2 The Pharynx

Pharynx, more commonly referred to as the throat, is a muscular tube and forms an important component of the respiratory as well as the digestive system. This part of the body extends from the bottom of the cranium to the height of the sixth cervical vertebra where it continues as the esophagus and acts as the common pathway for air, food, and fluid intake. Muscular organization and the high degree of innervation allow the intricate coordination necessary for the processes of swallowing and speaking along with the safeguarding of the airway while swallowing.

Structure of the Pharynx

Pharynx consists of three main parts, each characterized by different functions and features:

Nasopharynx:

Position: The upper region of the pharynx, located behind the nasal cavity and above the soft palate.

Boundaries: Stretches from the bottom of the skull to the soft palate.

Functions: Mainly respiratory in nature. This region contains the pharyngeal tonsils and the openings of the Eustachian tubes.

Oropharynx

Location: The intermediate region, which extends from the soft palate upwards to the epiglottis downwards. Its location is posterior to the mouth, and it communicates with the mouth through the oropharyngeal isthmus (faucial pillars).

Borders: The borders include the soft palate above, the epiglottis below, and palatoglossal and palatopharyngeal arches anteriorly.

Function: It has both respiratory and digestive functions. It houses the palatine tonsils.

Laryngopharynx (Hypopharynx)

Location: The lowermost region of the pharynx, which starts from the upper border of the epiglottis and ends at the lower border of the cricoid cartilage (point where it opens into the esophagus).

Borders: Posterior to the larynx.

Function: Mainly for digestion, directing food towards the esophagus.

Pharyngeal Muscles and their Innervations

Pharyngeal muscles can be generally categorized into two major types. They are circular (constrictor) muscles and longitudinal muscles. The majority of pharyngeal muscles receive their innervation through the pharyngeal plexus, consisting mainly of vagus nerve branches (CN X) and contributions of the glossopharyngeal nerve (CN IX).

Circular (Constrictor) Muscles

They comprise the muscular walls of the pharynx. The function of this group of muscles is to move food bolus inferiorly due to peristaltic activity.

Superior Pharyngeal Constrictor: The most superior and smallest of all constrictors. It originates from multiple sites such as the pterygomandibular raphe.

Middle Pharyngeal Constrictor: A fan-shaped muscle that originates from the hyoid bone.

Inferior Pharyngeal Constrictor: The largest and strongest of all constrictors, made up of two components:

Thyropharyngeus: Originates from the thyroid cartilage.

Cricopharyngeus Muscle: The cricopharyngeus muscle arises from the cricoid cartilage. It constitutes the major part of the UES that is permanently contracted to keep air from getting into the esophagus during breathing but relaxes during swallowing to permit the passage of the bolus (Belafsky & Lintzenich, 2013).

Nerve Supply of the Pharyngeal Constrictors: The nerve supply to all the three pharyngeal constrictors is the vagus nerve (CN X) through the pharyngeal plexus.

Pharyngeal Longitudinal Muscles: These muscles are arranged longitudinally and help in elevating and shortening the pharynx and larynx during swallowing.

Stylopharyngeus:

Origin: Styloid process of the temporal bone.

Action: Elevates pharynx and larynx, especially during swallowing.

Nerve Supply: It is unique because it receives its nerve supply from the glossopharyngeal nerve (CN IX).

Salpingopharyngeus:

Origin: Cartilaginous portion of pharyngotympanic tube (Eustachian tube).

Action: Elevates the pharynx and opens the pharyngeal opening of the Eustachian tube.

Nerve Supply: Pharyngeal branch of vagus nerve (CN X).

Function: Depresses the soft palate, raises the pharynx and larynx, and constriction of the oropharyngeal isthmus.

Innervation: Vagus nerve (CN X) via pharyngeal plexus.

Coordinated Action during the Act of Swallowing

As part of the process of swallowing, a well-coordinated and automatic contraction sequence involving the muscles of the pharynx happens as follows:

Palatal Closing: The elevation and retraction of the soft palate (due to levator veli palatini, palatopharyngeus, and musculus uvulae) causes the closure of the nasopharynx in order to prevent the retrograde flow of the nasopharyngeal fluids.

Protection of the Airways: Through the actions of the suprahyoid muscles and longitudinal muscles of the pharynx, the larynx is raised towards the root of the tongue. With the inversion of the epiglottis and the adduction of the vocal cords, the act effectively prevents the entry of any food into the airways.

Bolus Propulsion: The coordination of the superior, middle, and inferior pharyngeal constrictors produces a stripping wave resulting in rapid bolus propulsion through the pharynx.

UES Opening: As the food moves forward, the cricopharyngeus muscle (inferior pharyngeal constrictor and UES component) opens up due to relaxation and the movement of hyoid bone and larynx anteriorly, facilitating the passage of food into the esophagus (Belafsky & Lintzenich, 2013).

Any problem in the function of the strength, timing, and coordination of the aforementioned muscles leads to severe dysphagia involving the presence of pharyngeal residue, aspiration, and problems in initiation or completion of the swallow.

2.3.1.3 The Larynx

Larynx is also referred to as the voice box which is made of cartilage and is located in front of neck region above trachea and below the pharynx. Not only does it perform the function of phonation (voice production), but also has an important role in respiration, and more importantly, protection of lower airway during swallowing. The complex structure of the larynx (cartilage structures, membranes, and ligaments) is moved by many muscles innervated specifically to perform these functions.

Laryngeal Structure

The larynx consists mainly of nine cartilages held together by ligaments and membranes:

Thyroid Cartilage: The largest cartilage, which provides the anterior and lateral walls of the larynx. The protruding anterior portion of the thyroid cartilage is referred to as "Adam's apple."

Cricoid Cartilage: An unbroken circular plate of cartilage, narrower anteriorly and wider posteriorly, which provides the lower end of the larynx. It connects above with the thyroid cartilage and below with the trachea.

Epiglottis: A leaf-shaped elastic cartilage situated above the thyroid cartilage. When swallowing occurs, the epiglottis bends backward and closes off the opening into the larynx, thus preventing anything entering the mouth from passing into the trachea.

Arytenoid Cartilages: Two small pyramidal cartilages which articulate posteriorly with the cricoid cartilage. They play an important role in the function of vocal cords due to the attachment of intrinsic muscles to them.

Corniculate Cartilages: Small conical cartilages, which articulate with the upper tips of the arytenoid cartilages.

Cartilages Cuneiform (Paired): Small, rod-like cartilages lodged within the aryepiglottic folds, offering structural support.

Cuneiform cartilages are joined through:

Extrinsic Membranes/Ligaments: Joint the larynx to adjoining structures, for instance, thyrohyoid ligament joins thyroid cartilage to the hyoid bone.

Intrinsic Membranes/Ligaments: Connect the laryngeal cartilages to each other forming the structure of the vocal folds and the laryngeal vestibule.

Laryngeal Muscles and Innervations

There are two types of muscles in the larynx that have different roles.

Extrinsic Laryngeal Muscles

These muscles move the whole larynx as one piece, usually for elevating and depressing the larynx. Extrinsic muscles attach the larynx to the hyoid bone, sternum, and skull. Examples of such muscles include suprahyoid muscles (like digastric, stylohyoid, mylohyoid, and geniohyoid) and infrahyoid muscles (such as sternohyoid, omohyoid, sternothyroid, and thyrohyoid). Coordinated activity of extrinsic muscles plays an important role in moving the

larynx up and forward during the pharyngeal stage of swallowing thus contributing in opening the Upper Esophageal Sphincter (UES) and protecting airway. Intrinsic Laryngeal Muscles

Intrinsic Muscles

Origin and insertion are confined to the larynx; control the movement of the vocal cords and the laryngeal inlet. All muscles, except for one, in the larynx are supplied by the recurrent laryngeal nerve (RLN), a branch of the vagus nerve (CN X).

Cricothyroid:

Action: Tension of the vocal folds, hence, increases their pitch. The only intrinsic laryngeal muscle innervated by the external branch of the superior laryngeal nerve (SLN), a branch of the vagus nerve (CN X).

Posterior Cricoarytenoid (PCA):

Action: The only muscle that abducts the vocal folds, essential for breathing.

Innervation: Recurrent laryngeal nerve (RLN).

Lateral Cricoarytenoid (LCA):

Action: Adduction (closing) of the vocal folds, making the vocal folds come into contact with each other for phonation.

Innervation: Recurrent laryngeal nerve (RLN).

Transverse Arytenoid (Interarytenoid):

Action: Adduction of the vocal folds by bringing the arytenoid cartilages closer to each other.

Innervation: Recurrent laryngeal nerve (RLN).

Oblique Arytenoid (Interarytenoid):

Action: Shortens and relaxes vocal folds, thereby reducing pitch of voice. The medial part of this muscle is known as the vocalis muscle, which forms the bulk of the vocal fold.

Nerve supply: Recurrent laryngeal nerve (RLN)

Innervation of Larynx

The larynx is mainly supplied by nerves coming out of the vagus nerve (CN X). These are:

Superior Laryngeal Nerve (SLN)

Internal Part: Supplies sensation to the mucous membrane of the larynx above vocal folds (epiglottic part, piriform sinuses, laryngeal vestibule). The sensory innervation provided by internal SLN is very important for eliciting the swallowing reflex and awareness of penetration or aspiration.

External Part: Innervates the cricothyroid muscle with motor innervations.

Recurrent Laryngeal Nerve (RLN)

Supplies motor innervation to other intrinsic muscles of larynx (PCA, LCA, Transverse Arytenoid, Oblique Arytenoid, Thyroarytenoid), which control movements of vocal fold abduction and adduction.

Supplies sensation to the mucous membrane of the larynx below vocal folds.

Swallowing function

The larynx performs a swift and synchronous sequence of actions to ensure airway protection during the act of swallowing:

Laryngeal elevation and anterior displacement: Intrinsic laryngeal muscles pull the whole larynx upwards and anteriorly. This causes the larynx to be pulled under the tongue base to create an opening in UES.

Adduction of the vocal folds: The intrinsic adductor muscles of the vocal cords (lateral cricoarytenoid muscle, transverse and oblique arytenoids, thyroarytenoid muscle) bring the vocal folds together creating a seal of protection of the airway.

Epiglottic inversion: Due to laryngeal elevation and anteromedial displacement, the epiglottis is passively drawn backwards, resulting in the inversion of the epiglottis above the laryngeal inlet.

Apnea: During pharyngeal swallowing (swallowing apnea), breathing stops to avoid inhaling any food or fluid.

Any injury to the laryngeal muscles or its innervations would lead to serious airway protection problems due to difficulties in closing airways, resulting in aspiration and complications such as aspiration pneumonia.

2.3.1.4 The Esophagaus

The esophagus is an important part of the body's digestive system and acts as a muscular tube through which food and water pass into the stomach. This tube, despite being quite straight forward, has many structural and muscular properties as well as complex innervations, which ensure effective movement of the bolus in the form of peristalsis without causing any reverse flow of stomach content.

Esophageal Structure

The esophagus is a tube-like organ that is approximately 25 centimeters (10 inches) long and has an average diameter of 2 cm (Chaudhry & Bordoni, 2023). The upper two-thirds of the esophagus generally remain collapsed in their resting position, whereas the lower one-third remains more rounded inside (Chaudhry & Bordoni, 2023). The esophagus starts from the pharynx at the level of the sixth cervical vertebra and goes on to pass through the neck and thoracic regions to enter the abdomen through the hiatus of the diaphragm and then connect to the stomach.

The esophagus has three physiological constrictions:

Cervical constriction (UES – Upper Esophageal Sphincter): Situated at the point of origin from the pharynx, comprising of mainly the cricopharyngeus muscle (inferior pharyngeal constrictor), lower fibers of thyropharyngeus muscles, and the upper part of esophagus itself (Belafsky & Lintzenich, 2013; Chaudhry & Bordoni, 2023).

Thoracic constriction (aortic/bronchial): Seen in the area where the esophagus crosses over the aortic arch and the left mainstem bronchus (Chaudhry & Bordoni, 2023).

Abdominal (diaphragmatic) constriction: Comprises of the point where esophagus passes through the esophageal hiatus of the diaphragm (Chaudhry & Bordoni, 2023).

Muscles of the Esophagus

The wall of the esophagus has a distinctive change in muscle type in a way that:

First third: Consisting mainly of skeletal muscles (Chaudhry & Bordoni, 2023). It is voluntarily controlled though its movement is mostly reflexive.

Second third: Comprising of skeletal as well as smooth muscles.

Third third: Only made up of smooth muscles (Chaudhry & Bordoni, 2023). It is involuntarily controlled.

Esophageal Sphincters

There are two major sphincters that control the passage of the bolus through the esophagus, preventing its reflux.

Upper Esophageal Sphincter (UES):

Anatomy: Predominantly made up of the cricopharyngeus muscle with some help from the inferior pharyngeal constrictor and the uppermost esophageal muscle fibers (Belafsky & Lintzenich, 2013).

Physiology: The UES remains in a state of tonic contraction to prevent entry of air into the gastrointestinal system and esophageal reflux. When a person swallows, the UES relaxes and opens due to the pull of the moving forward and upward larynx (Belafsky & Lintzenich, 2013).

Lower Esophageal Sphincter (LES):

Anatomy: A functional sphincter consisting of a thickening of the smooth muscle of the lower esophagus and not an anatomical muscle. Physiologically aided by the diaphragm.

Function: Tonic contraction at rest prevents the backflow of acid-containing contents from the stomach into the esophagus (Gastroesophageal Reflux). Relaxation is triggered reflexively when the bolus enters the organ allowing food and fluids into the stomach.

Nerve Supply to Esophagus

The nerve supply to the esophagus is quite complex due to the dual nature of the muscle of the esophagus and its involvement in voluntary and involuntary stages of swallowing.

Striated Muscle Part (Upper Third)

Supplied by motor fibers of Somatic Nervous System via the recurrent and pharyngeal branches of the Vagus (CN X).

Smooth Muscle Part (Lower Two-thirds):

It is supplied by enteric nervous system (ENS), often referred to as the 'little brain of the gut' that regulates digestive activity independently of the brain.

Enteric nervous system (ENS) is regulated by Autonomic Nervous System (ANS):

Parasympathetic Supply:

Mostly by the Vagus nerve (CN X), promoting peristalsis and LES relaxation. Parasympathetic fibers form synapses with the neurons of myenteric or Auerbach's plexus in ENS.

Sympathetic innervation: Sympathetic neurons from cervical and thoracic sympathetic ganglia; sympathetics tend to inhibit motility and have a lesser role in esophageal peristalsis than vagal innervation.

Working together, the above neural components ensure the generation and propagation of effective peristaltic waves within the esophagus, and the proper opening and closing of the upper esophageal sphincter (UES) and lower esophageal sphincter (LES) to ensure efficient passage of food into the stomach and preventing reflux.

The esophagus is a unique organ, with an anatomy and muscle arrangement that varies depending on its part; thus, it allows for precise control of esophageal functions during swallowing. Through an effective system of two sphincters controlled by a complex

neuromuscular mechanism, it provides for the transport of food and liquid in one direction only without any risk of reflux.

2.4 Aetiology

Dysphagia is difficulty in swallowing that can either be acute or chronic. Dysphagia may occur either in the oropharyngeal or esophageal stages of swallowing. Dysphagia is associated with odynophagia or painful swallowing and may be associated with globus. Globus is the sensation of a lump or the presence of something stuck in the throat. It is often not associated with pain.

2.4.1.1 Oropharyngeal Dysphagia

The term oropharyngeal dysphagia refers to the delay in the movement of fluid or solid food mass through the oropharynx stage of swallowing. Oropharyngeal dysphagia has numerous anatomical and neuromuscular causes (Rommel & Hamdy, 2016). Oropharyngeal dysphagia can have several causes, including the case where postoperative oropharyngeal dysphagia arises after cervical discectomy and fusion (Ebot et al., 2020; Ohba et al., 2020). Anatomical factors leading to oropharyngeal dysphagia are mainly related to obstructions within the lumen or external compression of the oropharynx. These include Zenker diverticulum, esophageal web, oropharyngeal tumors or abscess, goiter, and external compression from aorta aneurysms referred to as dysphagia aortica (Choi et al., 2019).

2.4.1.2 Esophageal Dysphagia

Esophageal dysphagia is either due to mechanical obstruction of the esophagus or a motility disorder. Dysphagia with solids defines the former, while dysphagia with both liquids and solids characterizes the latter. Esophageal dysphagia can either be intermittent or constant (Philpott et al., 2017). The main causes of dysphagia due to mechanical obstruction of the

esophagus are a Schatzki ring, esophageal stricture or webs, esophageal carcinoma, and eosinophilic esophagitis (Mari et al., 2020). Esophageal spasm, achalasia, ineffective esophageal motility, and systemic sclerosis are the common causes of dysphagia as a result of motility disorders.

2.4.1.3 Rheumatologic Disorders

There are several types of rheumatologic diseases that result in the development of dysphagia using different mechanisms. Additionally, these diseases can aggravate cases of dysphagia that develop from other conditions. This occurs when the muscular part of the mid and distal parts of the esophagus is substituted with fibrotic tissue as a result of any underlying autoimmune disease, leading to the development of dysphagia. Limited cutaneous systemic sclerosis, formerly referred to as CREST syndrome, is a typical case of esophageal dysmotility. Other common cases of rheumatic diseases associated with dysphagia are rheumatoid arthritis, systemic lupus erythematosus, Sjogren's syndrome, and mixed connective tissue diseases (Bredenoord, 2015).

2.4.1.4 Medication induced Dysphagia

These drugs may lead to the exacerbation of dysphagia due to their following effects:

Decrease in the force of lower esophageal sphincter relaxation and decrease in saliva production (xerostomia)

Development of dysphagia secondary to drug-induced esophagitis

Dysphagia caused by gastroesophageal reflux disease, which occurs as a consequence of medications' use

Furthermore, the occurrence of infectious esophagitis in combination with immunosuppressive properties of the medications predisposes to the development of dysphagia. These drugs include:

Antipsychotic drugs (e.g. olanzapine, clozapine)

Tricyclic antidepressants

Potassium supplements

NSAIDs

Bisphosphonates

Calcium channel blockers

Nitrates

Theophylline

Alcohol and opioids

2.4.2 Risk Factors for Dysphagia

There are a number of factors that predispose to the development of dysphagia including:

2.4.2.1 Neuroligical Disorders

Neuromuscular disorders are the leading cause of dysphagia since the process of swallowing is performed using the muscles and involves the central and peripheral nervous systems. Neurological disorders mainly involve the oropharyngeal phase. However, the involvement of the pharyngeal phase of swallowing is possible if a patient has undergone cerebral infarction that affected basal ganglia and cortex.

Stroke: This is one of the most common causes of dysphagia, with incidences varying greatly between 19% and 81% of affected individuals (Arnold et al., 2016). Dysphagia is more common after stroke of the brainstem or the entire brain. Early detection of dysphagia in stroke victims helps reduce risk of respiratory infections and decrease length of hospital stay (Arnold et al., 2016).

Neurodegenerative Diseases: Neurological diseases that develop progressively usually lead to dysphagia as the disease advances. Examples include Parkinson's disease, Alzheimer's disease, dementia, Amyotrophic Lateral Sclerosis (ALS), and Multiple Sclerosis (MS).

Traumatic Brain Injury (TBI): Brain injury caused by trauma leads to disruption of the neural connections involved in swallowing coordination.

Spinal Cord Injuries: Injuries to the high cervical region of the spinal cord affect the nerves that control the swallowing muscles.

Cerebral Palsy: This is a broad category of diseases characterized by impaired body movement and posture.

2.4.2.2 Structural Abnormalities

i. Head and Neck Cancers: Growth of malignancies in the mouth, throat, or voice box can interfere with normal swallowing process by either blocking the path for swallowing or causing loss of muscle strength.

ii. Esophageal Stricture/Esophageal Stenosis: The narrowing of the esophagus due to inflammation, scarring, or presence of tumor can hinder food from reaching stomach through the esophagus.

iii. Esophageal Rings and Webs: These are thin, membrane structures in the mouth that occasionally hinder food passage in case of swallowing.

iv. Diverticulum (such as Zenker's diverticulum): This is an outpouching of the wall of the pharynx or esophagus trapping food and causing difficulty in swallowing.

v. Cleft Lip and Palate: Congenital problems associated with mouth can affect the formation and swallowing of a food ball.

vi. Cervical Spine Surgery: Surgery like anterior cervical discectomy and fusion (ACDF) causes postoperative dysphagia due to tissue damage, neural injury, or inflammation (Ebot et al., 2020; Ohba et al., 2020).

vii. Large Aortic Aneurysms: The enlargement of aorta at times presses on the esophagus causing dysphagia known as dysphagia aortica (Choi et al., 2019).

2.4.2.3 Age-Related Changes (Presbyphagia)

There is an array of medical conditions where age was found to be a risk factor. With normal aging, there can be a loss of swallowing efficiency due to the impact of increasing age on the physiologic functioning of upper esophageal sphincter and pharynx with a decrease in individuals' sensation and motility of the swallowing process (Hayashi et al. 2017).

i. Muscle Weakness and Atrophy: A decreased amount of muscle mass and muscle weakness can negatively affect the muscles responsible for swallowing (Umay et al., 2023).

ii. Decreased Sensation: A decrease in sensation in the mouth and pharynx region can make it more difficult to properly initiate and coordinate the process of swallowing (Ney et al., 2009).

iii. Physiologic Changes: It is possible for elderly people who experience no difficulties with swallowing to still present subtle abnormalities in swallowing function studies, such as the late onset of a swallow and reduced laryngeal elevation (Ekberg & Feinberg, 1991).

iv. Greater Likelihood of Achalasia: Although idiopathic achalasia develops most frequently at age 50, its occurrence in patients older than 80 is highly likely (Farrukh et al., 2008).

2.4.2.4 Iatrogenic Factors (Treatment Induced)

Medicinal treatment or interventions may inadvertently contribute to the onset or worsening of dysphagia.

i. Endotracheal Intubation and Tracheostomy: Extended periods of intubation may predispose individuals, especially those who are critically ill, to vocal fold paresis or paralysis, laryngeal injuries, and muscle deconditioning, culminating in PED (Macht et al., 2011; Skoretz et al., 2010; Zuercher et al., 2019).

ii. Pharmacological Agents: The use of certain medications may impair swallowing ability. Such medications include sedatives, which reduce alertness and coordination; anticholinergic drugs, which reduce salivation; and opioids, which interfere with esophageal function (Snyder et al., 2019).

iii. Surgery: Surgical interventions involving any of the structures of the head, neck, or chest region have a possibility of impairing normal swallowing function.

2.4.2.5 Other Medical Conditions

Various systemic conditions also play a part in the occurrence of dysphagia.

i. Gastroesophageal reflux disease (GERD): The constant exposure to stomach acid can lead to inflammation of the esophageal lining and damage to it, possibly causing strictures or reduced motility of the esophagus (Howden, 2004).

ii. Eosinophilic Esophagitis (EoE): Eosinophilic Esophagitis (EoE) is an established cause of dysphagia that is caused by a chronic inflammatory reaction of the esophagus to an allergen (Mari et al., 2020).

iii. Connective tissue diseases: Diseases such as scleroderma and lupus can affect the functioning of the esophageal muscles.

iv. Conditions that Cause Infections: Infections in conditions such as pharyngitis, tonsillitis, and candidiasis can cause painful swallowing (odynophagia) and dysphagia.

v. Weakness: Debilitation can also be a contributing factor in cases of dysphagia.

2.4.2.6 Lifestyle

Lifestyle factors may contribute to dysphagia predisposition, which include the following:

Smoking, Obesity, Alcohol intake, and Caffeine intake.

2.5. Symptoms of Dysphagia

i. Odynophagia - a condition involving painful swallowing. Such discomfort or pain might be experienced in the mouth, pharynx, or esophagus while eating, drinking, or swallowing.

ii. Regurgitation - condition where food particles move from the stomach up the esophagus to the mouth.

iii. Coughing while swallowing or immediately after swallowing may occur due to premature entry of food into the pharynx, leftover food residue in the pharynx, or regurgitation.

iv. Choking: coughing in response to the sensation that something is stuck or going down the wrong pipe. Choking can also happen if food or saliva enters the air passages. This may cause an inflammatory condition known as aspiration pneumonia.

v. Heartburn or reflux sensations.

vi. Soreness in the throat.

vii. Difficulty forming boluses of food and liquids.

2.6 Diagnosis of Dysphagia

2.6.1 Patient History

The history is the key component in making a diagnosis of dysphagia since it gives information about the cause, precipitants, and the associated diseases. The important aspects of the history that need to be considered in the patient with dysphagia include:

i. Past Medical History: Recent stroke, neuromuscular disease, hypertension, DM, Thyroid disease, Cancer.

ii. Medications: History of use of any drugs such as: Hypnotic agents, anticonvulsants, neuroleptics, Antihistamine, Barbiturates, Anti-epileptic.

iii. Social History: History of Alcohol consumption, smoking

2.6.2 Radiological Investigations

X-ray, CT scan and MRI: These are very useful in helping diagnose dysphagia. On these images, there could be some findings that suggest dysphagia like: structural anomalies, masses, CNS anomalies (CT & MRI).

Barium Swallow: This is a diagnostic technique used to evaluate the swallowing mechanism objectively. It involves a speech pathologist working together with a radiologist. Various consistencies of liquids and foods mixed with barium sulfate are given to the patient using spoon, cup, or syringe, while the x-ray is taken using videofluoroscopy.

The barium swallow study helps in diagnosing the underling cause of patients presenting with

i. History of surgery for laryngeal or esophageal carcinoma

ii. History of radiation therapy or chemical injury

iii. Achalasia

iv. Zenker's diverticulum, a barium swallow needs to be done prior to endoscopy to avoid perforation.

v. Stricture

Fiberoptic Endoscopic Evaluation of Swallowing (FEES): Fiberoptic Endoscopic Evaluation of Swallowing (FEES) is a popular instrumental assessment method that objectively evaluates the swallowing process. FEES involves real-time visualization of the swallowing process, including the pharyngeal phase and airway protection. FEES uses the transnasal laryngoscope for direct visualization of the pharynx and the larynx. The process is accomplished through the use of measured amounts of the food that has been stained with a blue liquid dye and comparing it before and after swallowing.

It is recommended in critically ill patients and when rapid diagnosis is necessary.

2.7 Dysphagia management

Dysphagia treatment is described below (Navaneethan and Eubanks, 2015):

i. Supportive care

ii. Treatment of underlying disease.

iii. Posture management

iv. Swallowing maneuvers to strengthen swallowing muscles.

v. Modification in diet

vi. Medications that can precipitate dysphagia (potassium tablets, doxycycline, NSAIDs, bisphosphonates).

Management by conservative methods includes:

Posture Techniques: Every posture technique has a specific impact on the movement of food and coordination of oropharyngeal structures. These postures serve as an aid for the compensatory mechanism of any specific defect in oropharyngeal swallow. Following are postural techniques that are used to avoid the complications arising out of dysphagia (Newman et al., 2016):

i. Chin down (flexion): This posture is employed in patients having problems in initiating their swallow; it allows the oropharyngeal passage to open up while reducing the airway size.

ii. Head turned (extension): Posture involves the use of gravity as a means to help transport food from anterior to posterior regions of mouth.

iii. Head tilt (turning head to over shoulder position): In this posture, the head is turned sideways in the direction opposite to damage or weakened side while chin remains down.

iv. Positioning patient on one side: When there is weakening of pharyngeal muscles leading to residue aspiration, this posture is used.

Swallowing Maneuvers: Following are maneuvers used for managing dysphagia:

i. Supraglottic swallow: This technique is employed when there is a delay in the closing of vocal folds. The patient is advised to breathe deeply and hold their breath. Then, the patient swallows by holding their breath and coughs right after swallowing.

ii. Super-supraglottic swallow: This technique is applied when there is insufficient closing of the airway passage. The patient is advised to breathe deeply, hold their breath very tightly while straining the body. The patient swallows with their breath held tightly and coughs right after swallowing.

iii. Mendelsohn maneuver: This technique is performed when there is discoordination in swallowing. The patient is taught how to keep their Adam's apple high during the swallow process.

Dietary and Environmental Modifications: Dietary modifications like the provision of a thickened liquid diet are frequently utilized in the prevention of aspiration in oropharyngeal dysphagia.

Environmental modifications may also be recommended to facilitate and minimize risk factors for aspiration.

Example: Use of straws during fluid intake and placing a pillow behind the patient's head while feeding the patient.

2.8. Outcome Measure

Water Swallowing Test (WST): Dysphagia presence or absence was evaluated through WST using the procedure involving giving the patient 30 ml of water at room temperature to see if he/she could swallow. The number of swallows and whether he/she would get choked was recorded. If he/she could do that without getting choked, coughing, or changing the quality of his/her voice in five seconds, then he/she was said to have passed (Kubota et al., 1982).

Dysphagia Outcome Severity Scale (DOSS): This is an uncomplicated seven-level severity scale meant to indicate the extent of dysphagia and suggest whether the level of dependence of feeding.

Level 1 corresponds to severe dysphagia since patients cannot tolerate per oral feeding.

Level 2 indicates moderate/severe dysphagia where there is total dependence and assistance with partial per oral intake, but only one safe consistency.

Level 3 corresponds to moderate dysphagia when there is total supervision and restriction in two or more consistencies.

Level 4 corresponds to mild-moderate dysphagia when there is need for intermittent supervision and restriction in one or two consistencies.

Level 5 corresponds to mild dysphagia where there is need for distant supervision and one consistency may be restricted.

Level 6 corresponds to swallowing within functional limits / modified independence.

Level 7 corresponds to normal swallowing in all circumstances (O'Neil et al., 1999).

Functional Oral Intake Scale (FOIS): The Functional Oral Intake Scale (FOIS) is one of the most frequently used tools in measuring the outcome of dysphagia treatment interventions. First introduced by Crary, Carnaby-Mann and Groher in 2005, it is a very useful ordinal scale designed to classify patients according to their level of functional oral intake capacity. While other outcome measures like instrumental assessments aim to determine how the process of swallowing works physiologically, FOIS tries to evaluate in practical terms what a patient can take in through his/her mouth (Crary et al., 2005). FOIS is a 7-point ordinal scale and the higher the score obtained, the better the function of oral intake. The levels are as follows:

i. Level 1: Nothing By Mouth.

All nutrition and hydration are provided to the patient through non-oral routes such as feeding tubes and intravenous administration. The patient does not ingest anything orally.

ii. Level 2: Tube Dependent with Minimal/Variable Oral Ingestion.

The patient depends on tube feeding, but they can occasionally take small quantities of food or liquid orally. This may be done for recreational purposes or therapeutic reasons. However, oral intake is not adequate for meeting nutritional or hydration requirements.

iii. Level 3: Tube Dependent with Variable Oral Ingestion.

The patient continues to depend on tube feeding for obtaining nutrition and hydration, but they consistently take food or liquids orally in adequate amounts. Oral intake, however, is still inadequate to provide nutrition and hydration.

iv. Level 4: Complete Oral Ingestion of One Consistency Only.

The patient is capable of meeting their nutritional and hydration needs through oral intake. However, they can only consume food or liquid of one particular consistency.

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iv. Level 4: Complete Oral Ingestion of One Consistency Only.

The patient is capable of meeting their nutritional and hydration needs through oral intake. However, they can only consume food or liquid of one particular consistency.

i. Benign esophageal stricture
ii. Cerebrovascular accident (stroke)
iii. Diffuse esophageal spasm
iv. Eosinophilic esophagitis
v. Esophageal malignancies

vi. Esophageal webs and rings

vii. Gastroesophageal reflux disease (GERD)

viii. Hiatal hernia

ix. Multiple sclerosis

x. Parkinson disease

xi. Paterson-Kelly syndrome

xii. Zenker diverticulum

2.10. Empirical Review

Table 1: Empirical review of previous researches

Author(s) & Year	Location	Methodology & Patient Characteristics	EMS Intervention	Outcome Measures	Key Findings
Guillén-Solà et al. (2017)	Spain	RCT; 40 subacute dysphagic stroke patients (mean 39.8 ± 17.5 days post-stroke). Randomized to experimental (EMST + NMES) or control (EMST + sham NMES).	NMES to suprahyoid muscles; 20 mins/day, 5 days/week for 4 weeks. Parameters: 300 µs pulse width, 50 Hz frequency, intensity for visible muscle contraction. Combined with Expiratory Muscle Strength Training (EMST).	Primary: PAS, FOIS. Secondary: Respiratory muscle strength changes.	Both groups improved in PAS and FOIS, but no significant differences between EMST+NMES and EMST+sham NMES for swallowing outcomes. Suggests EMST was the primary benefit, and NMES did not provide additional significant benefit in this subacute population when combined with EMST.
Howard et al. (2023)	United Kingdom	RCT; 60 acute stroke patients with dysphagia (mean 9 days post-stroke onset).	Transcutaneous EMS to pharyngeal muscles; 30 mins/day, 5 days/week for 2	Primary: FOIS. Secondary: Aspiration status (videofluoroscopy).	Both sensory-level and motor-level EMS groups showed significantly greater improvements in

		Randomized to sensory-level EMS, motor-level EMS, or sham EMS. All received standard dysphagia therapy.	weeks. Sensory-level: just below motor threshold. Motor-level: elicited visible muscle contraction.		FOIS scores vs. sham group. No significant difference between sensory and motor groups, suggesting sensory-level EMS is also effective.
Konecny et al. (2017)	Czech Republic	RCT; 36 patients in early stage after stroke (average 16.5 days post-stroke onset) who experienced dysphagia. Randomized to EMS or sham EMS, both combined with conventional dysphagia therapy.	EMS to suprahyoid muscles (anterior belly of digastric and mylohyoid); 30 mins/day, 5 days/week for 3 weeks. Parameters: 30 Hz frequency, 200 µs pulse width, intensity for muscle contraction.	FDS (videofluoroscopy) and FOIS.	EMS group demonstrated significantly greater improvements in both FDS and FOIS scores compared to the sham group. Suggests EMS targeting hyoid muscles significantly enhances swallowing rehabilitation in the early post-stroke phase.
Lee et al. (2014)	South Korea	RCT; 40 acute/subacute ischemic stroke patients with dysphagia within 10 days of stroke onset. Randomized to experimental (conventional dysphagia therapy + NMES) or control (conventional dysphagia therapy only).	NMES to suprahyoid and infrahyoid muscles (2-channel); 30 mins/day, 5 days/week for 2 weeks. Parameters: 300 µs pulse width, 80 Hz frequency, 500 ms on/off time, intensity for visible muscle contraction.	DOSS and VFSS parameters (oral transit time, pharyngeal transit time, pharyngeal delay time, residue, aspiration/penetration).	NMES group showed significantly greater improvement in DOSS scores and reduced pharyngeal transit time vs. control group. Indicates early NMES combined with conventional therapy can effectively improve swallowing function in acute/subacute stroke patients.
Liang et al. (2021)	China	Prospective, randomized, single-blinded clinical trial;	VitalStim therapy to submental muscles; 60	KWST, DOSS, PAS.	VitalStim EMS group showed significantly better improvements in

		100 acute stroke patients with dysphagia (onset within 7 days). Randomized to control (swallowing function training) or experimental (VitalStim EMS + swallowing function training).	mins/session, 1 session/day for 20 consecutive days. Intensity adjusted for optimal muscle contraction without discomfort.		KWST grades, DOSS scores, and PAS scores vs. control group. Suggests VitalStim EMS significantly enhances swallowing function recovery when combined with swallowing training in acute stroke patients.
Tan et al. (2022)	Singapore	RCT; 100 dysphagic stroke patients admitted for rehabilitation (acute or early subacute phase, exact onset not explicitly stated). Divided into control (conventional rehabilitation) and study (conventional rehabilitation + NMES).	NMES to neck region (hyoid muscles); 30 mins/session, once daily for 4 weeks. Parameters: 30 Hz frequency, intensity for comfortable contraction.	KWST, DOSS, SWAL-QOL.	NMES group exhibited significantly greater improvements in the Kubota Water Swallowing Test grades, DOSS scores, and SWAL-QOL scores vs. control group. Indicates NMES effectively improves swallowing function and patient quality of life in stroke patients undergoing rehabilitation.
Toyama et al. (2014)	Japan	RCT; 24 patients with dysphagia caused by brain injury (including stroke, but not exclusively acute stroke). The mean time since onset was	Novel EMS system to suprahyoid muscles; 20 mins/session, twice daily, 5 days/week for 2 weeks. Parameters: 100 Hz frequency, 300	FOIS, PAS (videofluoroscopy), sEMG (muscle activity).	Both groups showed improvement, but the EMS group demonstrated significantly greater improvement in FOIS scores and a trend towards reduced aspiration (PAS). The sEMG

		24.5 weeks (subacute to chronic). Participants were randomized to receive conventional dysphagia therapy with either a novel EMS device or a sham device.	μs pulse width, applied during swallowing tasks.		data indicated increased muscle activation in the EMS group. While not exclusively acute stroke, it supports the physiological effects of EMS.
Vasant et al. (2016)	United Kingdom	Prospective, randomized, single-blinded interventional study; 73 acute and subacute stroke patients (within 6 weeks of stroke onset) with dysphagia. Randomized to pharyngeal electrical stimulation (PES) or sham + standard care.	PES delivered via nasogastric tube to pharynx; 10 mins/day for 3 consecutive days. Parameters: 5 Hz frequency, 7 ms pulse duration.	Primary: Aspiration reduction (videofluoroscopy). Secondary: Return to oral diet (FOIS).	PES group showed a significant reduction in aspiration episodes and a greater proportion of patients returning to an oral diet vs. sham group. Highlights the potential benefit of intraluminal pharyngeal EMS in the acute/subacute phase.
Yue et al. (2015)	China	RCT; 60 patients with dysphagia specifically caused by medullary infarction (a type of acute stroke). Randomized to experimental (NMES + conventional rehabilitation) or control (conventional rehabilitation	NMES to suprahyoid and infrahyoid muscles; 30 mins/session, twice daily for 2 weeks. Parameters: 30 Hz frequency, 300 μs pulse width, and intensity set to achieve muscle contraction.	DOSS, KWST, VFSS (pharyngeal transit time, residue).	NMES group showed significantly greater improvement in DOSS, KWST, pharyngeal transit time, and residue compared to the control group. This suggests that NMES is an effective adjunct therapy for dysphagia in acute medullary infarction.

		only).			
Zhang et al. (2022)	China	RCT; 60 patients with post-stroke dysphagia (average disease duration 67.0 ± 23.77 days, subacute to early chronic). Randomized to NMES or control, both receiving conventional swallowing training.	NMES to suprahyoid muscles (digastric and geniohyoid); 30 mins/session, 5 times/week for 4 weeks. Parameters: 80 Hz frequency, 300 µs pulse width, intensity to evoke observable muscle contraction.	NIHSS dysphagia score, DOSS, penetration-aspiration severity.	NMES group demonstrated significant improvements in NIHSS dysphagia scores and DOSS compared to the control group. While the patient population was slightly beyond the typical "acute" phase, the findings support the beneficial effect of NMES on swallowing function post-stroke.

The empirical data from all these ten pieces of research generally prove the efficiency of using EMS in conjunction with traditional treatment methods for dysphagia patients with acute and early subacute stroke. Despite different parameters of EMS treatment and different indicators used to measure the efficiency of EMS application in each case, some common patterns can be identified.

Positive Impact on Swallowing: A considerable part of studies considered showed significant improvement in swallowing functions and related parameters (FOIS, DOSS, KWST, PAS, VFSS) due to the use of EMS treatment (Howard et al., 2023; Konecny & Elfmark, 2017; Lee et al., 2014; Liang et al., 2021; Tan et al., 2022; Vasant et al., 2016; Yue et al., 2015; Zhang et al., 2022).

Better Ability to Consume Food or Liquids Orally: The ability of such patients to consume food and drinks via mouth improved considerably because of EMS treatment.

Targeted Muscles: The surface EMS stimulates suprahyoid muscles (for instance, the anterior belly of digastric, mylohyoid, and geniohyoid muscles) to stimulate elevation of hyolaryngeal structure, whereas intraluminal EMS targets the pharyngeal region, as evidenced in studies like those by Vasant et al. (2016). Both interventions were found to provide therapeutic effects.

EMS in Combination: EMS was shown to be highly effective when used together with traditional swallowing rehabilitation exercises.

Type of Stimulation: According to Howard et al. (2023), for instance, sensory-level stimulation of muscles is also considered quite effective due to its enhanced comfort level for patients.

Timing: EMS treatments were proven to have a positive impact if applied at an early stage after a stroke (for instance, during the acute or subacute period).

2.11. Summary of Literature Review

Swallowing is a complicated process that involves the harmonious coordination of numerous nerve functions that regulate the coordination of the muscles involved in the act of swallowing. Possible symptoms may be chest pain, feeling that food is lodged in the throat, vomiting undigested food, and persistent sore throat. Dysphagia is a serious and common complication of stroke that requires appropriate rehabilitation measures. The diagnosis of dysphagia includes the presence of an impaired gag reflex and cough response, along with the abnormal water swallowing test.

Recently, EMS has become a potential complementary treatment modality that seeks to enhance the swallowing process by means of reinforcing the muscle fibers involved, improving sensory input, or stimulating cortical restructuring. Studies on the topic have employed

different research approaches, from the well-controlled experimental design of RCTs to less rigorous quasi-experimental methods.

However, based on the critical review of previous literature, there are several research gaps in the available empirical evidence, which this thesis proposes to bridge through quasi-experimental design:

Need for Definitive Evidence in the Acute Phase: Although several studies have reported positive results, the problem of lacking definitive evidence on the efficacy of EMS for dysphagia in acute stroke patients between 1-3months persists. Most of the previous researches have included both acute, subacute, and chronic phases, hence making it difficult to identify the effects in the acute phase. Even though randomized controlled trials are highly recommended, the feasibility of conducting such a trial in the acute phase makes it unachievable.

There is either little or no knowledge about the effectiveness of EMS on dysphagia among acute-stroke patients in Southern Nigeria and Nigeria at large, from the above-reviewed studies.

The use of a quasi-experiment in the present study is thus more realistic in the context of a clinical study rather than a RCT, as it will make it possible to assess the effect of EMS on these patients. The external validity of the results of this study is therefore increased.

In summary, even if the current literature gives some hints about EMS and its role in the management of dysphagia, several research questions still exist. The present dissertation, with a well-conducted quasi-experiment, will provide useful results regarding this field of study.

CHAPTER THREE

MATERIALS AND METHOD

3.1 Materials

3.1.1 Population

The population is made up of 32 acute-stroke patients with dysphagia amongst acute stroke patients in neurology unit of the Physiotherapy department, UBTH, Benin City.

3.1.2. Selection Criteria

This research was carried out amongst acute stroke patients with dysphagia in neurology unit, Physiotherapy Department of the University of Benin Teaching Hospital, Benin City.

3.1.2.1. Inclusion criteria

i. Adulthood (>18 years old)

ii. An acute stroke (1 – 3 months) as diagnosed by neuroimaging scans (CT and/or MRI).

iii. The presence of dysphagia verified through the swallowing assessment based on Functional Oral Intake Scale.

iv. Capability of compliance with simple instructions during the experiment.

v. Concluded informed consent from the subject or his/her legal guardian.

3.1.2.2. Exclusion Criteria

i. Cognitive impairment which makes him/her unable to take part in therapy.

ii. Tracheostomized.

iii. History of previous dysphagia or swallowing rehabilitation.

iv. Medical conditions where EMS is not applicable such as; Pacemakers, Unstable cardiac conditions, etc.

v. Severe non-stroke related neurological disorder.

3.1.3. Instruments

3.1.3.1. Electrical Muscle Stimulation (EMS) Device

i. The EMS device will be portable and have adjustable parameters (intensity, frequency, pulse duration). It must be medically certified as safe and efficient for the treatment of dysphagia.

ii. Electrodes appropriate for EMS device application will be used.

3.1.3.2 Functional Oral Intake Scale (FOIS)

The FOIS is a 7-point scale used to measure the functional level of oral intake of a patient. Crary, Carnaby-Mann, and Groher developed this scale in 2005. This ordinal scale can effectively classify the functional level of oral intake of a patient. The FOIS does not analyze the physiology of swallowing like instrumental assessments but determines what a patient can safely consume orally (Crary et al., 2005).

Reliability: It is very important to know whether the scale is reliable in measuring its intended construct. The FOIS shows great inter-rater reliability where high rates of agreement between different raters have been observed in addition to Kappa or Intraclass Correlation Coefficient (ICC) values. Perfect agreement rates of more than 85%, as well as Kappa values between

0.86-0.91 and ICC values more than 0.90 (Purnama et al., 2023; research findings based on different language versions), indicate that different clinicians after training can consistently assign scores to the same patient. Intra-rater reliability is also great, indicating that the same score is assigned by a particular clinician to a specific patient who remains unaltered since the last assessment session.

Sensitivity to change (responsiveness): meaning that the scale has capability to detect changes in patients' oral intake in terms of clinically significant improvement or deterioration. This trait will be very useful for the purposes of your research project, as you plan to measure the effects of EMS in patients with dysphagia.

Validity: The FOIS is well-known for its high content validity. It uses a seven-point ordinal scale that captures all levels of functional oral intake, from total tube feeding (Level 1) to total oral intake without restrictions (Level 7). All levels are precisely defined and reflect clinically significant differences in the patient's capacity to ingest food and fluids safely through their mouth.

Several research papers have shown significant associations between the FOIS score and gold-standard swallowing evaluations like videofluoroscopic swallow studies (VFSS) and fiberoptic endoscopic evaluation of swallowing (FEES). Higher FOIS scores are reliably linked to low aspiration and penetration incidents (such as low Penetration-Aspiration Scale [PAS] scores) and efficient swallowing (Newman et al., 2016; Purnama et al., 2023).

Predictive Validity: Predictive validity has also been demonstrated in the FOIS for certain clinical indicators. Patients with low scores on the FOIS (suggesting severe dysphagia) were found to have increased incidence of aspiration pneumonia, extended hospitalization, and

worse nutritional status compared to those who had higher scores (Newman et al., 2016). This emphasizes the importance of the test in determining the prognosis of patients and the resources required. Construct Validity: In terms of construct validity, the FOIS has been found to correlate properly with other indices that assess functional capacity and stroke severity, like the mRS and BI (Crary et al., 2005).

Scoring:

i. Level 1: Not Allowed Anything by Mouth.

ii. Level 2: Dependent on Tube Feeding With Minimal/Inconsistent Oral Intake.

iii. Level 3: Dependent on Tube Feeding With Consistent Oral Intake.

iv. Level 4: Total Oral Intake of One Consistency.

v. Level 5: Total Oral Intake of Multiple Consistencies That Need Special Preparation.

vi. Level 6: Total Oral Intake Without Special Preparation but Needs to Restrict Certain Food or Liquid Items.

vii. Level 7: Total Oral Intake Without Any Restriction. (Crary et al., 2005).

3.1.3.3 Routine Care Provided (TST)

i. Swallowing Exercises (Mendelsohn Maneuver, Supraglottic Swallow, Masako Maneuver, Effortful Swallow).

3.2. Methods

3.2.1. Research Design

A Quasi-experimental research design was used to assess the efficiency of EMS therapy alongside swallowing rehabilitation in enhancing swallowing disorders amongst acute stroke patients.

Quasi-experimental design was considered since randomization was not possible in this case. The design involves the use of non-randomly selected samples where natural conditions or naturally occurring samples are utilized in order to examine a cause-and-effect relationship.

Experimental Group: EMS therapy and regular care

Control Group: other patients admitted in the same ward undergoing routine care after recruiting the experimental group.

3.2.2. Sampling Technique

Purposive sampling design was adopted in selecting the sample where all subjects who met the inclusion criteria of having difficulty swallowing were offered EMS therapy.

3.2.3. Sample Size

Sample size was determined using the formula by Taro Yamane (Yamane, 1967), considering a confidence level of 95% and margin of error of 5%.

Taro Yamane's formula is $n=N/(1+N(e^2))$

Where:

n = the sample size

N = the population size

e = the desired margin of error (or level of precision)

N = 37

Therefore, $n = 37/ (1+37(0.05)^2) = 33.9 \sim 34$.

3.2.4. Ethical Considerations

The ethical clearance for the research was granted by the Research Ethics Committee of College of Medical Sciences, University of Benin, Benin City.

Informed consent was obtained from all participants or their authorized guardians before participating in the research.

The confidentiality of the information provided by the participants was ensured.

3.2.5. Data Collection Procedure

The patients who met the inclusion criteria were recruited from the Neurology Unit, Physiotherapy Department, University of Benin Teaching Hospital.

Prior to enrolment into the study, the informed consent was obtained from the patient or his/her authorised guardian.

Sociodemographic questionnaires were developed to capture information about the sociodemographic characteristics of the patients, their medical history, stroke details, dysphagia severity, treatment variables, and outcome measures. Prior to being selected for the study, all patients underwent a thorough baseline evaluation which includes: Patient's medical history and neurological evaluation, dysphagia severity measurement using the evaluation of Functional Oral Intake Scale (FOIS)

The population in this case underwent EMS as well as the routine treatment before the start of the experiment. EMS was administered by a trained researcher using a set protocol. The

electrodes were attached to the anterior neck muscles responsible for swallowing, for example, suprahyoid muscles. Adjustments were made to parameters including intensity, frequency, and pulse duration based on the participant's threshold but the standard was set to include pulse width 300μs, frequency 30Hz, and intensity of 3-4. EMS was done for a period of 10minutes each session for three times in a week for four weeks in total. Routine treatment was provided depending on the specific swallowing impairment and the level of neurology.

Participants are evaluated at predefined time intervals during each of the 4-week period of treatment to establish the progression of dysphagia and the status of functional oral intake. Evaluations are done using the same criteria which were taken at baseline (FOIS).

Data for the control group participants was collected from their medical records and compared with FOIS and then recorded at time intervals.

3.2.6. Data Analysis

Descriptive analysis with respect to mean, frequency, and standard deviation of data was carried out in order to describe the characteristics of the participant in each study group.

Comparison analysis was performed between variables using Wilcoxon Signed-Rank Test for continuous variable whereas Mann-Whitney U test was employed to analyze the change in outcome measure (FOIS score).

Statistical Package for Social Sciences (IBM SPSS), Version 25 was used in analyzing data.

Significance was set at $p < 0.05$.

CHAPTER FOUR

RESULTS

4.1 Introduction

Objectives

The first and foremost objective of this research is to evaluate the efficacy of EMS technique in treating dysphagia in acute stroke patients in University of Benin Teaching Hospital, Benin city.

4.1.1 Sociodemographic characteristics of the participants

32 participants with acute stroke and dysphagia were selected for this research where 22 belonged to intervention group and 10 participants constituted control group. The distribution of gender among the intervention group indicated that 18(81.8%) were female while the remaining 4(18.2%) were males. Also, the percentage of the intervention group with high blood pressure and diabetes was 10(45.5%), whereas the hypertensive subjects constituted 6(27.3%). Furthermore, 20(90.9%) subjects had experienced stroke for one month period while 12(54.5%) participants suffered from ischemic stroke. Age of participants ranged between 55 and 87 years with a mean age of 71.55±9.25

In the control group, 6 (60.0%) of the subjects were males, whereas 4 (40.0%) were females. 6 (60.0%) of the subjects were hypertensive and diabetic simultaneously. 8 (80.0%) of the subjects had a history of stroke that occurred one month back. 8 (80.0%) subjects experienced ischemic stroke. Age of the subjects varied between 53 to 75years, having a mean of 65.00 ± 9.02 as presented in table 1.

Table 2: Sociodemographic of the participants

Variables	Intervention N	group %	Control n	Group %
Gender				
Female	18	81.8	4	40.0
Male	4	18.2	6	60.0
Past Medical History				
DM+HTN	10	45.5	6	60.0
HTN	6	27.3	4	40.0
HTN+DM+HEART FAILURE	2	9.1		-
NIL	2	9.1		
PUD+HTN+DM	2	9.1		
Duration of stroke				
1 month	20	90.9	8	80.0
2 months	2	9.1	2	20.0
`				
Type of stroke				
Bi-hemispheric	2	9.1		
Bilateral intracerebral hemorrhagic	2	9.1		
Hemorrhagic	2	9.1	2	20.0
Ischemic	12	54.5	8	80.0
Repeat stroke-ischemic	2	9.1		
Repeat stroke-hemorrhagic	2	9.1		
	Range	**Mean ± SD**	**Range**	**Mean ± SD**
Age	55-87	71.55 ± 9.25	53-75	65.00 ± 9.02

4.1.2 Descriptive statistics on FOIS of the participants for the control and intervention groups

As shown in table 2, For the control group, the mean FOIS scores at baseline, first assessment, second assessment, third assessment, and fourth assessment were 1.00 ± 0.00, 1.20 ± 0.42, 1.60 ± 0.52, 3.20 ± 1.55, and 3.80 ± 2.25, respectively. For the intervention group, the mean FOIS scores at baseline, first assessment, second assessment, third assessment, and fourth assessment were 1.09 ± 0.29, 2.00 ± 0.98, 3.27 ± 1.08, 5.00 ± 1.31 and 5.55 ± 1.47 respectively.

Table 3: Descriptive statistics on FOIS of the participants for the control and intervention groups

Variable	Range	Mean ± SD
Control group		
Baseline	1 - 1	1.00 ± 0.00
First assessment	1 - 2	1.20 ± 0.42
Second assessment	1 - 2	1.60 ± 0.52
Third assessment	1 – 5	3.20 ± 1.55
Fourth assessment	1 - 7	3.80 ± 2.25
Intervention group		
Baseline	1 – 2	1.09 ± 0.29
First assessment	1 - 4	2.00 ± 0.98
Second assessment	2 - 6	3.27 ± 1.08
Third assessment	3 - 7	5.00 ± 1.31
Fourth assessment	3 – 7	5.55 ± 1.47

4.1.3 Wilcoxon Signed-Rank Test showing the effectiveness of EMS and other routine care on dysphagia

The effectiveness of EMS plus routine care on dysphagia was evaluated using the Wilcoxon Signed-Rank Test. The Wilcoxon Signed-Rank Test showed that EMS combined with routine care

significantly improved dysphagia outcomes ($p < 0.001$). Additionally, routine care alone also had a significant effect on dysphagia ($p = 0.011$), as shown in Table 3.

Table 4: Wilcoxon Signed-Rank Test showing the effectiveness of EMS and other routine care on dysphagia

Groups	Variable		N	Mean rank	Sum of ranks	Z	p
intervention	FOIS(Fourth-baseline)	Negative ranks	0^b	0.00	0.00	-4.149	<0.001
		Positive ranks	22^c	11.50	253.00		
		Ties	0^d				
Control	FOIS(Fourth-baseline)	Negative ranks	0^b	0.00	0.00	-2.533	0.011
		Positive ranks	8^c	4.50	36.00		
		Ties	2^d				

4.1.4 Mann Whitney U test to compare the outcomes between the intervention and control group

Mann Whitney u test was conducted to compare the outcomes between the intervention and control groups. The finding revealed there was a significant difference in the FOIS scores between the intervention and control group ($p=0.043$) as shown in table 4.

Table 5: Mann Whitney u test to compare the outcomes between the intervention and control groups

Variable	Group	Mean rank	Sum of ranks	U	p
FOIS	Control	11.90	119.00	64.000	0.043

	Intervention	18.59	409.00

4.2 Hypothesis testing

Hypothesis one: No significant effect exists of EMS combined with routine care on acute stroke patients with dysphagia

Statistical test used: Wilcoxon Signed-Rank Test

Significance level (alpha): 0.05

Obtained p-value: <0.001

Decision: As the obtained p-value is below 0.05, we reject the NULL HYPOTHESIS

Hypothesis two: No significant effect exists of routine care on acute stroke patients with dysphagia

Statistical test used: Wilcoxon Signed-Rank Test

Significance level (alpha): 0.05

Obtained p-value: 0.011

Decision: As the obtained p-value is below 0.05, we reject the NULL HYPOTHESIS

Hypothesis three: There is no significant difference in swallowing function between the intervention and control group

Statistical test used: Mann Whitney U-test

Significance level (alpha): 0.05

Obtained p-value: 0.043

Decision: As the obtained p-value is below 0.05, we reject the NULL HYPOTHESIS

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

One of the key objectives of this investigation was to prove that the use of EMS alongside the routine swallowing therapy is more effective than routine treatment alone in the case of dysphagia patients suffering an acute stroke. It seems that the hypothesis was proven to be true because the difference in swallowing function between the two studied groups was statistically significant.

According to the results obtained, both methods proved to be effective as they significantly improved swallowing function. The control group, which received only the routine treatments, such as swallowing exercises, positioning and diet change, revealed statistically significant improvement from baseline to the end point. This is the expected result since it has been proven that the routine swallowing therapy is efficient for dysphagia in post-stroke patients (Martino et al., 2005). This means that it promotes recovery and improves safety of swallowing process.

Nevertheless, one of the core findings of the present study is the enhanced effectiveness of the combined intervention. While the improvement in FOIS scores of the intervention group (that was treated with EMS and the usual treatment) was more prominent, even more important was that the FOIS scores at the end of the study period were significantly higher in the former group compared to those in the latter group. The average value of 5.55 (meaning total oral intake with some preparation) achieved by the EMS group, against 3.80 (being close to the use of a feeding tube while having consistent oral intake), illustrates an appreciable difference in functional abilities of the patients from the two groups. The present findings support a number of studies conducted earlier and reporting positive effects of neuro-muscular electrical stimulation (NMES, another name for EMS), on post-stroke dysphagia. The suggested reasons for the success of EMS therapy

include the following: EMS stimulates the suprahyoid muscles directly, forcing them contract and lift up the larynx. A greater amount of sensory feedback is obtained through the electrical current to the central nervous system.

An increase in sensory input may facilitate the development of new connections in the motor cortex of the brain, which controls the movements associated with swallowing (Power et al., 2006). Research conducted by Park et al. (2012) and Kiger et al. (2006) has revealed that NMES can bring substantial changes in terms of improving the hyolaryngeal excursion and elevation, which is important in protecting the airways and moving the bolus through the pharynx. The results of this research, indicating an improvement in oral diet types in the EMS group, could be considered as an additional proof of this physiological change. It coincides with international scientific evidence regarding the benefits of using EMS in early post-stroke therapy for dysphagia. Clinically significant changes in patients' FOIS score were observed in the experimental group within four weeks of the experiment. It means that stimulation of the suprahyoid muscles, in combination with standard treatment techniques including positioning and other manipulations, can expedite swallowing recovery in post-stroke population.

This EMS protocol – frequency 30 Hz, pulse width 300 µs, and intensity causing visible muscle contraction – was developed based on literature reviewed for previous research (Konecny et al., 2017; Liang et al., 2021). The application proved successful and no adverse outcomes were noted.

The results obtained in this study align with other findings obtained from randomized controlled trials that have shown the positive influence of EMS on swallowing in acute stroke patients. Konecny et al. (2017) found that there was a significantly better outcome of swallowing recovery for FOIS and FDS scores in stroke patients undergoing EMS on the suprahyoid muscle. This approach was adopted in the present study as well, with the same placement of electrodes and the frequency of 30 Hz. Additionally, Howard et al. (2023) found out that both motor and sensory

EMS resulted in significantly more pronounced FOIS improvements compared to sham EMS in patients with acute strokes (mean 9 days post-stroke). This suggests that the low-moderate intensity of stimulation used in the current study is applicable. Finally, Liang et al. (2021) utilized VitalStim EMS and found significant improvements in DOSS, KWST, and PAS scores, which proves that when EMS is combine. This result is consistent with our experimental design, thus emphasizing the effectiveness of EMS as a supplementary treatment modality. This assertion is also consistent with previous studies conducted by Yue et al. (2015) and Zhang et al. (2022), who found that EMS enhances swallowing function, particularly regarding pharyngeal transit time, residue, and aspiration severity. Although participants included in their sample were still within the early and subacute stages, the EMS treatments were similar in terms of frequency and duration, validating the results obtained in the current study. Additionally, Tan et al. (2022) and Lee et al. (2014) reported significant gains in SWAL-QOL and physiological factors such as pharyngeal transit time and residue due to EMS interventions.

Nevertheless, it is not unanimous in all the literature. According to Guillén-Solà et al. (2017), there were no significant added effects to EMS treatment with Expiratory Muscle Strength Training (EMST). However, it is worth mentioning that in the context of the present research, this investigation considered only subacute participants and sham NMES. It was the effects of EMST, rather than EMS, that were deemed to be of greater importance in the research. Unlike the current one, the latter introduced a combination of therapies rather than just EMS as the additional treatment to TST. Furthermore, Toyama et al. (2014) studied heterogeneous subjects (stroke cases were not solely analyzed), with improvement noted for FOIS outcomes but not so much for others. Considering that most of their participants were in the chronic period, different neuroplasticity may have affected results. Vasant et al. (2016) observed aspiration reduction and the ability to eat by mouth after the use of pharyngeal electrical stimulation (PES) given intraluminally. In fact, it is

EMS, but the mode of delivery, being transcutaneous and via nasogastric catheter in the case, made comparison difficult.

5.2 Conclusion

Overall, this research indicated that a combination of EMS and normal swallowing therapy was much more efficient than only normal swallowing therapy to recover swallowing functions of patients having dysphagia due to acute stroke. Both methods were efficient in the treatment process, yet adding EMS provided better results compared to using routine treatment methods.

5.3 Recommendations

Those physiotherapists who treat dysphagia after stroke may want to incorporate the use of EMS alongside normal swallowing therapy. This could help improve recovery by enabling a patient to start eating normally much quicker and avoid the consequences associated with the inability to eat normally, for example, dehydration, malnutrition, and even pneumonia.

5.4 Implications for Further Study

This research is yet another addition to the mounting body of literature supporting the use of EMS in early dysphagia rehabilitation for stroke victims. It is non-invasive, mobile, and fairly inexpensive. Further investigations would benefit from incorporating instrumental evaluations (such as VFSS or FEES) to determine the relationship between the gains made in the functional oral intake scale (FOIS) and changes at the physiological level of swallowing function. A future randomized controlled trial (RCT) involving several centers will help circumvent the shortcomings of the current quasi-experimental approach.

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APPENDICES

APENDIX 1

INFORMED CONSENT FORM

My name is ELUEMUNOR CHINASIA RHEMA. I am a final year student of the department of Physiotherapy, School of Basic Medical Sciences, University of Benin. I am conducting a study on "EFFECTIVENESS OF ELECTRICAL MUSCLE STIMULATION (EMS) ON DYSPHAGIA AMONG ACUTE-STROKE PATIENTS IN A TERTIARY HEALTH INSTITUTION IN BENIN CITY". This research is a way to expand the knowledge of the effect of EMS on acute stroke patients with dysphagia in improving swallowing. For the purpose of this study, the severity of the dysphagia will be measured using the Functional Oral Intake Scale and then electrodes will be placed on the anterior parts of the neck for stimulation. Your participation and responses will be appreciated and kept confidential.

My email is rhemachinasia@gmail.com and my phone number is 07084407482.

Please note that your participation in this study is voluntary and the participants has the right to withdraw from this study at any time.

Consent: Now that this study has been explained to me in details and I understand the nature purpose and benefits of the study, I consent for my ward to be a participant in this study

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Signature of the Guardian/Date **Signature of Researcher/Date**